Learning and Teaching in the Mobile Learning Environment of the Twenty-First Century

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"***The pace of change is accelerating…the result will be far greater transformations in the first two decades of the twenty-first century than we saw in the entire twentieth century." (Ray Kurzweil, The Age of Spiritual Machines – from D. Brown,2006).***

Abstract

Mobile learning, or learning accomplished with the use of small, portable devices (Mobile Learning, 2006), is not one of the new educational paradigms that suddenly blossom in the field of education, become wildly popular for a few years, then quietly fade away. It is simply a new vehicle for delivering education to today's learners via mobile phones, PDAs, tablet PCs, etc. Today's learners want to be able to learn anything, at any place, and just when they need that knowledge. Mobile learning devices are the perfect delivery vehicle for that type of learning. In this paper we will discover how mobile learning can be used effectively to teach the three generations of learners (Baby Boomers, Generation X, Millennial Generation) who are studying in our institutions of higher learning.

We begin with a discussion of how mobile learning is situated in the field of learning in general, in particular, how it is a subset of e-learning, which in turn is a subset of distance learning. Then, we discuss what mobile learning is, its history, its advantages, and some mobile learning devices. In section 2 of the paper we undertake a long journey into the pedagogy of mobile learning, because for it to be relevant in education it has to be considered a legitimate learning strategy. The third section of this report focuses on some of the challenges of mobile learning and some solutions to these challenges. In the fourth and last part of the paper we peer into our crystal ball and try to envision what the future of mobile learning will be like.

1.0 Introduction to Mobile Learning

1.1 Conventional Education

The world of education can be divided into the "continents" of conventional education and distance education. The terms traditional education, face-to-face education, and instructor-led-training have been used to describe conventional education, which takes place in schools and colleges, training centers and workshops. (Keegan, Undated)

Some of the characteristics of conventional education are: it takes place within the learning group, by interpersonal communication, and between the teacher and the student. (Keegan, Undated)

1.2 Learning Characteristics

1.2.1 Definition of Learning

Learning has been defined in many different ways. One definition is: "Learning is defined as a 'change in behavior, thoughts and/or attitudes resulting from education and/or experience." (Mobile Learning website: www3.telusnet/~kdeanna/mlearning/applications.htm). Mike Sharples describes learning as, "..a 'labile process' constantly open to change and adaptation, 'mediated' by knowledge and technology in supportive teacher, learner and peer relationships." (Ragus, 2006).Sharples has also described learning "as a process of coming to know, by which learners in cooperation with their peers and teachers, construct transiently stable interpretations of their world." (Y. Laouris and Eteokleous, 2006).Laouris and Eteokleous quote Sharples' definition of learning as "a process of coming to know, by which learners in cooperation with their peers and teachers, construct transiently stable interpretations of their world." (Laouris and Eteokleous, 2006). Social-constructivist learning theorists view learning as "an active process of building knowledge and skills through practice within a supportive community." According to them, learning involves the possibility of rapid and radical conceptual change. (Sharples, 2005).

1.2.2 Effective Learning

The National Research Council in a report published in 1999, concluded that effective learning is:

- Learner centered
- Knowledge centered
- Assessment centered
- Community centered (Sharples, 2005).

1.2.3 Lifelong Learning

Learning is now viewed as a lifelong process. New personal and mobile technologies have made possible a convergence between the new learning and these new technologies, as illustrated in Table 1. (Sharples, 2005)

Table 1: Convergence Between Learning and Technology	
New Learning	**New Technology**
Personalized	Personal
Learner Centered	User Centered
Situated	Mobile
Collaborative	Networked
Ubiquitous	Ubiquitous
Lifelong	Durable

1.3 E-Learning as a Subset of Distance Learning – Mobile Learning as a Subset off E-learning

Desmond Keegan says that mobile learning is best seen as a subset of distance education because, as stated above, he divides the world of education into the two halves of conventional education and distance education. He also says that the first distance educators broke with the 2000-year tradition of face-to-face learning and replaced it with:

- A largely individualized form of interaction
- Based on an apersonal form of communication
- That was mediated by technology (Keegan, 2006)

1.3.1 Definition of Distance Education

Keegan defines distance education as, "the provision of education and training at a distance by Open Universities, distance education institutions, and distance education departments of conventional institutions. (D. Keegan, 6) The ***Mobile Learning*** (http://www3.telus.net/~kdeanna/mlearning) website says distance learning "incorporates all forms of instruction in which instructor and student are physically removed from one another by time or space from traditional correspondence courses to web-based instruction." (Mobile learning and pervasive computing, 2006)

1.3.2 Types and Characteristics of Distance Learning Courses

Some of the types of distance education courses include

- Correspondence courses conducted through regular mail
- Internet courses conducted either synchronously or asynchronously
- Telecourse/Broadcast where content is delivered via radio or television

- CD-ROM or DVD where the student interacts with computer content stored on a CD-ROM or DVD
- Pocket PC/Mobile Learning where the student accesses course content stored on a mobile device or through a wireless server (Wikipedia, 2006)

1.3.3 History of Distance Education

One of the pioneers in distance education was Isaac Pitman, who taught correspondence courses in shorthand in Great Britain in the 1840s. (Wikipedia 2006) Correspondence courses were also taught in France, Germany, and the United States during this time period. In 1873 Anna Ticknow founded a society that mailed correspondence courses to women who wished to study at home. In 1883, Cornell University attempted to establish a Correspondence University, but it did not succeed. The first distance learning degrees were granted by Chautauqua College of Liberal Arts in New York State in 1883. Herbert Baxter Adams helped establish the extension movement at John Hopkins University. (B. Nasseh, 1997)

In 1915 a group of academicians who wanted to develop guidelines for measure the effectiveness of distance education, established the National University Extension Association (NUEA). In the early 1900s other means of delivering distance education, such as lantern slides and motion pictures were implemented.(History of Distance Education, University of Florida) The first catalog of instructional films was published in 1910. (M. Jeffries, Undated) Instructional radio was also developed, but by 1940 only one college-level credit course was offered by radio. The University of Wisconsin was established in 1892 and has helped foster acceptance of distance education. In 1958 the university was offering nearly 450 correspondence courses and teaching 12,000 students annually. (Florida website) In 1969 the Open University, the largest distance education university in the United Kingdom, was founded. Currently it has more than 180,000 students. (Wikipedia, 2006). The first open university in the United States as New York State's Empire State College, established in 1971. (B. Nasseh, 1997).

As early as the 1930s some educators saw promise in instructional television, and Iowa State was the first university to offer college classes via television. Educational television grew slowly, until by 1972 there were 233 stations. Ohio University, University of Texas, and the University of Maryland were among the first to create educational TV networks. (M. Jeffries, Undated) In the late 1960s and early 1970s universities began to establish microwave networks. During the 1970s, 80s, and 90s, many distance education for profit universities, such as the University of Phoenix, Walden University, Nova Southeastern University, and Capella University were established. Many schools offer bachelor's and

master's degrees via online Internet-based), computer-based instruction. Most online doctoral programs have some residency requirements.

1.3.4 Distance Education Delivery Systems

We have looked at several delivery methods for distance education in the section on the history of distance education. To recap, regular mail was the first delivery method for distance learning. Written material, videos, CDs and DVDs, audio tapes, and materials on SD cards and flash drives may be delivered to learners via regular mail. Today, distance classes are broadcast over broadband network connections, both wired and wireless, television, and radio. Some distance classes make heavy use of email, some make use of a LMS such as Blackboard that offer asynchronous discussion forums and synchronous discussions via whiteboards and text messages. Many distance learning instructors make course materials available over their website. (Wikipedia, 2006)

1.3.5 Some of the Advantages of Distance Education

Some of the many benefits of distance education, according to Desmond Keegan, are:

- Learners can learn at any time and in any place.
- Learners can acquire new knowledge and skills when they are ready to use them.
- Learners were freed from having to learn in a fixed place such as a university or training center, they no longer have to learn as part of a group – at a fixed time, fixed place, fixed period of time. (D. Keegan, Undated)

1.4 E-Learning

1.4.1 Definition of E-Learning

Laouris and Eteokleous quote Pinkwart's definition of e-learning as, 'learning supported by digital "electronic" tools and media.' (Laouris and Eteokleous, 2006). Lee and Polat say, "e-learning is education delivered through electronic means." (Lee and Polat, 2006). According to the Mobile Learning website, e-learning includes all forms of instruction "in which instructor and student are physically removed from one another by time or space from traditional correspondence courses to web-based instruction. (Mobile Learning website, 2006). Wikipedia says that "e-learning is an all-encompassing term generally used to refer to computer-enhanced learning, although it is often extended to include the use of mobile technologies such as PDAs and MP3 players. (Wikipedia, 2006). In this paper, mobile learning and e-learning are considered different forms of learning. Desmond Keegan says, "e-learning is the provision

of education and training via the WWW for students who study mainly as individuals using LMSs (or VLEs) like WebCT and Blackboard. (D. Keegan, Undated).

1.4.2 Four Fundamental Perspectives on E-Learning

Drawing upon research in theories, these four perspectives on e-learning have been identified:

- Cognitive perspective – It focuses on the cognitive processes involved in learning as well as how the brain works. Research in this view of learning as been done by Bloom, Gagné, Holmberg, Moore, and Rowntree.
- Emotional perspective – It focuses on motivation, engagement, and other emotional aspects of learning. Research on the emotional perspective has been done by Holmberg, Malada, Moore, Kearsky, Rogers, and Zimmer.
- Behavioral perspective – It focuses such factors as the skills and behavioral outcomes of the learning process. Some of the researchers in this arena are Cobb, Moore, Rowntree, and Verduin.
- Contextual perspective – It concentrates on the environmental and social aspects that can stimulate learning. Research in this area has been done by Black, Moore, Petraglia, Lave, Wenger, Bandura, and Vygotsky. (Wikipedia, 2006)

1.4.3 The History of E-Learning

Computer-enhanced learning began as far back as the 1960s when it had to be delivered via mainframe, and a bit later, mid-sized computer systems, but it really did not become popular until the development of the micro-computer. It growth was facilitated in the 1980s with the founding of schools such as the Western Behavioral Sciences Institute, the New York Institute of Technology, and the Electronic Information Exchange System of the New Jersey Institute of Technology. By 2003, more than 1.9 million students were learning online at institutions of higher learning in the United States. Now virtually all public institutions offer online classes. Many private institutions also offer online classes and degrees.

1.4.4 Advantages of E-Learning

Some of the noted advantages of e-learning are:

- Flexibility and convenience for the learner
- Ease of communication between learners
- More variety in learning experiences, largely due to the use of multimedia
- Video and audio instruction make it possible for the learner to pause, rewind, and listen again to the material.

- E-learning benefits organizations that have constantly changing learners and whose learners are distributed across many locations. (Wikipedia, 2006)

1.4.5 Problems and Disadvantages of E-Learning

Some of the problems and disadvantages faced by e-learning:

- Lack of face-to-face interaction with a teacher
- Distance learners often feel isolated.
- Expense of purchasing hardware and software for e-learning systems and keeping them updated (Wikipedia, 2006)

1.5 Mobile Learning

1.5.1 Definition of Mobile Learning

A search for the phrase "*mobile learning:define*" resulted in thirteen hits in Google Scholar and 171 in Google. The following list of definitions perhaps should be viewed as a brief taxonomy of definitions of mobile learning, which will enable the reader to reflect on which aspects of mobile learning are emphasized by the authors:

- "M-learning is the delivery of learning to students who are not keeping a fixed **location** or through the use of **mobile** or **portable** technology." (Wikipedia, 2006)
- "M-learning is the delivery of learning to students who are not keeping a fixed **location**." (The Free Dictionary, 2006)
- "M-learning is 'learning as it arises in the course of **person-to-person** mobile communication." (Oloruntoba, 2006)
- " Mobile learning refers to the use of small, **portable hand-held devices** (personal digital assistants or PDAs, smart phones, laptops) that usually operate in a **wireless** environment, and have a connection to the Internet." (MLearning World blog, Monday, September 18, 2006)
- "It is the **learner** that is mobile, not the technology." (Low and O'Connell, 2006)
- Polsani defines mobile learning as "a form of education whose site of production, circulation, and consumption is the **network**." (Laouris and Eteokleous, 2006)
- Keegan defines mobile learning as "the provision of education and training on PDAs/palmtops, handhelds, smartphones, and mobile phones." (Keegan, Undated). **Portable hand-held devices**.
- The Mobile Learning website defines mobile learning as "learning accomplished with the use of small, **portable computing devices**." (Mobile Learning website, 2006)

It may be of some value to consider the terms used most frequently is these eight definitions of mobile learning:

- Mobile or portable devices – 4
- Location 2
- Wireless 1
- Learner 1
- Network 1
- Person-to-person 1

It is interesting to note that only of these definitions notes that it is the learner who is mobile, not the technology, that of Low and O'Connell.

1.5.2 Comparison Between Mobile Learning and E-Learning

E-learning is an alternative to traditional education, but can be complementary to it as well. M-learning can also be complementary to both traditional learning and e-learning, but it allows the learner to interact with learning resources while away from his or her normal place of learning. M-Learning faces some challenges that e-learning does not face. Some of them are:

- Small screen sizes
- Limited processing power
- Reduced input capabilities (Wikipedia, 2006)

Table 2 illustrates some of the differences between e-learning and m-learning:

Table 2: Comparison Between E-Learning and M-Learing	
e-learning	**m-learning**
Computer	Mobile
Bandwidth	GPRS, G3, Bluetooth
Multimedia	Objects
Interactive	Spontaneous
Hyperlinked	Connected
Collaborative	Networked
Media-rich	Lightweight
Distance learning	Situated learning
More formal	Informal
Simulated situation	Realistic situation
Hyperlearning	Constructivism, situationism, collaborative
Source: Laouris and Eteokleous, 3	

1.5.3 History of Mobile Learning

Some date the beginning of mobile learning to the invention of the PDA, a little more than thirty years ago. According to Evan Koblentz, the Hewlett-Packard programmable calculator, which was developed in the early 1970s, was the precursor of the PDA. Satyan Pitroda obtained a patent for an early PDA.

Casio introduced the Casio PF-8000, the first PDA with character recognition. In 1984 a handheld computer that could be held in a person's hand were introduced. In about 1987 the Panasonic Personal Partner became the first palmtop computer to use a version of DOS. In 1990 the first PDA with a pen GUI and handwriting recognition was introduced.

Apple coined the term "personal digital assistant" in the early 1990s with the introduction of the Apple Newton. Most PDAs today have many of the functions of a laptop computer. Most can also be used as cellphones. Other capabilities are Internet connectivity, watching movies, listening to MP3s, and playing games.

1.5.4 Mobile Learning Characteristics

Many characteristics of mobile learning are discussed in the literature. The following list is not meant to be all-inclusive, but should provide a fair sampling of its characteristics:

1. It is the learner who is mobile, not the technology.
2. Mobile learning can both complement and conflict with formal education.
3. Mobile learning raises deep ethical questions involving privacy and ownership. (M. Sharples, 2005)
4. Mobile learning uses devices people are used to carrying around with them.
5. Mobile learning devices are friendly and personal.
6. Mobile learning devices are inexpensive and easy to use.
7. People use mobile learning devices in all walks of life and in many different settings. (D. Keegan, Undated)
8. Learning can be considered mobile in terms of space, between different areas of life, and with respect to time. (L. Naismith, et al, 2004)

1.5.5 Mobile Learning Environments

Several platforms have and are being used for mobile learning. Some of them are cell phones, laptop computers, palmtop computers, and GPS systems. According to the Mobile Learning website, common features of these platforms include;

- Communication tools
- Games
- GPS
- Information managers
- Internet
- Multimedia
- Personal
- Professional
- Travel

- Text and reference (Infrastructure article on Mobile Learning website, 2007)

Several types of learning portals have been developed for m-learning systems. A couple of them are mPortal and Intelligent Web Tutor. MPortal consists of a series of mini web pages with navigation pointing to:

- Learning materials, such as lecture notes
- Mini web page builder tools
- Collaborative activities tools such as noticeboards
- Peer-to-peer communication services such as chat rooms and e-mail
- Messages, chat, discussions, and blogs
- The learning management system
- Simple help guides for the system, such as FAQs
- Links to interesting and relevant sites on the Web (R. Oloruntoba, 2006)

There are thousands of mobile learning projects one might list. Here are a few of them:

Table 3: Mobile Learning Projects

Title	Project Leader	Tools	Outcomes
From E-Learning to Mobile Learning	Ericsson Education, Dublin	PDAs, Microsoft Reader Works	1. Students able to comfortably read text on small screens 2. Developed courseware for phones
Mobile Learning: Next Generation of Learning	Ericsson Education, Dublin	Macromedia Dreamweaver, XHTML, CSS, Adobe Photoshop, Flash Lite	Developed courseware for PDAs
IST M-Leaning	LSDA, UK	Mobile phones	Developed courseware for mobile phones

(Source D. Keegan, Undated)

1.5.6 Advantages of Mobile Learning

Mobile learning offers many advantages for today's learner from Generation X. Some that may be listed are;

1. Generation X learners have a sense of intimacy with devices they hold physically close, over time, and in nonpublic spaces.
2. Mobile learning devices are good tools for collaboration as students share devices, communicate via text messages, and can find a private physical space to share. (B. Alexander, 2004)
3. These learners have grown up with a cognitive disposition towards mobile devices, even if they don't need portability in their learning. (Wikipedia, 2006)
4. Generation X learners are "always on," experimental and community oriented.

5. They are focused on connectedness and social interaction and prefer group-based activities in study and social occasions. (Cobcroft, et al, 2006)
6. Mobile communication devices empower smartmobs to show up at sites around town, perform an action, then disappear. (*Mobile Learning-Issues*, 2006). Designers of materials for mobile learning will be challenged to develop meaningful content for these potential learners.

Some other advantages of m-learning for all learners are:

1. M-learning increases the flexibility of learning spaces. (B. Alexander, 2004). Mobile learning tools free the learner from the classroom and the power grid. (Low and O'Connell, 2006)
2. Mobile learning enables on-demand learning.
3. It connects formal education with informal situated learning experience. For example, students can study on trains or in airports. (E. Wagner, 2006) A study by Vavoula in 2005 found that 51% of everyday learning takes place at home or in the learner's office in the workplace. (M. Sharples, Taylor, and Vavoula, 2005)
4. Mobile learning sees learners as participants who are creative and communicative, not as passive consumers. (B. Alexander, 2004)
5. The knowledge that an organization needs is in the heads of its employees. Mobile learning devices can assist in codifying that knowledge in a more flexible format than traditional formal content. (C. Quinn, 2002)
6. Mobile learning gives teachers and learners increased flexibility and new opportunities for interaction. (Oloruntoba, 2006)
7. Mobile learning can assist in Competency Based Training (CBT). (*Mobile Learning-Applic*ations, 2006)
8. Current mobile tools provide remote and instant access to a range of people and resources, and an ability to process data that was never possible before.
9. M-Learning is inexpensive (mLearning-World blog, 09-30-06)
10. Learners who live in remote locations can utilize mobile learning tools. (D. Keegan, Undated)

Advantages of mobile phones:

1. The mobile phone demolishes boundaries, private or public. Learners can learn when they want to, wherever they want to, and however they want to. (Laouris and Eteokleous, 2006)
2. They are already in common use in our lives and in our social practice, so little extra effort is required to get people to adopt and use mobile phones.

1.6 Mobile Learning Devices

1.6.1 Is There a Perfect Mobile Learning Device?

Clark Quinn in a blog at **mLearning-World** addressed the issue of finding the perfect device for mobile learning. Quoting Quinn, "Where we as eLearning practitioners seem to fail is we keep looking for the perfect device to support mLearning. Instead, it is time to realize that the perfect mLearning device is whatever device our audience already had. This could be a cell phone, laptop, iPod, or other device." (M. Nehrling, *mLearning-World* blog, posted December 3, 2006)

1.6.2 A Look at some Mobile Learning Devices

Some of the features currently offered by today's mobile learning devices are;

- Global Positioning Systems (GPS)
- Radio Frequency Identification (RFID) transponders
- Bluetooth technology
- Instant messaging
- Mass storage (E. Wagner, 2005)
- Wireless access points (WAPs) (B. Alexander, 2004). There are two popular wireless standards, Wi-fi (wireless fidelity, also known as 8021l networking) and Bluetooth. Wi-fi is used primarily for Internet access. Bluetooth is used primarily to replace cable. Bluetooth's range, though, is limited to about thirty feet. (D. Bills, etal,2006)
- Screencast and screencasting – A screencast is a computer-based presentation tool that may be used online or offline, and may be viewed as a sequence of dynamic screenshots presented in a format that combines the features of a PowerPoint presentation and a video podcast (Vodcast). (R. Oloruntoba, 2006)

Some of the mobile learning devices in use today are:

- Tablet PCs
- iPods
- Palmtop computers
- PDAs
- Mobile phones and SMS (Short Messaging Service) (Cobcroft and Low, 2006). Mark Prensky estimated that there were more than 1.5 billion mobile phones in the world in 2004. (R. Oloruntoba, 2006)
- PDA/phone combinations (C. Quinn, 2002)
- Portable video game devices, such as the Nintendo DS and the Nokia N-Gage (mLearning World blog, 2006)
- Pocket PCs
- Digital cameras (B. Alexander, *2004*)

Mobile learning platforms may be categorized as:

- Smart Phones
- Tablet Computers
- Pocket PCs
- Portable Media Centers
- Mobile Printers (*Mobile Learning – Technology* , 2006)

1.6.3 A More Detailed Look at Some Popular Mobile Learning Devices

1.6.3.1 Classroom Response Systems – According to Wikipedia a classroom response systems (CRS), audience response system, or clicker, is a device that allows interactivity between a presenter and his or her audience. They combine wireless hardware with a presentation system such as Microsoft PowerPoint®. (Wikipedia, 2006) One of the most popular CRSs is distributed by TurningPoint Technologies. (http://www.turningtechnologies.com/). Some teachers at Austin Community College use the TurningPoint audience response system in their classes. They are especially effective in subjects such as Government, where instructors use them to anonymously poll their students on the topics under discussion. The instructor shows a PowerPoint slide that contains the question; each student answers by pressing the response button on his or her "clicker."

Classroom response systems are an effective tool for formative assessment in the classroom. Some of their advantages are;

- Students can get much more feedback than normal.
- They can see where fellow students share their misunderstandings and that they are not alone.
- Since polling is anonymous, students are not as likely to be embarrassed if they answer a question incorrectly.
- Teachers can engage their students in knowledge-rich conversations through peer instruction. (J. Roschelle, 2003)

CRSs allow the teacher to ask short answer or multiple choice questions. It instantly collects and totals students' responses. The teacher's device aggregates the responses and presents them in a coherent form, usually in a histogram. They allow teachers to see patterns in the responses of their students. (Frohberg, 2006) For example, in a U.S. Government class the teacher asks the class which political party they belong to. When the responses are totaled and displayed on the teacher's machine the breakdown could be shown as: Democrats 25, Republicans 10, Independent 5, Undecided 2.

1.6.3.2 PDAs as Mobile Learning Tools

An article on the silicion.com website says 7.4 million PDAs were sold in 2005.

Many teachers now use PDAs in the classroom to provide a collaborative learning environment for their students. Some of the educational uses of PDAs in the classroom are:

- Digital note taking – Students can quickly spell-check and modify their class notes. Mark Szuchman at Florida International University encourages his students to take their classroom notes on their PDAs. He was given a grant to carry out a two-year project in which his students used Palm Pilots in the classroom. The objectives of the project were to:
    1. Guide student behaviors toward digital note-taking
    2. Improve note-taking skills
    3. Accumulate and use notes to enhance cognitive skills
    4. Create mechanisms that will continue to yield benefits
    5. Strengthen the quality of research papers, in particular, the analytical components. (NOTE: I have been unable to find any references online about the outcome of this study, which he did in 2002-03. He makes not mention of it on his website). (M. Szuchman, 2002)

- Teachers can distribute course material via PDAs through the Internet or IRDA connections.
- Teachers can use educational software that runs on PDAs in their classes.
- Students can download electronic textbooks to their PDAs. (Wikipedia, 2006)
- Jeremy Roschelle in an article published in 2003, discusses the use of wireless mobile devices in participatory simulations. One possible scenario he mentions is an exercise in which one student's mobile device is "infected" with a disease. The disease is spread from device to device as students exchange messages. The students are tasked with control the spread of the disease.
- Roschelle also mentions how mobile devices could be used in collaborative data gathering. He discusses how students could use their Palm Pilots and probes to gather data on water quality. (J. Roschelle, 2003)
- Carol Savill-Smith and Phillip Kent published a paper in 2003 which reviewed the literature on the use of palm top computers in education. They give several example of using them for learning, including:
    - The Cooties Game – (Yes, those cooties!!) – Focus: Explore the spread of communicable diseases through handheld computers
    - Geney – Focus: Collaborative problem-solving application to help children explore genetic concepts

    - The Dockhands Learning Acceleration Project – Focus: To increase the amount of children's reading and writing
    - Science fieldwork – Example: A visit to a botanical garden after which the children created databases of technical terms and botanical information
    - Physical and sports education – Example: Students can use their palmtops to record and analyze their own physical performance and send their reports to their teachers.
    - Reflective logs – Students record their observations in the professional situation they are working in. (Savill-Smith and Kent, 17-22)
- David R. Rawlinson and Kimberlee Bartel published an article in the *Educause Quarterly* in 2006 in which they listed the following uses for PDAs in education:
    - Note taking
    - Data collection
    - Digital imaging
    - File and data sharing

1.6.3.3 Reasons PDAS are popular in education

In Ted Smith's article he says PDAs are popular for general users because:

- The hardware is reasonably mature
- They are very useful for managing calendars and contacts
- Medical and nursing students find them very useful to record patient information and medical reference and learning materials on the ward
- Users can attach them to a keyboard and input large amounts of data
- They are more convenient for students to carry around than laptops, offering the possibility of anywhere, anytime computing
- It is easy to synchronize them with laptop or desktop computers
- Wireless communications are easy to configure and use
- Users do not have to wait for an operating system to boot up
- They have a much longer battery life than laptop computers
- They can hold large amounts of data
- Data can easily be kept up to date
- They are less expensive than laptops

Agnes Kukulska-Hulme in her article, *Current Uses of Wireless and Mobile Learning* (From Savill-Smith article 2005), identifies these reasons for the increased use of palmtop computers in education;

- They promote information literacy They support independent learning
- They assist with students' motivation

- They help students become better organized They track students' progress
- They can be used for assessment (A. Kukulska-Hulme, 2005)

Ted Smith identifies the following reasons why PDAs are popular with instructors:

- They are a useful tool to use in discussions when used with exercises or lectures.
- Students can use PDAs to access reference material.
- Students can access interactive quizzes and exercises on their PDAs.
- In classes with wireless connections they can provide instant feedback to instructors.
- They can help motivate students (Ted Smith article, 2003)

Mark Prensky, the educational gaming guru says that handheld computers are important tools for digital game-based learning and mentions their use for language learning and in the medical education field. (Savill-Smith and Kent 2006).

1.6.4 Tablet PCs

In Ted Smith's report on PDAs in education he also discusses tablet PCs. They offer stylus-based input via touch screens, handwriting recognition, quick start-up, built-in WiFi, and office applications. Some of their limitations are:

- Their handwriting recognition software cannot be trained.
- They have a short battery life.
- The robustness of tablet PCs has yet to be tested. (T. Smith, 2003)

1.6.5 Smart Phones

Smart phones are basically mobile phones that offer varying degrees of the personal information manager functionality of PDAs, according to Ted Smith. (T. Smith, 2003). Smith was writing in 2003. In the four years since then, smart phone manufacturers have added many more features to them, making it harder and harder to distinguish between PDAs and smartphones. Most college students now own mobile phones. If they can be persuaded to upgrade to smart phones, then eventually in the opinion of this writer, smart phones will become the predominant mobile learning device in the next few years.

An article on the silicion.com website says 7.4 million PDAs were sold in 2005. Smart phones are eclipsing PDAs. In 2005, 374. million units were sold. (Source: Silicon.com website, 2007)

1.6.6 Short Messaging Service (SMS)

Wikipedia defines Short Message Service (SMS) as, a service available on most digital mobile phones, other mobile devices (e.g. a Pocket PC, or occasionally even desktop computers) and some fixed phones, that permits the sending of short messages between mobile phones, other handheld devices and even landline telephones." SMS is more popular in Asia than in the Western word at this point. (Wikipedia, 2006) Some teachers complain that some of their students are using their mobile phones to text-message answers on exams to each other. In today's mobile learning environment teachers and instructional designers will be challenged to find creative ways to use SMS as an instructional device.

1.6.7 General Packet Radio Service (GPRS)

General Packet Radio Service (GPRS) is a mobile data service available to owners of certain types of mobile phones. It can be used for WAP service, SMS, MMS, email, and access to the World Wide Web. (Wikipedia article). John Traxler of the University of Wolverhampton, UK, participated in a learning project that give disadvantaged young people access to an online learning community via various mobile devices. GPRS mobile was one of the devices utilized in the project. The content of the learning materials they developed covered basic skills, such as literacy and math. Content is delivered a small soap opera format. The aim is to bring about cognitive and metacognitive change. (B. Little, Undated)

1.6.8 Summary of Section 1

In the first section of this report we laid the foundation for this study of mobile learning by first discussing conventional education and the characteristics of learning. You cannot study mobile learning unless you know that it is a subset of distance learning, which is a subset of e-learning, so we briefly discussed these forms of learning. Then, having laid our foundation, we began our discussion of mobile learning. First, we learned what it is and how it differs from e-learning. Then, we looked at the history of mobile learning. We also discussed some of the characteristics of mobile learning, mobile learning environments, and the advantages of mobile learning. In the last part of this section we looked at several types of mobile learning devices and their uses.

2.0 Pedagogy of Mobile Learning

2.1 Introduction to the Pedagogy of Mobile Learning

In this, the most important section of the report, we are going to take a detailed look at how mobile learning devices are being used in education, how they facilitate the learning process, and at how mobile learning should be designed. Mobile learning can support many theories of learning, from the behaviorist models developed in the early through the mid-twentieth century to the latest theories of learning such as Pask's Conversation Theory. We will consider how it supports over a dozen learning theories. Then, we will take another look at mobile learning devices and applications, focusing on their specific application in facilitating learning. We will conclude this section by considering which learning activities can be supported by mobile learning and how mobile learning can be evaluated.

2.1.1 How Mobile Learning Benefits Learners

Agnes Kukulska-Hulme and John Traxler, in their book, *Mobile Learning: A Handbook for Educators and Trainers* (2005) say the reasons for using mobile learning technologies are mainly to:

- "Improve access, by:
    - Improving access to assessment, learning materials, and learning resources
    - Increasing flexibility of learning for students
    - Improving access to students with special needs and complying with disability legislation, such as Section 508 of the ADA"
- "Exploring changes in teaching and learning, through:
    - Exploring the potential for collaborative learning, for increasing students' appreciation of their own learning process, and for consolidation of learning
    - Guiding students to see a subject differently than they would have done without the use of mobile devices
    - Identifying learners' needs for just-in-time learning
    - Exploring whether the time and task management facilities of mobile devices can help students manage their studies
    - Reducing cultural and communication barriers between staff and students by using channels that students like
    - Wanting to know how wireless/mobile technology alters attitudes, patterns of study, and communication among students." (Kukulska-Hulme, 2005)

- o
- "Alignment with institutional or business aims:
  - o Making wireless, mobile, interactive learning available to all students without them having to buy expensive hardware
  - o Delivering communications, information, and training to many people wherever they are located
  - o Blending mobile technologies into e-learning infrastructures to improve interactivity and connectivity for the learner
  - o Harnessing the existing proliferation of mobile phone services and their many users." (Kukulska-Hulme, 2005).

2.1.1.1 Cobcroft et al

Cobcroft, et al., list the following reasons for the popularity of mobile learning:

- Cost-wise mobile and wireless access now compares favorably with on-campus computer facilities, even if students are provided with subsidized or free hardware when they first enroll
- Mobile learning supports "user-led" education because students can create their own content and collaborate with other students and communities within and outside the classroom
- Mobile technologies facilitate the creating of "always-on" learning that is accessible to the masses but tailored to the individual.
- Mobile technologies overcome the weaknesses or coordination, communication, organization, negotiation, interactivity, and mobility characteristic of collaborative learning undertaken with technology.
- Mobile learning provides a shared conversation space, in which effective learning can take place through conversations as learners question each other and share their descriptions of the world.
- Mobile learning increases learning flexibility because it is a more learner-centered and personal learning environment.
- Mobile learning can support the social construction of knowledge by engaging their critical, creative, collaborative, and communicative faculties.
- Mobile technologies can assist the development of distributive learning networks by challenging learners to collaborate and communicate with each other. (Cobcroft, et al., 2006)

2.1.1.2 Laouris and Eteokleous

Laouris and Eteokleous write that mobile learning permits a contextual as well as a constructivist approach to learning because the learning experience can now be taken outside of the classroom into authentic learning environments. (Laouris and Eteokleous, 2006)

2.1.1.3 Naismith, Roschelle, and Oloruntoba

Research done by Naismith, Roschelle, and Oloruntoba supports the view that mobile learning devices provide improved opportunities for:

- Portability
- Social interaction
- Contextualization of learning
- Connectivity
- Personalization of learning (Low in *The Knowledge Tree*, 2006)

2.1.1.4 Jacobs and Polson

Jacobs and Polson in their article, *Mobile Learning, Social Learning*, relate that experimentation, customization, and personalization are driving the adoption of mobile learning technologies and that mobile learning creates a kind of 'content concierge' that fosters active engagement and the production of new content. Burns (2004) has described this active information access and consumption space as a 'producer' environment and it is key to understanding the nature and scope of new learning experiences. The authors go on to say that today's students are using mobile learning tools to understand and exchange ideas about the world at a speed and in a manner that doesn't necessarily match existing education strategies. (Jacobs and Polson, 2006)

2.1.1.5 Leonard Low

In Leonard Low's blog for mLearning World posted September 30, 2006,he says that people are always surprised when he tells them that mobile learning is actually cheap. He uses mobile phones as an example. If the teacher uses them as a platform in a m-learning activity hardware cost might be zero, if the students already have mobile phones. (Low, September 30 ,2006)

2.1.1.6 E-Learning Queen – Susan Nash

Susan Nash writes a blog for mLearning World under the penname of "eLearning Queen." In her post for September 26, 2006, she says that one of the benefits of mobile learning that is generally overlooked is "cognitive receptivity," or a state of mental preparedness. She states that cognitive receptivity results when the individual learner has:

1. A high desire to understand the material
2. A high tolerance for frustration
3. A good foundation upon which the content will be built
4. Support, either remote or face-to-face
5. High level of motivation, generally a combination of intrinsic and extrinsic motivators, and clear rewards

6. A way to relate the material to his or her experiences

She concludes by saying that a mobile learning device can help the learner capture content when he or she is at the highest level of cognitive receptivity. (Nash, 2006)

"School is where we go to pass exams – but real learning takes place outside of school." (Brown, 2006)

2.1.1.7 Doug Brown

Doug Brown presented a report on personalized learning at the 2006 Global Summit on Technology Connected Futures. In his report he discusses what the UK is doing to address the challenges and opportunities to education presented by the technologies of the twenty-first century. These are the ways he thinks hand-held learning devices can help the residents of the United Kingdom meet the challenges of creating a more personalized learning environment in the new century:

- **Access** – Those in charge of educational policy in the UK are supporting developments where all students can access educational material wirelessly through the Internet on their own PDA device.
- **Collaboration** – The British have created 'Gridclub', an online community where 6-12 year olds meet, share interests and learn together. For 13-19 year olds the BBC created Blast which encourages young people to go into dance, movies, art, writing, and music. In the UK Ask an Expert websites give user access to experts who share their passion for their subjects freely.
- **Learners as creators** – Under this topic Brown mentions blogs, Fanfiction (anyone can be a writer), new stories written for the Hitch Hikers Guide to the Galaxy, and over 268,000 new Harry Potter stories contributors have written.
- **Parallel processing or using new tools in different ways** – He mentions examples of how today's young learners can learn while listening to music or playing video games. He says that some schools are experimenting with playing background music as part of creating the right learning environment.
- **Informal versus formal learning** – There is a vast amount of content in museums and libraries and archives of audio and video assets that could be made available to learners outside of schools.
- **Multi-media / Multi-modal content** – In the UK students are being diagnosed to discover their learning styles so learning can be differentiated. He says that in the future learning will be tailored to match

each student's learning style. Brown also mentions that the British are studying the use of video games in education. (Brown, 2006)

A report published in the Future Lab series in 2004 reinforces what Brown says about the personalized nature of mobile learning devices. The authors say that mobile technologies are well suited to engaging learners in individualized learning experiences, and to giving them increased ownership and responsibility for their own work. (Naismith, et al., 2004)

2.1.1.8 Carol Savill-Smith

Carol Savill-Smith in her review of the literature on the use of palmtop computers in education (2006) offers the following reasons for using them in education:

- Palmtops are relatively inexpensive, compared with desktop and laptop computers
- They offer the possibility of ubiquitous computing. This refers to a situation where technology becomes virtually invisible in our lives.
- Palmtops offer access to information and promote the development of information literacy.
- They offer the possibility of collaborative learning.
- Palmtops offer the possibility of independent learning. (Savill-Smith, 2006)

2.2 Mobile Learning and the Learning Process

The authors of the Future Lab series say that the learning process involves these five aspects:

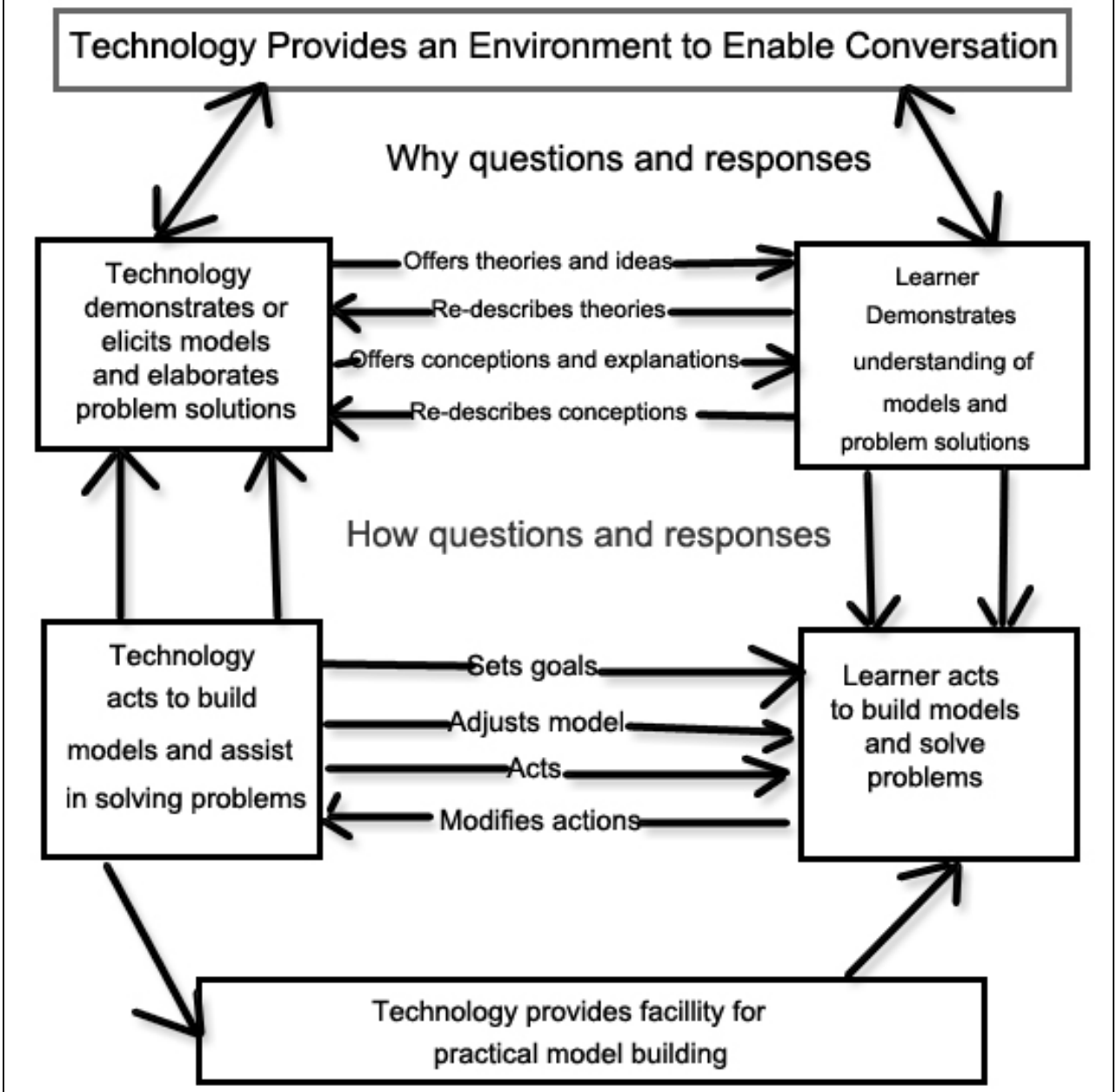
1. Apprehending structure
2. Integrating parts
3. Acting on descriptions
4. Using feedback
5. Reflecting on goal-action-feedback (Naismith, et al, 2004)

2.2.1 Technology may Provide the Environment in which Conversational Learning Takes Place

How does technology provide an environment to enable conversation? For one thing, it can extend the range of activities and the reach of a discussion through games, mobile phone, or e-mail. Technology provides a shared learning space which can be used by both single learners and groups. (Naismith, et al, 2004)

Figure 1 on the next page illustrates how technology supports conversational learning.

Figure 1: How Technology Provides an Environment to Enable Conversation



Source: Naismith, et al., 2004

2.2.2 Thiagi's Four Doors

In Matthew Nehrling's mLearning World blog of October 17, 2006, he writes about how the youngest three generations of learners are not served by traditional instructional models. To summarize his contents

- Generation X (born between 1965 and 1975) demands self-study.
- Generation Y (born between 1976 and 1985) demands choice in delivery.
- The Millennial Generation (born in the 1980s and 1990s. There is no consensus on exact dates.) demands social networking.

Nehrling discusses Thiagi's (Dr. Sivasailam Thiagarajan , http://www.thiagi.com/) Four Doors of eLearning and how they support the needs of these three generations of young learners. His Four Doors are:

1. **The Library** – The library is perfect for Generation X and prior generations who like self-study and like to tackle problems at their own pace.
2. **The Playground** - It gives Generation X and Generation Y the opportunity to learn through gaming.
3. **The Café** – Generation Y and the Millennials can learn through social interaction, using blogs, message boards, My Space, etc.
4. **The Torture Chamber** – It provides an opportunity for students to test their skill or knowledge through various forms of assessment. (Nehrling, October 17, 2006)

Students can access the Four Doors through their mobile learning devices.

2.2.3 The Mobile Learning Environment

Laouris and Eteokleous write that learners learn with a well-defined learning environment, but they do not have to learn within walls, and the teacher is not necessarily the main source of knowledge. Table 4 summarizes the contrasts between the traditional and the mobile learning environment.

Table 4: Components of Traditional versus Mobile Learning Environment

Traditional Learning Environment	Mobile Learning Environment
1. Learner with paper and pen	1. Learner may have many different hand devices
2. Teacher or other facilitator/coach	2. Technical equipment is constantly changing
3. Access to knowledge and books	3. Many processes run parallel to each other
4. Structured curriculum with pre-defined tasks and targets as well as methods of interaction	4. Logistics must be treated as integral part of learning process.
5. Learner is part of learning community	

Source Laouris and Eteokleous, 2006

2.2.4 Four Factors of Successful Classrooms

Jeremy Roschelle in his article on unlocking the power of wireless mobile devices discusses how they can facilitate development of a successful classroom. These factors were identified in a study of learning science research done by Samuel S. Donovan et al. in 1999. The successful classroom becomes more:

1. Learner-centered
2. Assessment-centered
3. Knowledge-centered
4. Community-centered

Roschelle writes about how different types of classroom assessments can be developed using wireless internet devices (WILD). (Roschelle, 2003)

2.2.5 Effect on Educational Practices

Kukulska-Hulme in her study of current uses of wireless and mobile learning writes about how mobile learning devices can affect educational practices in the following ways:

- There is now a broader range of where learning takes place
- Increasing emphasis on filling small gaps of time
- The realization that it takes time for new patterns of use to evolve
- The realization that teachers need to become 'device-aware', in other words, to understand the potential, the features and limitations of wireless and mobile devices. (Kukulska-Hulme, 2005)

2.2.6 Intelligent Object Delivery

Clark Quinn published a report in 2002 titled *Flexible Learning: Mobile Learning Objects*. In his study he discusses the rise of informal learning, mobile learning, a content model for mobile learning objects, and intelligent object delivery. He says that to the extent that we know the user, context, device, and need, we can deliver:

- The right information
- To the right person
- On the right device
- In the right way
- At the right time
- In the right context

2.2.7 A Mobile Learning Object Framework

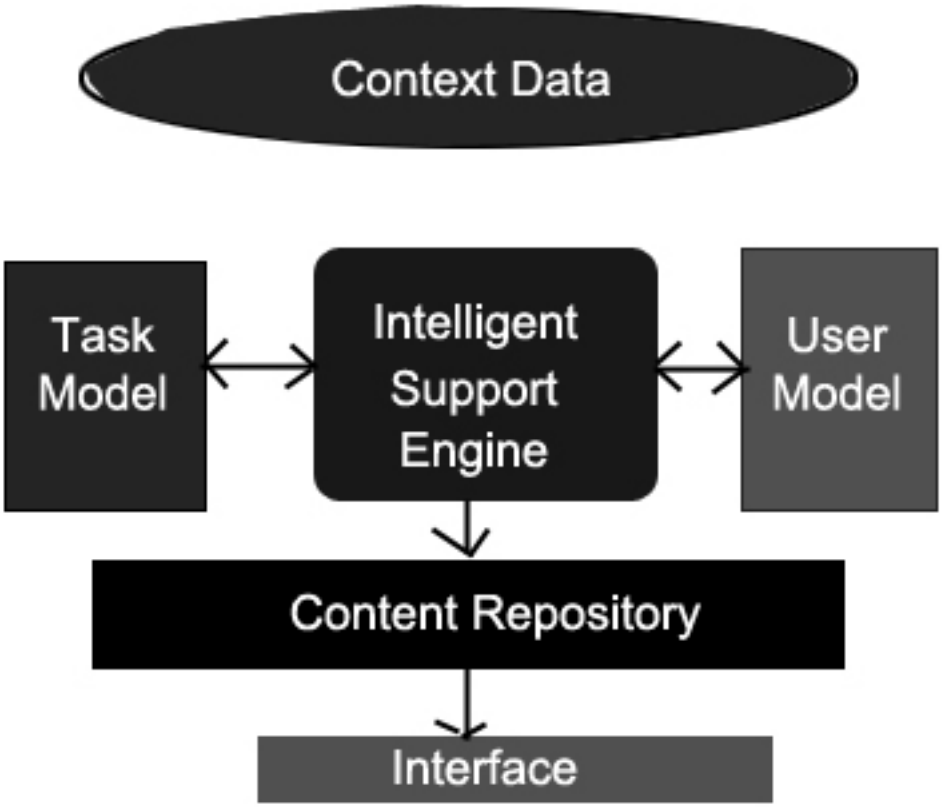
Quinn develops a content model that is navigable by the user to illustrate flexible content display. This content model, which resembles navigation buttons on a web page, is shown in **Figure 2**.

Figure 2: Quinn's Content Model

Source: Quinn, 2002

At the next level, Quinn says we need to add an architecture to his content model that provides knowledge of the user and his/her context, as well as knowledge of the content available, to provide the right match. He says this requires a user categorization scheme and a mapping process to create an intelligent delivery environment. The map Quinn developed is shown in **Figure 3**, on the next page.

Figure 3: Clark Quinn's Content Model Map



Source: Quinn, 2

2.2.8 Nine-Point Matrix

Desmond Keegan developed a nine-point matrix for the use of mobile learning in mainstream education and training. One axis is composed of three types of mobile learning devices: PDAS, smartphones, and mobile phones.

The other axis is types of learning that can be provided by mobile learning:

- Mobile learning academic administration SMSs (short messaging servives)
- Mobile learning academic summaries
- Full modules by mobile learning

Desmond Keegan's nine-point matrix of mobile learning:

Mobile learning for academic administration on PDAS
Mobile learning for academic administration on smartphones
Mobile learning for academic administration on mobile phones
Mobile learning academic summaries for PDAS
Mobile learning academic summaries for smartphones
Mobile learning academic summaries for mobile phones
Full modules by mobile learning for PDAS
Full modules by mobile learning for smartphones
Full modules by mobile learning for mobile phones

2.2.9 Key Factors from Mobilearn Project

Sharples summarized the lessons that had been learned from the Mobilearn project (http://www.mobilearn.org/) at the 2005 CAL conference. The key realizations were:

- It's the learner that's mobile
- How learning is interwoven with everyday life
- Mobile learning can both complement and conflict with formal education
- Context is constructed by learners through interaction
- Ethical issues, which include privacy and ownership

2.2.10 Design Relationships in Mobile Learning

In the article by Jacobs and Polson they discuss the need for building opportunities for interaction into design of games for mobile learning. They emphasize the importance of creating new content that focuses on social incentives rather than just taking an existing game and developing educational content around that game or interface.

Although there is no one methodology for designing educational games that are fun and interactive and that facilitate a multi-disciplinary social learning experience, they do identify some factors that might be considered. In no particular order of importance they are

- **Representation and simulation** (of learning content) – The audio and video content of the game should be designed so that it will be integrated with the learning content.
- **Communication enablers** (for the reception of content) – This refers to the selection of the devices, formats, and services used to deliver content.
- **Logic design** (support for content) – This refers to the underlying design of the system and the rules that determine the parameters of interaction and user profiling.

- **Feedback qualities** (interacting with content) – This refers to control, feedback, and how the designer will let the user take meaningful actions and see the results of those actions.
- **Identity and relationships** (representation of the user(s) – Refers to how the user and the game are related to a complex network of social, spatial, cultural, historical, and social factors in the "real" world. (Jacobs and Polson, 2006)

2.2.11 Some Examples of Interactive Learning Games Designed for Museum and University Contexts

The ACID Human Dimensions Matrix (HDM) – This game was commissioned by the Brisbane, Australia, City Council "to create a location-based game for backpacker tourists in the dynamic suburb of Fortitude Valley in an effort to make the location more accessible and enjoyable. The game is intended to 'extend upon existing relationships and to create new kinds of interactions between people, places, and artifacts.'" (Jacobs and Polson, 2006). **Table 5** shows the interplay between the relationships between participants, their dimensions, and the questions that were identified and addressed.

Table 5: Interplay Between Relationships in HDM and Questions Identified

Relationships	Dimensions	Questions
Social	Backpacker / Backpacker Backpacker / Local	Who are backpackers? What cultures, practices, and dispositions do they share? What relationships develop with each other and locals? How do these relationships develop?
Spatial	Backpacker / Site	How do they currently relate to Fortitude Valley as a physical social and cultural space?
Technical	Backpacker / ICT	What relationships do they currently and potentially have to the technology and the interaction it can provide?
Temporal	Mobility, Duration, Rhythm of Stay	Where does Fortitude Valley fit in the context of the journey? How long do backpackers stay and why? How do they spend their days (a day in the life)?

Source: Jacobs and Polson, 2006

2.2.11.1 Mobile Learning with Cipher Cities

One of the developments of this project in addition to HDM was a complex web application named Cipher Cities that can be used to organize and deliver content to users in multiple contexts. All the components of Cipher Cities can be used to combine the virtual and physical worlds in everyday environments. Learners who meet the requirements of this environment must perform:

- Active discovery
- Analysis
- Interpretation

- Problem-solving
- Memory
- Physical activity

resulting in extensive cognitive processing. **Table 6** shows the interplay of relationships and the questions identified in Cipher Cities.

Table 6: Interplay of Relationships in Cipher Cities and Questions Identified

Relationships	Dimensions	Questions
Social	Student / Student Student / Faculty Student / Lecturer Student / Tutors	Who are the students of the sites? What cultures, practices, dispositions do they share? What relationships develop with each other and the supporting faculty? How do these relationships develop?
Pedagogical	Students / Learning Materials Students / Learning Activities	How do students interface with learning materials?
Culture	Student / Student Students / Student Work Students / Visiting Artists Work	What kinks of expectations do the students have relating to the cultural artifacts in the site (access, understanding, interaction)? How might they want to contribute culturally?
Spatial	Student / Site	How do they currently relate to the site (Creative Industries Precinct)?
Technical	Student / ICT	What relationships do students currently and potentially have to the technology and the interaction it can provide?
Temporal	Mobility, Duration, Rhythm of Stay	How long do students stay and why? Do they return and why? How do they fit the various locations into their daily lives?

Source: Jacobs and Polson, 2006

2.3 Mobile Learning and Theories of Learning and Categories of Activity

2.3.1 Introduction

Mobile learning technologies support many theories of learning. In this section of the paper we will examine how it supports all the major theories from behaviorism through the latest theories of learning such as Sharples, Taylor, and Vavoula's Cultural Historical Activity Theory. Naismith, et al, in their landmark study of mobile learning, Literature Review in Mobile Technologies and Learning (2004), list six theories of learning and categories of learning activities supported by mobile learning. We will attempt to combine as many of the theories of learning as possible under these six categories. These six categories are also mentioned by Kukulska-Hulme (2005) and Frohberg (2006). They are:

1. Behaviorist
2. Constructivist
3. Collaborative
4. Situated
5. Informal and Lifelong
6. Learning and Teaching Support

Leonard Low in his article "Connections: Social and Mobile Tools for Enhancing Learning," says digital mobile learning activity, as a whole, may be described in these four broad categories:

1. A learner may create or capture (**record**) their own data – Supports ***constructivist*** learning
2. A learner may access (**recall**) resources – Supports **Instructivist** learning
3. A learner may use a digital device to process learning stimuli (**reinterpret**) – Supports ***cognitivist*** learning
4. A learner may communicate (**relate**) with peers, mentors, or in other learning relationships – Supports ***social constructivism*** and ***connectivism*** (Low, 2006)

Table 7: Learning Theories and Categories

Learning Theory /Category	Sub Categories (Added by JDC)	Key Theorists	Activities
Behaviorist Learning		Skinner, Pavlov	Drill and feedback Classroom response systems
Constructivist Learning	Constructivism Social Constructivism Social Learning Social Constructivism	Piaget, Bruner, Papert	Participatory simulations
Situated Learning	Situated Learning Pervasive Learning	Lave, Brown	Problem and case-based learning Context awareness
Collaborative Learning	Collaborative Learning Pask's Conversation Theory Communicative Learning	Vygotsky, Brown Bereiter, Scardamalia, Lave, Wenger	Mobile computer-supported collaborative learning (MCSCL)
Informal/Lifelong Learning	Informal Learning Lifelong Learning	Eraut	Supporting intentional and accidental learning episodes
Learning/Teaching Support		N/A	Personal organization ` Support for administrative duties (example: attendance)

Source: Naismith et al, 2004, and Jimmy Clark

2.3.2 How Mobile Learning Technologies Support Behaviorist Learning

Naismith et al. define behaviorist learning activities as "activities that promote learning as a change in learners observable actions." "Learning is thought to be best facilitated through the reinforcement of an association between a particular stimulus and a response." (Naismith, et al., 2004) In computer-aided learning a problem is presented (stimulus), the learner responds, then receives quick feedback. Naismith and her colleagues include classroom response systems in this category and delivery of content by text

messages to mobile phones. The Mobile Learning website says behaviorist strategies can be used to teach the facts. (Mobile Learning, 2006) Frohberg in his article, *Mobile Learning is Coming of Age – What We have and What We Still Miss,* writes about different categories of context in mobile learning. The first category is free context, examples of which are learners riding public transportation or in a public eating place. He says that most free context learning projects fits the behaviorist model, as those projects "adopt a transmission model, where learning takes place through the transmission of information from the tutor (the computer) to the learner." (Frohberg, 2006)

Under each of these six categories the authors list learning activities that support each type of learning. The list that follows simply lists the case studies without discussing them in detail. For a complete explication of each case, download and read Naismith's article at the FutureLab website. (http://www.futurelab.org/uk/research/reviews/reviews_11_and12/11_07.htm).
Behaviorist case studies

- Skills Arena
- BBC Bitesize
- Mobile phones for language learning
- Classroom response systems

2.3.3 How Mobile Learning Technologies Support Constructivist Learning

Under constructivist learning I am grouping:

- Constructivism
- Social Constructivism
- Social Learning
- Social constructivism

2.3.3.1 Constructivist Learning

Constructivist learning theories were developed during the 1960s and 1970s by Jerome Bruner and others. According to Bruner, learners construct new ideas or concepts based on their current and past knowledge. They were heavily influenced by the work done earlier by Jean Piaget. Naismith et al. define constructivist learning as "activities in which learning is an active process in which learners construct new ideas or concepts based on both their current and past knowledge." Seymour Papert was one of those who developed the concept of using computers in constructivist learning contexts. Constructivist learning projects designed for mobile learning are often participatory simulations. Some examples they list are:

- **The Virus Game** (Collella 2000) – Students were asked to take part in a simulation about the spread of a virus. They wore tags with colored lights that indicated whether or not they were infected and "spread " the virus

by interacting with each other. Participants had to answer questions such as "Where did the disease start? How does it get spread? Who can catch it?" You may download this and other free games at this website: http://education.mit.edu/pda/games.htm

- **Savannah** (Facer et al) – Students in this game play the role of lions roaming in the wild in an area 100m X 50m. Each student carries a PDA which they used to play the game. They were able to explore various aspects of lion behavior, and reported that the game had increased their understanding of lions.

- **Environmental Detectives** (Klopfer and Squire) – The goal of this game was to teach secondary school and college freshmen the skills of environmental inquiry, using a simulated environmental problem. The game centered around the spill of a ground water contaminant called Tri-Chloro-Ethelene. The players used a GPS module attached to a Pocket PC to detect it. The goal of the game was to discover the source of the toxin and prepare a plan to remediate it. (Naismith et al, 2004)

Low says that mobile learning spaces are well-suited to supporting constructivist learning because:

- Mobile devices support various personalized learning experiences
- This mobility enables learners to explore knowledge and situations in their own way, often outside traditional classroom-based teaching
- Mobile devices can also increase motivation, facilitate interactive learning and control of the learning process, and emphasize its relationship with the real world (Low, 2006)

2.3.3.2 Social Constructivist Learning

Rachel Cobcroft, et al, say that a social constructivist view of learning "considers that students learn best when given the opportunity to learn skills and theories in the context in which they are used. Students then construct their own interpretations of a subject and communicate those understandings to others." (Cobcroft et al, 2006) If you wish to learn more about social constructivism, read the works of such scholars as Brown, Collins, Duguid, Resnick, Soloway, Roschelle, Gay, and Vygotsky. Mobile technologies can support social constructivist theories of learning by expanding discussion beyond the classroom and providing new ways for students to collaborate and communicate in their own classes and around the world. (Todd Bryant, 2006).

Low says that social constructivism, along with connectivism; emphasize the importance of the social context in the construction of learning and the connectedness of learners. (Low and O'Connell, 2006). Ragus (2006) and Torrisi-Steele (2006) have written that mobile technologies are increasingly

integrated with the social needs of consumers and they increasingly support the principles of social interaction in learning and a learner-centered philosophy.

In his article Low also writes about how digital mobile learning can be supported in learning networks, which he defines as "structures we create in order to stay current and continually acquire, experience, create and connect new knowledge (external)." He goes on to say that "learning networks can be perceived as structures that exist within our minds (internal) in connecting and creating patterns of understanding." (Low, 2006). How does digital mobile learning support the learning networks it enables? It gives them the opportunity to create an always connected mobile external network they can access at any time to contribute to the development of their internal network. (Low, 2006)

2.3.3.3 Social Learning

Low also discusses social web tools for digital mobile learners. He says the 'Social Web' or 'Web 2.0' make it easy to share information, and the construction of information and people. He says that social websites provide lots of user interactivity, and allow users to create and modify content themselves. (Low, 2006). Examples include blogs and wikis.

Jeremy Roschelle in his article "Unlocking the Power of Wireless Mobile Devices," discusses how Wireless Internet Learning Devices (WILDs) make possible a new "informatic" participation among connected devices. Students and teachers are interacting in the traditional classroom environment, and at the same time, students can be interacting with each other via their PDAs. He says that key communication issues will affect whether WILDs are another passing fad or a resounding pedagogical success. (Roschelle, 2003). In other words, students can use their wireless mobile devices to construct knowledge, or they can use them to distract each other in class.

2.3.4 How Mobile Learning Technologies Support Collaborative Learning

2.3.4.1 Collaborative Learning

Naismith, et al, define collaborative learning activities as, "activities that promote learning through social interaction." (Naismith, et al, 2004). It was developed from research on computer-supported collaborative work and learning, and is rooted in Vygotsky's socio-cultural psychology. (Naismith, et al, 2004). Mobile devices provide a practical additional communications medium and a portable means of sharing information electronically. (Kukulska-Hulme, 2005).

Research into collaborative learning supported by mobile devices is based to a large extent on research on CSCL (computer-supported collaborative learning. Naismith and her collaborators say the most convincing examples of

conversational learning occur when mobile technology is used to provide a shared conversation space. They conclude that effective learning occurs when people can converse with each other and question and share their descriptions of the world. An example of using mobile devices in MSCL they list is:

- **Chile** is using MSCL in face-to-face classrooms for primary and secondary education. The device used is the Pocket PC. In the cases they mention, statistically significant results show that MCSCL assisted learning. This is the only example Naismith lists under collaborative learning.

2.3.4.2 Pask's Conversation Theory

Gordon Pask, an English cybernetician and psychologist, developed Conversation Theory in 1975. In his book he describes learning as a conversation between different systems of knowledge. Naismith, et al, write that mobile learning devices can support mobile computer-supported collaborative learning by providing another means of coordination without attempting to replace any human-computer interactions. They compare MCSCL to online discussion boards which substitute for face-to-face discussions. (Naismith, et al, 2004)

Naismith, et al, in their summary of Conversation Theory, point out that in order to learn, a person or system must be able to converse with itself about what it knows. More specifically, the learner must be able to:

- Create a description of herself and her actions
- Explore and expand that description
- Use that description in a future activity

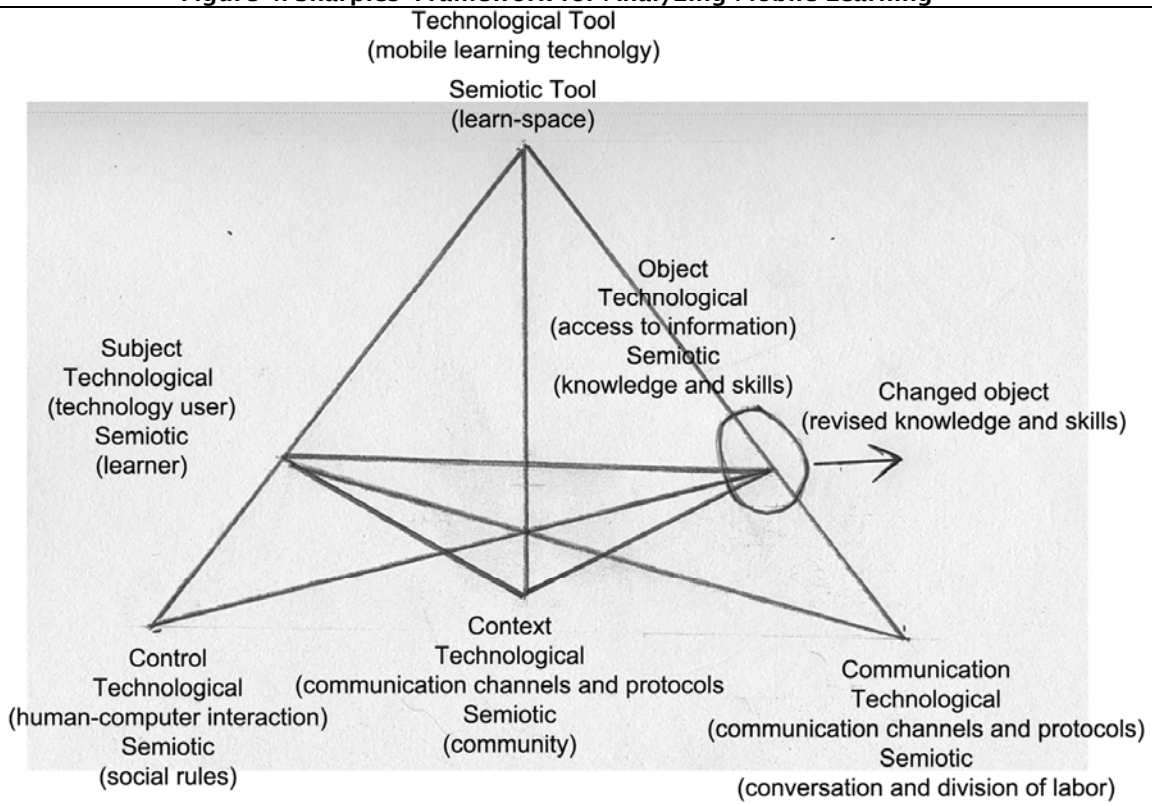
Learners also learn by conversing with each other. Through their conversation they come to a mutual understanding of the world. Thus, we learn through conversation with the external world, with ourselves, and with other learners and teachers. (Naismith, et al, 2004)

2.3.4.3 Learning as Conversation in Context

Mike Sharples (2005) developed an analysis of learning as conversation in context, drawing upon Dewey's philosophy of Pragmatic Technology (http://www.dkrc.org/bib/dkrc/pubtype/incollection_JohnDeweyspragmatictechnology.shtml) and Pask's Conversation Theory. He and Taylor and Vavoula in their paper on mobile learning use Cultural-Historical Activity Theory (http://lchc.ucsd.edu/People/MCole/browncole.html) to analyze the activity system of mobile learning. An important facet of their approach is the separation of learning into two layers, the semiotic (http://simple.wikipedia.org/wiki/Semiotics) layer, and the technological layer. This framework is replicated in **Figure 4**. Refer to their article

(Sharples, et al, 2005) for a more complete explanation of Cultural-Historical Activity Theory.

Figure 4: Sharples' Framework for Analyzing Mobile Learning



Source: Sharples, et al, 2005

Roschelle mentions the use of mobile devices in **collaborative data gathering**. An example he discusses is the use of handheld probes and Palm Pilots to evaluate water quality. (Roschelle, 2003)

2.3.5 How Mobile Learning Technologies Support Situated Learning

In this section, I am discussing situated learning and pervasive learning.

2.3.5.1 How Mobile Learning Technologies Support Situated Learning

Naismith, et al, define situated learning as "learning that posits that learning can be enhanced by ensuring that it takes place in an authentic

context." (Naismith, et al, 2004). Kukulska-Hulme says that can take a mobile device into a specially equipped location such as a museum and learn about it in an authentic context. (Kukulska-Hulme, 2005). J. S. Brown, J. Lave, and E. Wenger have done research on the benefits of just-in-time situated learning. Nyiri says that knowledge is information in context (2002). Mobile devices are well placed to enable learning and the construction of knowledge because they facilitate the delivery of context-specific information. (Naismith, et al, 2004)

Jean Lave developed the situated learning paradigm in 1991. She says that learning is a process of social participation. The learning situation has a great impact on the learning process. J. S. Brown et al (1989) emphasize the process of cognitive apprenticeship. The two requirements of situated learning is that learning must be presented in authentic contexts and learners must participate within a community of practice.

Three threads are especially relevant to the use of mobile devices:

1. Problem-based learning
2. Case-based learning
3. context-aware learning

2.3.5.2 Problem-based Learning

Timothy Koschmann (http://edaff.siumed.edu/tk/) has done some of the most significant research on problem-based learning (PBL). He says that PBL aims to develop students' critical thinking skills by giving them an ill-defined problem that reflects what they would encounter as a practicing professional. O'Malley et al (2003) say the problem is used for "learning by analogy and abstraction via reflection." Applications of PBL include:

- Medical education
- Business administration
- Nursing (Naismith et al, 2004)

2.3.5.3 Case-based Learning

Janet Kolodner (http://home.cc.gatech.edu/jlk) and Mark Guzdial (http://www.cc.gatech.edu/gvu/people/Faculty/Mark.Guzdial.html) of Georgia Tech did the ground-breaking research on case-based learning (CBL). CBL is more flexible than PBL, and it uses more well-defined problems, that may or may not be representative of what students might encounter in the real world.

2.3.5.4 Context-aware Learning

Naismith and her collaborators write that students using mobile devices gather information from the environment to measure what is going on around the user and the device. They say the museum and gallery sector has been on

the forefront of context-aware mobile computing. For example, a student takes a mobile device into a museum that in turn, provides additional information about exhibits base on the visitor's location. (Naismith et al, 2004)

2.3.5.5 Case Studies for Situated Learning

Some case studies illustrating how mobile learning devices support situated learning are:

- Ambient Wood – (2002) – This project was designed for 10-12 year-old students in several areas of England. The students studied habitats and the plants and animals in them and the relationships between them. The mobile learning tool used was the PDA. For a very detailed discussion of this project, read the article by Naismith and her collaborators.
- Natural science learning in Taiwan – This project involved a butterfly-watching system at an elementary school in Taiwan. The system that was set up included a wireless network and PDAs with digital cameras. The students visited a butterfly farm, took pictures of the butterflies, and tried to match their photos with images in an online database.
- Multimedia tours at the Tate Modern museum in London -

2.3.5.6 Pervasive Learning

The Pervasive Learning website defines pervasive learning as learning that, "relies on the 'always on' concept that is fundamental to pervasive games. It is 'always on' education that is available 24 hours a day, 7 days a week, anywhere, at any time." The authors of the site go on to state that it is a social process that connects learners to communities of devices, people, and situations so that learners can author meaningful and relevant learning experiences. (Pervasive learning website at: http://www.pervasivelearning.org/index.php, Accessed March 23, 2007) Mobile learning technologies furnish them with the tools needed to construct these learning experiences in locations, and at times they find meaningful and relevant. The four key elements of pervasive learning are:

1. Community
2. Relationality
3. Autonomy
4. Locationality

Some examples of learning activities that help learners construct these learning experiences are field trips, trips to museums, and educational gaming. (Pervasive Learning website).

Cobcroft et al quote Thomas (2005), who describes pervasive learning as learning, "where a learner 'authors himself in a location that the learner finds meaningful and relevant.'" Cobcroft says the development of pervasive learning

cannot be an end in itself, but is itself a response to learners' new ways of being. (Cobcroft et al, 2006).

2.3.6 How Mobile Learning Technologies Support Informal and Lifelong Learning

2.3.6.1 Informal Learning

Clark Quinn in an article he published in 2002, says that formal course account for less than 25% of workplace learning. He says we are putting 80% (classroom-based learning) of our effort into meeting 20% of our needs. (Quinn, 2002) Naismith et al report that research on informal and lifelong learning happens all the time and is "influenced by both our environment and the particular situations we are faced with." It may be either intentional (deliberate learning projects) or accidental (conversations, newspaper articles, television programs). Informal learning by its nature takes place outside the classroom and can be supported by mobile technologies. (Naismith et al, 2004) Kukulska-Hulme points out that mobile devices go with users in their everyday lives and that they are an important source of information or communication medium that assists with learning, or records it on the go for future reference. (Kukulska-Hulme, 2005). People learn in order to be able to perform a new task, or to accomplish an old task in a more efficient way. (Naismith et al, 2004)

2.3.6.1.1Case Studies for Informal Learning

Some case studies Naismith mentions for informal learning are:

- M-leaning: Reaching out to disadvantaged youth – This is a three-year European program (2001) that uses mobile technology to teach basic literacy and math skills. The target audience is young people, aged 16-24 who are at risk because they are not enrolled in formal education. The tools involved include VoiceXML, SMS, and iPaq Pocket PCs.
- Mobile device for breast cancer cure – This is an English project in which cancer patients use PDAs to educate themselves about the disease. It began in 2002. (Naismith et al 2004).

2.3.6.2 Lifelong Learning

According to Wikipedia, lifelong learning is the concept that "It's never too soon or too late for leaning." Societies that practice lifelong learning will make provide their learners with learning opportunities at all ages and in many contexts, through both formal and informal channels. (Wikipedia article on lifelong learning). Mobile learning devices offer lifelong learners the same affordances and advantages as they do informal learners.

2.3.7 How Mobile Learning Technologies Offer Learning and Teaching Support for Learners

2.3.7.1 Introduction

Naismith et al define learning and teaching support as "activities that assist in the coordination of teachers and resources for learning activities." (Naismith et al, 2004). They list the following ways teachers may use mobile devices:

1. Attendance reporting
2. Reviewing student grades
3. Accessing school data
4. Managing their schedules more effectively

Uses of mobile devices more specific to higher education are;

1. Providing course material to students
2. Providing due dates for assignments
3. Providing course management information to students

Curriculum developers should consider these challenges in learning and teaching with mobile technologies:

1. **Context** – How do they match gathering and using information about students with students' need for anonymity and privacy?
2. **Mobility** – Students can use their mobile devices to link with the outside world, but it also affords them the opportunity to engage in activities that do not support the teacher's agenda or the curriculum.
3. **Learning over time** – Effective tools are needed to record, organize, and retrieve mobile learning experiences.
4. **Informality** – Students may stop using their mobile devices if they think their network is under attack.
5. **Ownership** – When students bring their own mobile devices to the classroom it may present challenges, such lack of compatibility with the school's network, they may not support the needs of the curriculum, etc.

Some guidelines for addressing these and other issues are:

1. Develop a cost model for infrastructure, technology, and services.
2. Study the requirements of everyone who will be using the technology to make sure that it is usable and acceptable.

3. Be sure the technology is suitable for the learning task and examine the advantages and disadvantages of available technologies before deciding which one to use.
4. Assign responsibilities to those who will initiate and support mobile learning
5. If the institution provides the equipment, develop procedures and strategies for managing it.
6. Provide training and support for teachers who use mobile technologies
7. Consider using mobile technologies for student administration tasks.
8. Consider using mobile technologies to support collaborative and group learning.
9. Map the applications that match classroom needs to the curriculum.

10.0 Make sure that students' security and privacy are protected. (Naismith et al, 2004)

2.3.7.2 Examples of how Mobile Devices can be used to Support Learning and Teaching

Some examples of how mobile devices can be used to support learning activities for students, teachers, and administrators mentioned by Naismith and her colleagues are:

1. Helping university students organize their own learning – Researchers at the University of Birmingham, UK, developed a Student Learning Organizer, based on a wireless-enabled Pocket PC. The tools that were included enable students to create, delete, and view timetable events and deadlines, and to download course material packages, in Microsoft Reader format. The evaluation of this project showed that students thought the technology was useful, even though it did not revolutionize or improve their learning significantly. This project was conducted in 2002-2003.
2. Support for teachers and administrators – This project was conducted in 2002-2003, in thirty schools in the UK. PDAs were used to help teachers manage their workloads and support teaching and learning The teachers found the devices were useful in helping them manage classroom administration chores, but they were frustrated by the devices' small screens, short battery life, and volatile storage.
3. SMS supports students at risk – This study was conduced at the University of Wolverton in 2002-2003. The students used SMS text messaging to receive information such as room changes, appointments, feedback, and exam information. The students found the SMS messages to be successful if they were short, personalized and focused.

2.4 Learning Activities Supported by Mobile Learning

2.4.1 Introduction

In this section we will take a look at various learning activities that can be supported by mobile learning devices. We will focus on activities that were not covered in **Section 2.3**.

2.4.2 How Mobile Learning Supports Learning in Different Contexts

The primary source for this discussion is the article; *Mobile Learning is Coming of Age – What we have and what we still miss*, published by Dirk Frohberg in 2006. Frohberg places mobile learning into these five categories of context:

1. **Free context** – Frohberg says that mobile learning activities that are classified as free context "do explicitly **not** consider the particular context of the learner as relevant for the learning activity." (Frohberg, 2006). He goes on to state that these activities are the first generation of mobile learning projects and are mainly technology driven. A few examples he mentions are AvantGo (http://avango.com), the many showcases on the Macromedia (now Adobe) website (http://www.adobe.com/cfusion/showcase/index.cfm), and e-tutor (http://e-tutor.ch/site). The later is a German website.

   He also lists some free context applications that are pedagogy-driven, such as calendar, learning games, quizzes, calculators, and schedulers.

2. **Formalized context** – Frohberg says that mobile learning in this context is "learning within a well defined curriculum, being offered by some educational establishment and led by some central actor, i.e. a teacher, tutor, instructor, moderator, and the like." (Frohberg, 2006). He says learning usually takes place in a classroom, or a similar venue, but could be in a virtual classroom. He then discusses classroom response systems, which he says promises to overcome some of the disadvantages of the traditional classroom. (See discussion of classroom response systems in Section 1.7.3).

3. **Digital context** – Think of digital context as a playground for the learner that replaces physical context. Some of the advantages of digital context are
   - The teacher has full control over the learning environment.
   - The learning environment is independent from physical restrictions.
   - Complexity is reduced and made more adaptable.

The disadvantages of digital context are:

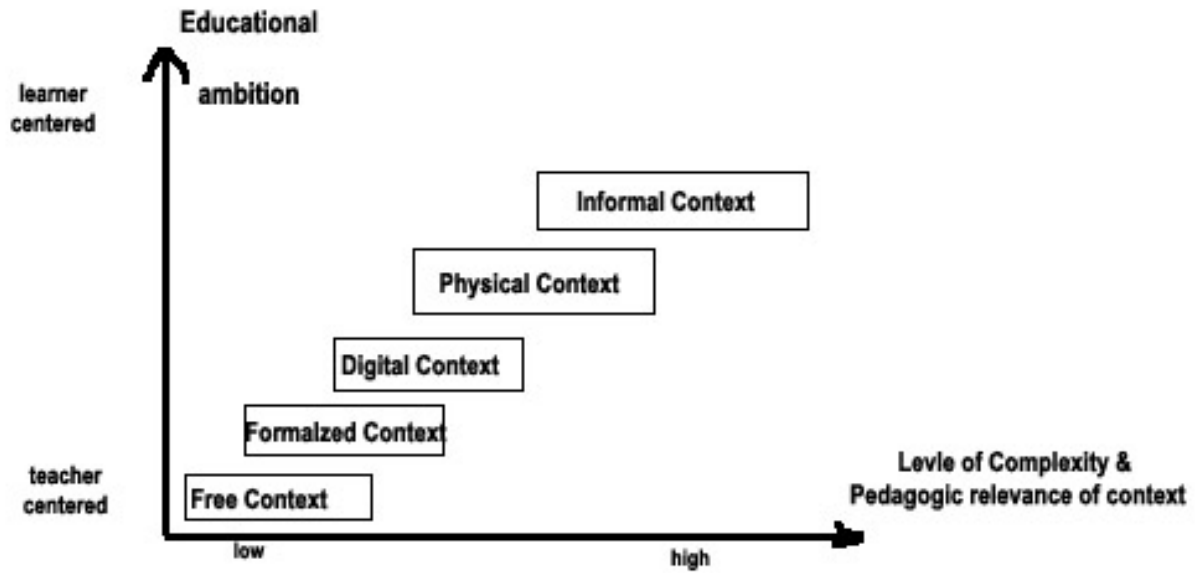
- It is difficult to add physical, social, or emotional activities in a digital context. (Note from J. Clark – Interactive learning games such as Second Life are overcoming this limitation).
- The challenge of making the digital environment seem authentic.

4. **Physical context** – Frohberg says that "physical context is dedicated to situated, cooperative, and explorative learning in a real environment." It requires the use of objects, people, places, and physical artifacts from the environment. Mobile technology should be used to enrich the physical environment digitally. An example is students using mobile devices such as cell phones on a class trip to a museum.

5. **Informal context** – Frohberg says, "Informal learning is any activity involving the pursuit of understanding, knowledge or skill which occurs without the presence of externally imposed curricular criteria." Most of the learning we do in our everyday lives is informal learning. Studies have shown that most adult learning is informal learning. Mobile learning technologies can help shift informal learning from solitary experiences to cooperative learning experiences. (Frohberg, 2006)

Figure 5 illustrates Frohberg's mobile learning contexts graphically.

Figure 5: Frohbherg's Mobile Learning Contexts



Source: Frohberg, 2006

2.5 Mobile Learning – Applications and Devices

In this section of the report we will look at several applications and devices used in mobile learning. Doug Brown points out that "each new generation challenges the previous generations about what limitations (or even damage) new technologies might bring." (Brown, 2006). All the mobile devices listed in this section were developed to be used in data processing, communications, and entertainment. Our challenges as educators is to adapt these devices so that they can be effectively used in education.

2.5.1Determining which Applications to Use

Keegan says we should consider these five factors when considering which mobile applications to use

1. How trustworthy is the technology?
2. How frequently will it be used;
3. How easy is it to use?
4. Is it cheap?
5. Is it fashionable? (M. Thomas, 2006)

Bates and Poole (2003) developed the following criteria for determining technology choices for effective learning and teaching in higher education:

1. Appropriateness and access
2. Ease of use and reliability
3. Costs
4. Teaching and learning approaches
5. Interactivity
6. Organizational issues
7. Novelty and speed (Cobcroft, et al, 2006)

According to the Mobile Learning website, the many types of instructional applications that may be used for training and learning, but the technologies have been narrowed down to these few

1. Text
2. Audio
3. Video
4. Animation
5. Evaluation formats

2.5.2 Advantages of Handheld Computers

Carol Savill-Smith and Phillip Kent reviewed the literature on the use of palmtop computers in education and published their research in a report in

2006. They list the following reasons for using palmtop computers in education:

1. Palmtops are relatively inexpensive, compared with full-sized desktop and laptop computers
2. Palmtops offer the possibility of ubiquitous computing. Ubiquitous computing refers to the situation where technology becomes virtually invisible in our lives.
3. Palmtops offer access to information and promote the development of information literacy. Pownell and Bailey (2000) describe information literacy as "an information-age problem-solving process resulting in the productive use of information', which they consider to be at the heart of lifelong learning." According to Bailey and Lumley, in this century the ability to identify, access, apply and create information will be the equivalent of literacy. (Savill-Smith and Kent, 2006)
4. Palmtops offer the possibility of collaborative computing. Studies of students using laptop computers have shown that the experience offers the possibility of students producing higher quality written work, better thinking skills and problem-solving in learners, and more collaboration between students with the laptops.
5. Palmtops offer the possibility of independent learning. People who have to, or prefer to learn on their own, can be helped with the use of handheld mobile learning devices.
6. Palmtops can be motivational simply because of their novelty value.
7. They have also been found to help high-achieving students increase their writing skills.
8. Palmtop computers have also been found to help students increase their math skills.
9. Some studies have shown that palmtops have been found to help students increase their social skills.
10. There have been a number of projects in which palmtops were used with students who had special needs, such as hearing loss, developmental disabilities, and motor impairments. (Savill-Smith and Kent, 2006).

    Mark Prensky considers handheld computers are an important platform for digital game-based learning. (Savill-Smith and Kent, 2006)

2.5.3 Advantages of PDAS and Mobile Phones

Until very recently with the increasing popularity of smartphones, PDAs have been the most popular mobile learning device for educational use. Ted Smith defines PDAs as "small, handheld computers that are designed essentially to be personal information managers (PIMs)." (T. Smith, 2003). In his article, published in 2003, Smith lists several reasons why PDAs are popular for general

use and several why they are popular for educational use. Reasons they are popular for general use include:

- Reasonably mature hardware
- Useful for managing calendars and contacts.
- Useful for recording medical information
- Can be used with a keyboard to enter large amounts of data
- Easier to carry than laptops
- Easy to synchronize with a desktop or laptop computer
- Wireless communications are easy to configure and use.

Smith gives the following reasons why PDAs are popular in education:

- The assist with discussions when used in conjunction with exercises or lectures.
- They provide a very useful means of accessing reference material.
- They act as a study aid via interactive quizzes and exercises.
- When associated with a wireless connection, they can provide instant, in-class feedback to tutors on understanding.
- They help to motivate students. (T. Smith, 2003)

Becta (British Educational Communications and Technology Agency) in its report on the use of PDAs in schools concludes that the characteristics of PDAs that met universal approval are:

- Small size- You always have it with you.
- Do not have to wait for an operating system to boot up.
- Much longer battery life than laptops
- Can hold large amounts of data
- It is easy to keep data up to date
- Easy to synchronize and share data through infrared port
- They cost less than laptops (T. Smith, 2003)

Rawlinson and Bartel (2006) offer the following characteristics that make PDAs effective learning devices in the classroom:

- Ability to access network resources anytime, anywhere
- Can be used for note taking, data collection, and digital imaging
- Can be used to facilitate file and data sharing (Rawlinson & Bartel, 2006)

The main advantage in using mobile phones in education is that they are owned by many more people than PDAs (Kukulska-Hulme, 2005). She identified these key factors as reasons for the increasing use of PDAs and mobile phones in education:

- The widespread adoption of mobile devices
- The changing strategic demands of the educational environment – increasing emphasis on lifelong learning and greater participation

- Developments in pedagogy which have moved towards active learning using constructivist models that emphasize learner autonomy (Kukulska-Hulme, 2005)

2.5.4 Advantages of iPods

Dr. Michael Thomas (2006) points out that the development of the iPod has occurred at the same time as the emergence of PDAS and mobile phones. He writes about the iPod experiment initiated by Duke University in 2004, in which all freshmen students were given 20GB iPods and a voice recorder to use in recording audio from lectures. Duke and Apple Computer collaborated in a project which allowed the iTunes software to be used to host academic content, which included language lessons, music, lectures, and audio books.

After one year the plan was evaluated. As a result, in the second year of the program iPods were given only to students who were enrolled in courses in which the iPod was required as an integral tool. The evaluation indicated that the iPods were used primarily for:

- Course content dissemination tool
- Classroom recording tool
- Field recording tool
- Study support tool

The evaluation showed that the students with iPods were more mobile and that their motivation was increased. Two challenges identified by the use of the iPods were:

- The pedagogical consequences were not thought out before the students were issued iPods.
- The short battery life of the devices
- Sharing information between different iPods

2.5.5 Advantages of E-Books

Savill-Smith and Kent say that, “electronic books are digitized versions of books that can be read on a desktop computer, handheld device, or with a dedicated book reader.” (Savill-Smith & Kent, 2006). They write that e-books have so far failed to make a significant impression on consumers or in schools. In the past they were bulky and had low-contrast screens, but they point out that the screens have improved in the past few years. They say that e-books could be more cost-effective than traditional textbooks. The future looks promising for e-books, according to the authors, but the studies done so far have been inconclusive. (Savill-Smith & Kent, 2006).

2.6 Learning Activities Supported by Mobile Learning Technologies

Some of the learning activities supported by mobile technologies were covered in section 2.3, which focuses on how mobile learning technologies support the major theories of learning. This section will focus more on how mobile learning devices support various learning activities, some of which could involve more than one theory of learning.

2.6.1 Collaborative Learning Activities Supported by Mobile Learning Technologies

Carol Savill-Smith and Philip Kent agree with Gay et al (2002) who developed a categorization scheme for the objectives which motivate the use of mobile computers in education. The highest level 4, is communication and collaboration. The categories are replicated in **Table 8**.

Table 8: Levels of Objectives: Mobile Computers in Education

Level 1	*Level 2*	*Level 3*	*Level 4*
Productivity	Flexible Physical Access	Capturing and Integrating Data	Communication And Collaboration
Sample Applications			
· Calendars · Schedule · Contact · Grading	· Local database · Interactive prompting · Just-in-time instruction	· Network database · Data collection · Data synthesis · Mobile library	· Real-time chat · Annotations · Data sharing · Wireless e-mail
Content-Intensive Users: Individual Mostly asynchronous Hardware-centered Isolation			Communication-intensive Users: Group Mostly synchronous Network-centered Interconnection
Source: Savill-Smith and Kent, 2006 (From Gay et al, 2002)			

2.6.1.1 Some examples of using palmtop computers to support collaborative learning

- The **Cooties Game** – This project was developed by the University of Michigan and designed for middle school students. The objective is to allow students to study the spread of communicable diseases using their palmtop computers. Students create a personalized "cootie" on their computers, one student's machine is "infected" with a "disease" and tries to spread it to other students' cooties. A teacher at a middle school in Detroit where the game is taught says it works for several reasons
    1. It capitalizes on the gregarious nature of middle schoolers.
    2. It teaches subtle concepts in a fun engaging way that models true scientific thought.
    3. It provides a safe way for discuss real-life issues.
    4. It gives teachers a safe way to discuss sexually transmitted diseases. (Savill-Smith & Kent, 2006).

- **Geney™** - This game runs on Palm PDAS and it is a collaborative problem-solving application to help children explore genetic concepts. The game's developers studied the following research questions:
    1. How can handhelds be adapted for use by children (as they are primarily understood and designed for adults)?
    2. How can handhelds be used for collaborative activities?

    The purpose of this game is for students to work collaboratively to produce a fish with a particular set of characteristics. Each Palm has a single pond of fish, and the students exchange fish with their friends through the Palm's infrared port. The most striking observation made after the project was evaluated was the rich social interaction among the children that it produced. (Savill-Smith & Kent, 2006).

- **The Dockhands Learning Acceleration Project** – This project was run by the National Literacy Association in London. Acorn Pocket Book computers were distributed to fifteen schools, and 600 seven-year-old students were involved. The sole aim of the project was to increase the amount of the children's reading and writing. The project evaluation showed that the students' reading achievement increased from 8 months reading age per 12 months to 11.5 months per 12 months, after one year of using the palmtops (Pyke, 1997). (Savill-Smith & Kent, 2006).

2.6.2 How Mobile Learning Devices Support Student Field Trips

In **Section 2.4.2** we discussed how mobile learning supports learning activities in five contexts: free, formalized, digital, physical, and informal. Field trips supported by mobile devices are classified in the physical context category. Frohberg (2006) says that "physical context is dedicated to situated, cooperative, and explorative learning in a real environment." He goes on the make the point that the determining attribute of learning projects in the physical context is that these projects make significant educational use of objects, people, places, and physical objects from the environment, and that the role of mobile technology is to enrich the physical environment digitally.

He quotes Taylor, Sharp et al (2003), who say, "artifacts often play a cognitive role in learning. They are not simply additional elements of the situation. They have an active role and can make significant contributions to understanding." Some examples of mobile learning devices being used to support field trips are:

- Providing mobile support to a learner

    1. Tate Museum Tours (Proctor & Burton, 2003)
    2. A botanical garden (Naismith, et al, 2005).

3. Tourist areas of a city – Example: Somers Town (Bradley et al, 2005)
4. A forest – Example: Ambient Wood (Rogers et al, 2002)
5. Butterfly farm – Example: Butterfly Watching Learning System (Chen, et al, 2004)

- Mobile learning systems built for groups of learners on an expedition:

    1. King Middle School – (Lehner et al, 2003)
    2. ME-Learning Experience – Students were in a nature preserve endangered by tourists (de Crom & Jager, 2005)
    3. Denali National Park Fire Succession Study – Students were studying an area that had been burned over by forest fires

- Mobile learning systems where the real context is enriched and mixed with a digital context:

    1. Environmental Detectives – The learner has to deal with a fictional environmental disaster at the site where he or she currently is. (Klopfer, 2002)
    2. These projects were all developed at MIT: Mystery, @ The Museum, Charles River City, Outbreak @ MIT.

Roschelle (2003) writes about participatory simulations from a pedagogical viewpoint. He refers to a study by Wilensky & Stroup (2000) who say participatory simulations, "use the availability of a separate device for each student and the capability of simple data exchanges among neighboring students. They enable students to act a agents in simulations in which overall patterns emerge from local decisions and information exchanges."

Roschelle says researchers who have studied participatory simulations are enthusiastic because:

1. The seem to make very difficult ideas about 'distributed systems' and 'emergent behavior' more accessible to students. (Resnick, 1996; Stroup et al, 2002)
2. Participation embeds student engagement in a playful social space. (Colella, 2000; Stroup et al, 2000).

Savill-Smith and Kent discuss B. Graham's (1997) report on a project where students used palmtop computers on a visit to a botanical garden to:

- Prepare for a visit to the garden by creating databases of technical terms and botanical information
- Conduct observations and environmental measurements during the visit
- Analyze the collected data and write up a report after the visit

The evaluation done after completion of this project found that the use of palmtop computers helped increase the literacy level of the students. Gay et al (2002) wrote a report on a pilot study of undergraduate students using palmtops in botanical gardens. This research was based on **Activity Theory**. Activity Theory is more a set of basic principles that can be used to generate more specific theories than a strict "theory." The basic principle of Activity Theory are: object-orientedness, internalization/externalization, tool mediation, hierarchical structure of activity, and continuous development. The evaluations of this project are mixed. If you wish to read about more work by these researchers, go to: www.hci.cornell.edu/. (Savill-Smith & Kent, 2006).

2.6.3 How Mobile Learning Devices Support Informal Learning

Informal learning is defined in section 2.4, but it bears repeating: "Informal learning is any activity involving the pursuit of understanding, knowledge, or skill which occurs without the presence of externally imposed curricular criteria." (D. Livingstone, 2000).

Frohberg says informal learning projects would be for the purpose of addressing the development of

- Soft factors
- Social skills
- The change of habits
- Training people to interact more successfully with other people

Some of the few projects that have been developed to support informal learning are:

- A project that allows people training for the nursing profession to produce short videos about what they have learned and to share them with others (Brandt & Hillgren, 2004)
- Project Keyoe which supports people who are trying to lose weight with diet tracking and nutrition analysis tools (Burke, et al, 2005)
- Project Moop – Students "bring observations from nearby surroundings to the classroom and to school teaching situations where they are handled cooperatively. (Mattila and Fordell, 2005)

- The Active Campus Explorer – "Supports several location aware applications, including location-aware messaging and maps of the user's location annotated with dynamic hyperlinks and maps of nearby buildings, digital graffiti, etc. (Mattila and Fordell, 2005)

2.6.4 How Mobile Learning Devices Support Simulations

In Frohberg's discussion of mobile learning in digital context he mentions some its advantages and disadvantages. Advantages include:

- Full control of the teacher over the learning environment
- Independence from physical restrictions
- Reduction and adaptivity of complexity.

Disadvantages of digital context include:

- Challenge of authenticity
- Until now it has allowed very little physical, social or emotional activities, because the learner is tied to a computer screen and limited to interaction with the computer. (Note from JDC: Complex educational games such as Second Life provide rich, almost "real" interaction among participants). (Frohberg, 2006)

Participatory simulations are supposed to overcome the latter disadvantage. In Roschelle's article he quotes Wilensky & Stroup (1999) and Colella (2000) who say that participatory simulations "use the availability of a separate device for each student and the capability of simple data exchanges among neighboring students. They enable students to act as agents in simulations in which overall patterns emerge from local decisions and information exchanges." (J. Roschelle, 2003). In the **Section 2.6.1** (using palmtop computers to support collaborative learning) we discussed some participatory simulations such as the Cooties Game. Some others that have been developed are:

- Big Fish, Little Fish, Live Long and Prosper (http://education.mit.edu/pda/igenetics.html)
- Some others at MIT: Tit for Tat, Discussion, Sugar and Spice, Nets Work, Palmagotchi
- Savannah – Kids pretend to be lions trying to survive in the wild (Facer et al, 2004) (All the above were referenced in Frohberg's article.)
- Simulations involving swarming ants, traffic jams, and flocking birds (Roschelle referencing Colella et al, 2001)
- Mathematical simulations – Example: A group of students create the same function, but with different parameter values (Roschelle referencing articles by (Kaput, 2002 and Stroup et al, 2002).

2.6.5 How Mobile Learning Devices Support Student Logging

Savill-Smith and Kent discuss two types of student logging (regular recording of particular kinds of information) in their article on using palmtop computers for education. They are manual logging and electronic logging. We will discuss each one in turn.

2.6.5.1 Manual (Reflective) Logging on Handheld Computers

Students learn better when they reflect on their learning. The palmtop computer (may be a PDA or a smart phone) is ideally suited for this task because the student can always carry it with him/her. Savill-Smith and Kent define reflective logging as using a palmtop computer to record students' observations in the professional situation they are working in. Many medical students and student teachers use this learning tool.

A study by Crippen and Brooks (2000) reported on a project in which supervisors of student teachers used palmtops to record their observations. Interactions between them and their student teachers became much more frequent. It was also found very helpful for the teachers to keep daily journals on their PDAs. (Savill-Smith & Kent, 2006).

Smart mob transformed into community of practice - Up to this date there is not much literature on reflective logging. There is a large body of literature on classroom blogs as a learning tool, and reflective logs kept on mobile learning devices are very similar. In June 2003, Dr. John Lester of Harvard Medical School and Massachusetts General Hospital presented a paper at the 10th International Conference on Human-Computer Interaction, explaining how a smart mob participating in a Halloween scavenger hunt morphed into a highly focused community of practice. Lester says that smart mobs "naturally emerge when communication and computing technologies amplify human talents for cooperation." (Lester, 2003)

The smart mob that transformed itself into a community of practice kept a successful communal blog. All the participants used the T-Mobile Sidekick device, which they used to text message each other during the scavenger hunt. Dr. Lester says that by being active members of the communal blog, this group had the three essential elements of a successful community of practice:

1. The establishment of social capital
2. The creation of weak ties that foster creativity
3. The formation of a sense of place within which everything can happen (See studies by H. Rheingold, R. Teigland, M. M. Wasko, S. Harrison, and P. Dourish).

The fourth and final element was the introduction of a specific and challenging goal – the scavenger hunt. (Lester, 2003).

Social learning with blogs – a case study – This case study, the ACID Rapid Testing Project draws on an earlier project (the Beyond :30 Project). Its purpose is to isolate the incentives to participate in a collaborative network. Jacobs and Polson say regarding the behavior of people interacting in a collaborative network, "there is something compelling about being part of an ongoing conversation, an active social sphere for idea negotiation. Participants who engage with subject matter using social software and distributed networking devices (including mobile telephony) tend to find the experience more enjoyable and productive than one-way (and dead-end) publishing, in that there is fluidity in the presentation of ideas, and an opportunity to alter an argument, subject to collective peer assessment of statements."(Williams & Jacobs, 2004; Patel et al, 2004; Stafford, 2005).

They also point out that social interaction is a vehicle for understanding, as well as an intrinsic motivator. Jacobs and Polson feel that the act of publishing blogs and wikis is inherently motivating, unlike extrinsic motivators which can backfire. When participants write blogs and contribute to wikis, they realize that all their ideas are 'fair game' for analysis and debate. (Jacobs & Polson, 2006). While these two paragraphs are not directly related to mobile learning, people may use mobile devices for blogging and contributing to wikis.

2.6.5.2 Electronic Logging

Electronic logs are also called audit trails. The software used automatically records what or when knowledge or information the learners consult on their devices. Savill-Smith and Kent conclude that these logs can be useful to researchers for triangulation, or providing statistics about the use of a palmtop computer. (Savill-Smith and Kent, 2006).

2.6.6 How Mobile Learning Devices Support Student Sampling

Ubaydli and Dean published a report in 2001 on a trial with 100 medical students at the University of Cambridge using m100 Palm Pilots. The software developed for the project focused on the issue of information sharing. The students were asked to fill out questionnaires about their experience with the project. (Savill-Smith and Kent, 2006 Note: I tried to find this article on the Web to learn more about this project, but could not locate it.)

2.6.7 How Mobile Learning Devices Support Physical and Sports Education

Susana Juniu wrote a report in 2002 on the use of PDAs in physical and sports education. She says that the most important benefit for educators and students using PDAs is the ability to extend the learning environment beyond the classroom. (Juniu, 2002 – Referenced by Savill-Smith & Kent, 2006). Some of the benefits of palmtop computers in physical and sports education are:

- Teachers can record, analyze, and grade students' performance on the small computer.
- They can use a palmtop and a digital projector to give presentations in the field.
- Students can record and analyze their own performance on the palmtop.
- Students can use the palmtop to send reports to their teacher. (Savill-Smith & Kent, 2006).

Some of the uses of palmtop computers listed by Juniu are:

- Grading and attendance
- Assessment portfolios
- Fitness and wellness assessment
- Lesson plan organization
- Quiz preparation (Juniu, 2002 - Referenced by Savill-Smith & Kent, 2006).

2.7 Evaluation and Assessment of Mobile Learning

In section of the report we will first discuss the evaluation of mobile learning, which refers to judging the quality of the mobile learning tool, device, application, or process. The second part of this discussion will cover using mobile devices to conduct assessments of student learning. The third section will present a rubric for assessing students' podcasts. A search of the Web did not find any articles on assessing mobile learning activities.

2.7.1 Evaluation of Mobile Learning

Agnes Kukulska-Hulme in article on the current uses of wireless and mobile learning, published in 2005, discusses the evaluation of mobile and wireless learning. The types of evaluations she mentions are questionnaires, interviews, discussions, and focus groups. She lists some examples from the book she and John Traxler published in 2005, *Mobile Learning: A Handbook for Educators and Trainer* (Routledge, London):

- Feedback from students, obtained several times during the project. It may be requested via the telephone, a class poll, a questionnaire, or a focus group (Levy & Kennedy)
- An automatic logging system (see section – **Electronic Logging**) that records when students use a PDA, which applications are used, when

students beam information to each other or to the teacher. The data collected can be used to do a quantitative analysis (Trinder et al).
- Interviews in the field, observations and walk-throughs, plus experimental interventions (Smodal)
- Questionnaires, discussions, electronically logged data, and an online poll (Luckin et al)
- Questionnaires, focus groups, logbooks (Sharples, et al).

Kukulska-Hulme points out the fact that there is no agreed-upon method and there are no widely used novel tools for collecting evaluation data for mobile learning. One of the reasons for the relative few evaluations in this field is that most teachers are not yet trained in the evaluation of these still new technologies. Also, there is still a fairly small amount of evidence on how students use their mobile devices.

In the JISC case studies of wireless and mobile learning (2005), the outcomes for learners were discussed in terms of:
- The development of the following types of skills: reflective, discussion, oral, social, peer review, independent learning, ICT (information computer technology – a subject taught in British schools)
- Students being able to keep in contact with other group members while working in different locations
- Learners' perceptions that they became more efficient and productive learners
- Support for evidence gathering, in cases where a lifelong learning approach was anticipated
- The variety of media and self-pacing features of the learning material
- Continuity of content
- The portability of the media used
- The fact that mobile technologies are great motivators

In Bob Little's article on m-learning he discusses how John Traxler (a researcher with the National Research Centre for ICT at the University of Wolverton, UK) evaluated the EU m-learning Project (gives disadvantaged young people access to an online learning community using a variety of mobile learning devices). The key points that Traxler made about the evaluation of mobile learning are that evaluation must be:
- Rigorous, with trustworthy and transferable conclusions
- Authentic, reflecting what learners are really feeling and what they really mean
- Consistent – across devices, groups of learners and time
- Appropriate to the devices used, the learners and the ethos of the project

The evaluation methods Traxler used were:
- Conventional, through

    - Focus groups
    - Interviews
    - Observation
    - Questionnaires
- Courseware – Identified learners' specific cognitive gains using educational software such as pre- and post-testing
- Objective methods, using data produced by technology through electronic logging
- Contrived methods, such as card sorts and 'laddering'

2.7.2 Assessment using Mobile Learning Devices

In the blog Geoff Stead posted on Blogspot.com on February 26, 2007, he discusses using technology to assess learning. He has tried out several ideas he has on mobile assessment, which include;

- Mobile, multimedia evidence – Leeds Metropolitan University is using a "mediaBoard" to collect and organize photos, sounds, and text files students capture on their mobile phones while working with clients.
- Mobile skills assessments – The London Foyer Association used PDAs loaded with locally installed skills checks to assess the basic skills levels of all the residents in the association. Each learner logged in, takes some tests, and logs out. The results of all residents' tests were uploaded in bulk to the online tracking system.
- Text message skill checks – They have sent out contextualized skills checks to over 150,000 learners in twenty different industries.
- Online skills checks and , if needed, detailed (adaptive) skills assessment (Geoff Stead, 2007)

Tony Wheeler's blog for March 17, 2007, posted on the Handheld Learning website (http://www.handheldlearning.co.uk/) is entitled *Creative Assessment with Handhelds*. He reported on the e-scape project, which is based at Goldsmiths University in London. Goldsmiths is a school for creative people. This project is a new approach to the assessment on creativity and design innovation at the graduate school level. Students use their PDAS to send evidences of the projects they are working on to their teachers. The teachers load files sent by their students into a web-based multimedia portfolio. One of the advantages of this PDA-facilitated grading system is that teachers no longer have to receive and file thousands of paper files each semester. (Tony Wheeler, 2007).

2.7.3 A Rubric for Assessing Student's Podcasts

This is not a rubric for assessing mobile learning per se, but podcasts can be recorded and uploaded and downloaded via mobile devices. It was developed by Ann Bell of the University of Wisconsin-Stout. The rubric is in **Table 9.**

Table 9: A Rubric for Assessing Students' Podcasts					
CATEGORY	**Exemplary**	**Proficient**	**Partially Proficient**	**Incomplete**	**POINTS**
Introduction	**9 points**	**6 points**	**3 points**	**0 points**	
	□ Catchy and clever Introduction. Provides relevant information and establishes a clear purpose engaging the listener immediately.	□ Describes the topic And engages the audience as the introduction proceeds.	□ Somewhat engaging (covers well-known topic), and provides a vague purpose.	Irrelevant or inappropriate topic that minimally engages listener. Does not include an introduction or the purpose is vague and unclear.	
	□ Tells who is speak-Ing, date the podcast was produced, and where the speaker Is located.	□ Tells most of the following: who is speaking, the date of the podcast, and location of the speaker.	□ Alludes to who is speaking, date of the podcast, and location of speaker.	□ Speaker is not identified. No production date or location of the speaker is provided.	
Content	**9 points**	**6 points**	**3 points**	**0 points**	
	□ Creativity and original content enhance the purpose of the podcast in an innovative way. Accurate information and succinct concepts are presented.	□ Accurate information is provided succinctly.	□ Some information is provided succinctly.	□ Information is inaccurate.	
	□ Vocabulary enhances content.	□ Vocabulary is appropriate.	□ Vocabulary is adequate.	Vocabulary is inappropriate for the audience.	
	□ Includes a wide variety of appropriate, well-researched and informative sources and has well-edited	□ Includes appropriate and informative quotes from "expert" sources. Source quotes	□ Includes some variety of informative quotes from some "expert" sources, and one or more source quotes	□ Includes no source quotes or includes source quotes with multiple citation errors.	

	quotes from "expert" sources. Quotes and sources of information are credited appropriately.	are credited appropriately.	need some editing. One or more source quotes are not credited.		
	□ Keeps focus on the topic.	□ Stays on the topic.	□ Occasionally strays from the topic.	□ Does not stay on the topic.	
	□ Conclusion clearly summarizes key information.	□ Conclusion summarizes information.	□ Conclusion vaguely summarizes key information.	□ No conclusion is provided.	
Delivery	**3 points**	**2 points**	**1 point**	**0 points**	
	□ Well rehearsed, smooth delivery in a conversational style.	□ Rehearsed, smooth delivery.	□ Appears unrehearsed with uneven delivery.	□ Delivery is hesitant, and choppy and sounds like the presenter is reading.	
	□ Highly effective enunciation and presenter's speech is clear and intelligible, not distant and muddled. Expression, and rhythm keep the audience listening.	□ Enunciation, expression, pacing are effective throughout the presentation.	□ Enunciation, expression, rhythm are sometimes distracting during the podcast.	□ Enunciation of spoken word is distant and muddled and not clear. Expression and rhythm are distracting throughout the podcast.	
	□ Correct grammar is used throughout the podcast.	□ Correct grammar is used during the podcast.	□ Occasionally incorrect grammar is used during the podcast.	□ Poor grammar is used throughout the podcast.	
Interview	**6 points**	**4 points**	**2 points**	**0 points**	
	□ Open ended questions and follow-up are used that draw interesting and relevant information from the interviewee.	□ Open ended questions and follow-up questions are used appropriately.	□ Open ended questions and follow-up questions are occasionally irrelevant to the topic.	□ Only yes-or-no questions are used. No follow-up questions are asked.	
Graphic and Music Enhancements	**6 points**	**4 points**	**2 points**	**0 points**	
	□ The graphics/artwork used create a unique and effective presentation and enhance what is being said in the	□ The graphics/artwork relate to the audio and reinforce content and demonstrate functionality.	□ The graphics/artwork sometimes enhance the quality and understanding of the presentation.	□ The graphics are unrelated to the podcast. Artwork is inappropriate to podcast.	

	podcast and follow the rules for quality graphic design.				
	□ Music enhances the mood, quality, and understanding of the presentation.	□ Music provides supportive background to the podcast.	Music provides somewhat distracting background to the podcast.	□ Music is distracting to presentation.	
	□ All graphics and music enhancements are owned by the creator of the podcast or copyright cleared with appropriate documentation.	□ Graphic and music enhancements are owned by the creator of the podcast or copyright cleared.	□ Use of copyrighted works is questionable.	□ Copyright infringement is obvious.	
Technical Production	**6 points**	**4 points**	**2 points**	**0 points**	
	□ Presentation is recorded in a quiet environment without background noise and distractions.	□ Presentation is recorded in a quiet environment with minimal background noise and distractions.	□ Presentation is recorded in a semi-quite environment with some background noise and distractions.	□ Presentation is recorded in a noisy environment with constant background noise and distractions.	
	□ Transitions are smooth and spaced correctly without noisy, dead space.	□ Transitions are smooth with a minimal amount ot ambient noise.	□ Transitions are uneven with inconsistent spacing; ambient noise is present.	□ Volume changes are highly distracting.	
	□ Podcast length keeps the audience interested and engaged.	□ Podcast length keeps audience listening.	□ Podcast length somewhat long, or somewhat short to keep audience engaged.	□ Podcast is either too long or too short to keep the audience engaged.	
	□ Podcast is linked to a site that included descriptive subject tags.	□ Podcast contained subject tags.	□ Podcast contains limited subject tags.	□ Podcast has no subject tags and difficult to locate online.	
Group/Partner Work	**6 points**	**4 points**	**2 points**	**0 points**	
	□ All team members contributed equally to the finished product and assist in editing process by offering critique and sharing in skill development.	□ Performed nearly all duties of assigned team role and contributed knowledge, opinions, and skills to share with the team. Completed most of the assigned work.	□ Performed a few duties of assigned team role and contributed a small amount of knowledge, opinions, and skills to share with the team. Completed some of the assigned work.	□ Did not perform any duties of assigned team role and did not contribute knowledge, opinions, or skills or share with the team. Relied on others to do the work.	
Source: Ann Bell's rubrics page on University of Wisconsin-Stout website. Available at					

2.8 Summary of Section 2

Section 2 is the longest and most important section of this report because here we have attempted to explain the pedagogical rationale for using mobile learning devices and technologies in teaching and learning. Section 2 begins with an introduction to the pedagogy of mobile learning, in which we discuss how mobile learning benefits learners, drawing upon the research of many scholars who have studied this issue. Next, we look at mobile learning and the learning process, then at how technology may provide the environment in which conversational learning takes place. In the third subsection of section 2 we discuss how mobile learning can support many theories of learning and how it offers learning and teaching support for learners.

Next we discuss several types of learning activities that are being supported by mobile learning, and then, at some applications and devices that are used in mobile learning. In the final part of section 2 we discuss the evaluation and assessment of mobile learning, including how mobile devices may be used to evaluate students' learning.

3.0 Mobile Learning – Challenges and Solutions

In the previous two sections we have discussed many of the benefits of mobile learning and some of the many ways it may be used effectively in various learning environments. Mobile learning does offer many benefits for today's learners, but it also presents many challenges and problems, some of them unique to mobile learning. In the third section of this report we will take a detailed look at some of these problems and solutions to some of them.

3.1. Mobile Learning Challenges

The mobile learning challenges this writer discovered while researching this report can be categorized under technical issues, pedagogical issues, and social issues. We will look at each one in turn.

3.1.1 Technical Issues

3.1.1.1 Accessibility Problems – Students have the right to expect uniformity of access in mobile learning. In other words, all mobile learners should be on a level playing field. (Susan Nash, 2006, September 26).

3.1.1.2 Equipment Issues

Design Issues – Here we are talking about such problems as:

- Web content that was developed to be run on desktop PCs is often very hard to read on the tiny screen of a mobile device.
- Navigation on these small devices is often difficult.
- Keyboards are too small for efficient typing. (Free Dictionary, 2006)
- Poor battery life of mobile devices
- Stylus is only suitable for entering small amounts of data
- Screens are too small
- Devices are not rugged enough for school use
- Unstable data storage (Ted Smith, 2003)
- Requires fine-motor skills and visual abilities that some students, especially those with disabilities, do not possess (Rawlinson & Bartel, 2006)
- Incompatible technology platforms
- Lack of printing capability (Ted Smith, 2003)

Other Equipment Issues

- Cost of devices
- Delivery time when mobile devices are ordered (Rawlinson & Bartel, 2006)

Network Issues

- Lack of network connectivity standards (M-Learning article in Wikipedia)

3.1.2 Pedagogical Issues

3.1.2.1 Teacher Issues

Teachers who teach with mobile learning technologies often appreciate the many benefits of mobile learning, but they also often have many problems teaching with these new technologies. Some of these issues are:

- **Changes in teaching and learning** – According to Kukulska-Hulme, teachers using mobile learning in their classes now need to focus more on:
  - Identifying and catering to students' specific knowledge needs
  - Fostering reflection on the learning process
  - Helping with the management of learning
  - Monitoring performance
  - Developing new strategies for consolidation of learning and assessment (A. Kukulska-Hulme, 2005)

- Teaching with mobile learning devices is **challenging** for teachers – Some issues raised by Kukulska-Hulme are:
    - Lack of success may be due to inappropriate use for a given pedagogical context (Kukulska-Hulme, 2005). Learners should be educated about appropriate uses of technology to support their learning. (Low & O'Connell, 2006)
    - Material transferred to a mobile environment may need redesign
    - Technology may cause more problems than it solves
    - Loaned devices may lose the benefits of personalization
    - Inadequate usability may lead to the rejection of the devices. (A. Kukulska-Hulme, 2005)

- **Change fatigue**

- **Lack of** teacher **confidence** in **mobile learning** (Cobcroft, et al, 2006)

- **Lack of** teacher **confidence** in **training** (Cobcroft, et al, 2006)

- Having to **adjust settings** on students' mobile devices – "Learner-centered settings are challenging because they still must be managed, scaffolded, and moderated, so learners do not lose orientation and the learning remains coordinated."
- **Not having control** of students' mobile devices when students leave classroom (Frohberg, 2006)

- **Evaluation** of mobile learning is difficult because:
    - Learners are not always truthful when questioned by the evaluator
    - Cultural gaps in the evaluation exercise
    - Bandwidth and interface issues (Bob Little, undated)

- **Equity of instruction** – Some instructors are trained more effectively than others (Susan Nash, 2006)

3.1.2.2 Student Issues

Some of the issues and problems that students have in mobile learning environments are:

- Students using their mobile devices in ways that do not meet class goals (Kukulska-Hulme, 2005))

- Motivation to participate in mobile learning may be due to the novelty factor rather than the desire for interaction (Jacobs & Polson, 2006)
- Computer literacy issues – Don't assume that all your students will be computer literate. (Bob Little, undated)
- Students disrupting classroom with their mobile devices
  - Students want to own and control their mobile devices, but this can cause problems when they bring them into the classroom (Savill-Smith & Kent, 2006)
  - Instant messaging in class (Roschelle, 2003)
- Student learning preferences may not be addressed (Susan Nash, 2006)
- Location and mobility issues (Wikipedia article on m-learning)
- Cheating (Roschelle, 2003)
- Sometimes mobile learning does not adequately support students with disabilities. (Savill-Smith & Kent, 2006)

3.1.2.3 Course Development Issues

Some of the issues that fall under this heading are:

- Aligning mobile learning with the goals of the institution (Jacobs & Polson, 2006)

- The need for a more focused approach to ensure learning outcomes – Tools need to be developed for different learning outcomes. (Jacobs & Polson, 2006)

- The need to develop relevant learning experiences – Simply developing a course to be taught via mobile devices does not guarantee a valuable learning experience for the student. (Wagner, 2005)

- Different kinds of learning demand appropriate strategies, tools, and resources – "There is no such thing as a 'one size fits all' technology solution for learning." Operational learning and teaching complex problem-solving require different teaching strategies. For example, students can learn a programming language from a textbook, but if the goal is to teach him or her how to land an airplane, this subject is best learned on a flight simulator, in a safe, risk-free environment. (Wagner, 2005)

- Technology in and of itself cannot guarantee better learning – Wagner lists several ways technology may be used to improve the learning experience for students, including:

- Can help focus attention and attract and maintain learner's interest
- Can engage learners by structuring and organizing information, by displaying and demonstrating procedures and operations
- Can help make a learning experience more memorable and can help relate new information to that which is already known
- Can simulate many conditions, plunge people into virtual environments, and provide safe practice opportunities as mastery is developed
- Allows students to have relationships with information in our own, unique ways (Ellen Wagner, 2005)

3.1.2.4 Institutional Issues

Institutional issues are problems and issues with mobile learning that have to be addressed at a higher level than classroom/teacher/student issues. For example, the school or college or university has to decide if it wishes to invest more time and money in IT training. These issues include:

- Need to invest in IT training – There needs to be a greater investment in IT skills training before mobile learning can become more widely used. (Bob Little, undated)

- Lack of acceptance for mobile learning (Keegan, undated)

- Mobile learning devices are being developed for general use, not for mobile learning. One of the results is that there is not very much good educational software. (Savill-Smith & Kent, 2006)

- There is little support for mobile learning (Bob Little, undated)

- The need for effective tools to record, organize, and retrieve mobile learning experiences (Kukulska-Hulme, 2005)

- Equity of access to mobile technologies (Low & O'Connell, 2006)

- Need to train mobile technology users in many skills younger learners take for granted (Low & O'Connell, 2005)

- There is little support for informal learning (Frohberg, 2006)

Effect on educational practices – Kukulska-Hulme (2005) in her discussion of how educational practices are being affected in the following ways by mobile learning:

- There is now a broader range of where learning takes place
- Increasing emphasis on filling small gaps of time
- The realization that it takes time for new patterns of use to evolve
- The realization that teachers need to understand the potential, the features and limitations of mobile devices

3.1.3. Social Issues

Mobile learning faces many social and cultural issues, such as language barriers. Some of them are:

- Non-biased culturally delivery and expectations (Susan Nash, 2006)
- Presumption that social practices surrounding education remain the same as technology moves from large desktop computers to small handheld ones (Roschelle, 2003)
    - If students think their social networks are under attack they may abandon their use of certain technologies
- Language barriers (Susan Nash, 2006)
- Students need to recognize the consequences of their actions in an impersonal and sometimes invisible world
    - Students may feel that they can post offensive content and remain anonymous (Susan Nash, 2006)
- Cyber-bullying and cyber-stalking (Susan Nash, 2006)
- Gender issues (Susan Nash, 2006)
- Privacy issues:
    - Obtaining and using information from users based on their location and activity may violate students' privacy rights. (Kukulska-Hulme, 2005)

3.2. Some Solutions to Challenges of Mobile Learning

In the first part of **Section 3** we discussed many problems and challenges associated with mobile learning. In this part we will look at solutions that have been found for some of these problems.

3.2.1 Solutions to Technical Issues

3.2.1.1 Solutions to Platform and format issues (Low & O'Connell, 2006)

- Become educated about the various major platforms and formats for delivery of mobile learning. Learn about the relative strengths and weaknesses of each and how popular in the market it is.
- Design and develop learning activities on to be deployed on as wide a range of devices as possible and test learning activities for cross-platform compatibility and accessibility.

- Know that resources can be developed so that they can be deployed on non-mobile and mobile platforms.
- Reduce the use of video and other processor-hungry formats to a minimum.

3.2.1.2 Overcoming physical limitations of mobile devices

Navigation issues – Try using voice commands for navigation (Wikipedia article on m-learning)

Limited memory of mobile devices - Use memory extension packs on devices such as PDAs. (Wikipedia article on m-learning)

Small PDA/smartphone screens - Use e-books instead of these devices when it is feasible. Hayhoe (2001) offers these guidelines for dealing with small palmtop screens and limited brightness and contrast:

- Teachers and institutions should realize that reading online at low resolution and contrast reduces reading comprehension significantly.
- Use very small pieces of text in written material.
- Display text in font sizes that are large enough for the user to read on the mobile device.
- Make limited use of bold, italicized, or colored text.
- Realize that font selection will be limited.
- Use graphics only when they are necessary to explain learning material.
- Don't assume that other supporting material will be available.
- Remember that most handheld and wireless devices have very modest capabilities. (Author's Note: Hayhoe wrote these guidelines in 2001)
- Consider the capabilities of the standard device students are using when designing for a particular installed base.
- When designing Web pages to be read over a mobile device, remember that their screens use portrait orientation and that they are very narrow. (Savill-Smith & Kent, 2006)

Difficulty in entering data with a stylus – Attach a keyboard to the PDA. (Ted Smith, 2003)

Hayhoe developed these guidelines to help designers relate to users' environments and the tasks they perform:

- Do a user analysis when designing online documents for wireless and handheld platforms.
- In the design stage, consider the users' environments regarding issues such as places, times, atmospheric conditions, lighting and noise levels, etc.
- Minimize file sizes.
- Limit the amount of interactivity and scrolling.

- Remember the user will usually be using holding the device in one hand and that he or she will only have one hand to use the device.
- Be aware that users will assume different postures when using the mobile device.
- Use sound only when necessary, and allow the user to mute it when necessary. (Savill-Smith & Kent, 2006)

3.2.1.3 Overcoming shortage of good educational software – PDAS have standard built-in software such as word processors, spreadsheets, and graphics/drawing programs. Use this software to develop resources for your classes. (Savill-Smith & Kent, 2006)

3.2.2 Solutions to Pedagogical Issues

3.2.2.1 Need to educate learners about appropriate uses of technology to support their learning – Focus on the activity and let it guide the technology. (Low & O'Connell, 2006). Each institution should develop a fair use policy that sets out guidelines on how the mobile learning technologies it sponsors will be used in and out of class.

3.2.2.2 Solutions to Student / Learner Issues

Developing a Learner-Centered Environment for Mobile Learning - Jipping and Dieter (2001) suggested these guidelines for putting the learner at the center of his or her learning:

- We need to create a learning environment that will put the student at its center and make him or her comfortable and confident at the computer. This involves HCI (human-computer interaction and issues such as mobility and computer size.
- We need to make the student, not the computer the target of information. To facilitate this, send updated Web pages and files to the student's computer and collect information from students daily.
- Make the tools used on the computer fit the student and his or her uses. Don't try to make the student fit the technology.
- Configure the computing environment to assist in creating a community of users. (Savill-Smith & Kent, 2006)

Making Mobile Learning Serve the Needs of Students with Cognitive Disabilities – Carmien (2002) says a mobile device needs to:

- Be easy to carry
- Display an image with quality high enough to be perceived as an image, not an icon
- Have sound quality and enough volume for users to clearly hear prompts when they are outdoors
- Be robust both as an software platform and as hardware

- Be designed so that users whose fingers are not so finely coordinated can efficiently use them
- Provide positive visual or auditory feedback when controls have been activated (Savill-Smith & Kent, 2006)

Students Disrupting Classroom with their Mobile Devices – J Roschelle suggests several ways disruptive classroom behavior may be minimized, including:

- Applications used in participatory simulations may be structured so that only messages relative to the classroom content may be displayed.
- The topology of local networks may be configured so that data can be exchanged only among students working in groups.
- Use software, such as Classtalk, that gives teachers a classroom map so her or she can tell where messages come from on a classroom seating chart. (J Roschelle, 2003)

Offsetting the High Cost of PDAs

- Encourage students to team up and share the cost and use of a PDA
- Provide a opportunity for students to sell the devices to new students after they have completed the course.

Need for Training in the use of PDAs and Basic IT Skills – Spend the first few weeks of the semester training students in basic IT skills.

3.2.2.3 Course Design Issues

Kukulska-Hulme and Traxler offer these strategies for integrating quality control and evaluation into the development and implementation of mobile learning technologies:

- Integrate the design, planning, and implementation of mobile technologies into the process at the planning stage.
- Keep in mind that mobile learning will not suit every learner in every situation. (Cobcroft et al, 2006)

Jacobs and Polson (2006) suggest an **experience design approach**, a broad approach to instructional design for mobile learning that is best developed by a multidisciplinary team. They say that this approach incorporates "aspects of representation, communication, application, and interaction between and through users, content, systems, and the surrounding contexts." The most valuable benefit from this approach to design is that these experiences become embedded in the everyday use of everyday devices in the everyday lives of the people for whom they are designed.

The specific design considerations they list are:

- Representation and simulation of learning content – This refers to the way learning content is selected, made, and displayed.
- Communications enablers for the reception of content – This refers to the devices that are used to send and receive content.
- Logic design or support for content – This refers to the underlying system, logic, and rules.
- Feedback qualities that enable users to interact with content
- Identity and relationships, or how the users are represented – For example, how does a user playing a game interact with it? (Jacobs & Polson, 2006)

3.2.3 Solutions to Institutional Issues

3.2.3.1 Making mobile learning acceptable in the mainstream education and training world – Keegan has developed these criteria for the inclusion of mobile learning in mainstream education and training:

- Enroll mobile learning students in courses in the school's official catalog
- Enroll mobile learning students into fee-paying courses
- Enroll mobile learning students into assessed courses
- Enroll mobile learning students into accredited courses

3.2.4 Solutions to Social Issues

Susan Nash offers these solutions to the social issues she discusses in her blog of September 2006:

- Privacy issues – Establish clear guidelines covering how students' privacy will be protected and enforce them.
- Uniformity of access – Make sure that all students are on a level playing field.
- Non-biased culturally equitable delivery and expectations
    - Have focus groups to beta test courses and mobile learning devices
    - Establish clear rules for proper mobile learning behaviors
    - Make sure students are not accessing and posting invasive or offensive items
- Language barriers – Remember that colleges are ethically obligated to provide training, mentoring, and support to learners who don't have the background or language skills to succeed in mobile learning.
- Learning preferences – Do not penalize learners for having different learning preferences.
- Equity of instruction – Follow the same training and teaching philosophy when training all teachers.

- Posting and other concerns – Make students give their real identity when posting messages to a discussion forum and impose social control in the online class.
- Cyber-bullying and cyber-stalking – Assure an environment where individual learners cannot be forced to suffer because of antisocial behavior.

4. The Future of Mobile Learning

In the final section of this report we will peer into our crystal ball and try to predict what the future holds in store for mobile learning. The topics we will consider are:

- Developing a theory of mobile learning
- Teaching tomorrow's learners with mobile technologies
- The mobile learning environment of the future
- Mobile administration and documentation systems
- Mobile learning networks of the future
- Future developments in technology and devices
- Social learning environments of the future
- Software for the mobile learning of the future
- Developing the literature of mobile learning

4.1 Developing a Theory of Mobile Learning

Mobile learning is still a new teaching and learning model. As with all new paradigms, at present there is no agreed-upon theoretical framework that can be used to position it in its proper place in the wider world of learning. Much research has been done in this area, however, and in the first part of section 4 we will summarize some of the findings and suggestions of scholars who have studied this issue.

4.1.1 Reasons for Contemporary Advances in the Study of Learning

The past couple of decades have witnessed many advances in the study of learning. Even before mobile learning devices began to be widely used in educational settings, research on knowledge acquisition, transfer of learning, situated learning, and other areas, was leading to new theories about how people could learn in authentic settings, such as at work, while commuting to work. etc. Mobile devices are a natural facilitator of learning that is situated in the "real world." In the year 2000 a study entitled How people learn: Brain, mind, experience, and school (edited by Brandford, Brown, and Cocking) was published. According to this book the reasons for the contemporary advances in the study of learning are:

- Because of research in cognitive psychology we have a better understanding of skilled performance and the principles of knowledge organization that underlie our ability to solve problems.
- We now know that young children are capable of reasoning at a higher level than previously thought, making it possible to develop a more innovative curricula.
- Researchers who have studied how knowledge is transferred have discovered important principles for structuring learning experiences so people can use their knowledge in new settings.
- We now realize that learning takes place in the social and cultural context of individual learners and powerfully influences learning and knowledge transfer.
- Researchers now understand more about the nature of how learning and teaching takes place in various settings and how learning practioners can share their expertise with students. (Oloruntoba, 2006)

4.1.2 Criteria for Theory of Mobile Learning

Sharples et al (2005) suggest that a theory of mobile learning must be tested against these criteria:

- " Is it significantly different from current theories of classroom, workplace, or lifelong learning?"
- "Does it account for the mobility of learners?"
- "Does it cover both formal and informal learning?"
- "Does it theorize learning as a constructive and social process?"
- "Does it analyze learning as a personal and situated activity mediated by technology?" (Sharples et al, 2005)

4.1.3 Research that Needs to be Done before a Theory of Mobile Learning is Developed

J. Roschelle (2003) says research needs to be done so we can understand the lack of surface resemblance between enabling technology and desirable social practices of learning. This research should enable us to:

1. Identify the separate roles of technology-based communication and non-technology-based interpersonal communication.
2. Identify the ties that bind them together in exemplary teaching and learning.
3. Adopt a critical attitude toward the economic plausibility of developing a ubiquitous, mobile, personal teaching and learning platform that will run all the best pedagogical applications.

Roschelle says these challenges are part of a thematic emphasis on coupling, and that wireless and mobile technologies in education will succeed to the extent that coupling is increasingly understood:

- Within the **informatic** world
- Within the **social** world
- Across the informatic and social worlds (J. Roschelle, 2003)

4.1.3.1 Promising Areas for Research in Mobile Learning

Agnes Kukulska-Hulme has identified these aspects of practice that the mobile research community is reflecting on:

1. Collaboration and community – Some examples are:

    - Mobile computer and mobile phone supported collaborative and informal learning
    - Seamless access to shared Web sessions from multiple devices
    - Interactivity in large classes using wireless devices
      Assessment of learners in collaborative mobile learning

2. Content for mobile learning - Some Examples are:
    - Capturing case studies in workplace contexts
    - Game-based learning on mobile phones
    - Messaging technologies in support of retention and for language learning
    - Converting e-learning content to mobile learning
    - Learning objects on mobile devices
    - Content adapted to user's location

3. Technical innovation.- Some examples are:
    - Using digitally augmented paper and mobile devices to bridge use of paper and hypermedia
    - Wireless Learning Management Systems
    - Seamless integration of tools for learning, collaboration, and time management
    - 'Team awareness' features to enhance learning in context

4. Reaching new kinds of learners - Some examples are:
    - M-learning for the underprivileged
    - Addressing poor literacy and math skills by using mobile devices
    - A hospital information system that can be accessed through mobile devices
    - Mobil first aid and emergency management

5. Understanding the field of mobile learning – Some examples are:

- Ethical and legal challenges in mobile learning
- Use of scenarios to understand user requirements (Agnes Kukulska-Hulme, 2005)

4.1.3.2 Researching impact of mobile learning on teaching and learning practice

Kukulska-Hulme says that in post-16 education it has been difficult to distinguish between established uses of mobile and wireless technologies and the leading edge of research. She goes on to say that we are beginning to understand the key issues well enough that a good understanding of the unique advantages of wireless and mobile devices is emerging. (Kukulska-Hulme, 2005)

Savill-Smith and Kent conclude that so far there have been few

- Comparative research studies
- Studies that relate their work and outcomes to theories of learning
- Studies referencing or examining in depth, the views of the participants, especially the learners, to the handheld technologies they are using (Savill-Smith & Kent, 2006)

In their review of the literature of mobile computing the authors say the following topics need to be taken into account in research and design activities:

- Information literacy
- The design of both collaborative and independent learning activities
- Game-playing and learning
- The use of palmtop computers for activities outside the traditional classroom, for example, physical education and sports
- Reflective logs and blogging
- Guidelines for the design of interfaces and the presentation of material on handheld devices (Savill-Smith & Kent, 2006)

4.1.4 Developing a Conceptual Framework for Mobile Learning

Michael Thomas in his article on iPods in education discusses the development of a framework to evaluate the future of mobile devices such as iPods. He references a study Jochems, van Merrienboer, and Korper (2004) did of blended learning. They said three main factors should be considered:

1. Pedagogical
2. Technological
3. Institutional

Jochems, et al say that according to this framework, e-learning innovations must demonstrate a value-added dimension, which depends on the three factors listed above having a strong interrelationship. (M. Thomas, 2006)

4.1.4.1 Key Questions that Should be Asked

Bryan Alexander in his article on m-learning says that as schools enter the world of wireless, mobile learning in order to make m-learning work for higher education's core missions of teaching and research, these key questions need to be asked:

- How can institutions best manage m-learning support in a sustainable fashion, beyond external grants and pilots?
- How should institutions recognize and support mobile learning communities, both financially and in policy terms?
- What are the best practices for collaboratively sharing information or support among institutions?
- How can institutions best support mobile learning off-campus?
- Are campus IT departments ready to support the variety of mobile hardware platforms, or should campuses focus on a narrow selection?
- How widely applicable is augmented reality, in terms of pedagogy and support?
- What networks and practices can best support collaborative learning object development for m-learning? (B. Alexander, ECAR, 2004)

4.1.4.2 Characteristics of the Framework for Mobile Learning

According to Cobcroft et al, 2006), a framework for the design of mobile learning should consider the following:

- How to achieve the achievement of learner-centered, highly situated, personal and collaborative mobile learning (Naismith, Lonsdale, Vavoula, & Sharples, 2004, p. 36)
- How to provide educators with the ability to understand and respond to systemic challenges in offering a realistic vision for efficient and effective mobile learning and teaching
- Learners' creative, collaborative, communicative, and critical engagement
- How learners learn through play (Mitchell & Popat, 2003; Mitchell & Savill-Smith, 2004)
- Engagement with distributed learning networks and remote communities (Hine, Rentoul, & Specht, 2003; Laroussi & Derycke, 2003; Viljoen, 2005)

Cobcroft, et al, say researchers in the field of m-learning should consider how to identify the 'tipping point,' "where the use of mobile and wireless technologies will gain a critical mass which compels institutions to adopt effective and efficient mobile learning plans and approaches." When m-learning moves beyond this tipping point the potential for pervasive and seamless m-learning pedagogical approaches will be realized for learners, teachers, and institutions. They conclude with the thought that as we move toward that point,

"the philosophical underpinnings of such m-learning pedagogies will also need to be further developed." (Cobcroft, et al, 2006)

4.1.4.3 The Role of Technology in Delivering Learning

Ragus says people, especially those within traditional learning delivery areas, need to understand that technology is here to assist in, and be part of, a range of flexible delivery options. He goes on to say that it is not here to take anything away from traditional teaching methods, but it can be a valuable and engaging addition to them. (M. Ragus, 2006)

4.1.4.4. Organizational Implementation of Mobile Learning Framework

Marcus Ragus says the framework should allow groups and organizations to "easily initiate, and implement mobility within their existing structures and management hierarchies." (M. Ragus, 2006)

4.2 Teaching in the Mobile Learning Environment of the Future

4.2.1 Teaching Today and Tomorrow's Learners

Doug Brown makes the point in the paper he delivered at the 2006 Global Summit on Technology Connected Futures that learning in the 21st century is personalized and that it is inextricably linked to the use of technology. Learning is also distributed across all the situations learners find themselves in and teachers must realize and cope with the fact that 85% of learning is outside their immediate control. How will we train teachers and support workers to function effectively in this new (to them) world? Brown also contends that schools will have to be places which respond to the needs of their students and deliver their societal expectations. (D. Brown, 2006)

4.2.2 Recommendations to Consider before Adopting New Technologies

Agnes Kukulska-Hulme offers several recommendations institutions should consider before adopting new technologies. They are:

- Consider all the possibilities for a new technology. Specially, its potential to support teaching, learning, and the management of teaching and learning.
- How can the information available in a learner's location that is relevant to his or her needs be captured and delivered in a context that will contribute to teaching and learning?
- How can we take advantage of the fact that learners may have mobile devices available in the workplace and at home, as well as in the learning

institution so that what he or she learns in formal learning settings can be continued in informal learning venues?
- Evaluate the various communication channels between you and your students, from both a pedagogical and a social point of view.
- Do not overlook pedagogical, technical, logistical, usability, and social constraints when deciding when and where and how to use new technologies.
- Consider the physical environments in which new technologies will be used, and how they could affect learning.
- Lookout for unexpected benefits of learning outcomes, as well as unanticipated disadvantages.
- Try to understand how new student audiences and patterns of study that emerge when learners obtain access to wireless and mobile technologies, including nontraditional students. (Kukulska-Hulme, 2005)

4.2.3 The Role of Educational Gaming

Marcus discusses initiatives in Australia and around the world that have demonstrated the educational benefits of gaming. He mentions a gaming interface developed in the UK by the MobiBuild™ company. This software can be used to develop learning resources that can be used on mobile devices.

Ragus says that gaming has the potential to add significantly to the delivery of mobile education because it provides a way to engage learners in a way that traditional approaches can't. Studies of the gaming generation indicate that:
- Gamers are always the star of their games
- They always know that there is a solution to their game
- They know that failure precedes success. (Trendwatching.com 2005) (M. Ragus, 2006)

4.3 The Mobile Learning Environment of the Future

What will the mobile learning environment of the future look like? We can't say what it will look like at this time, but here are some suggestions on how to design it from researchers who have studied this issue.

4.3.1 Breaking out of Your Technology Box

Matthew Nehrling in a blog posted in October 2006, encourages us to break out of our technology boxes, which are sometimes more imaginary than real. Some examples of technology boxes he lists are reluctance to add Flash content to a learning exercise, being afraid to use online discussion groups, and not wishing to add audio to a presentation to get the learners more engaged.

He lists some creative ways teachers can break out of their technology boxes, such as:

- Mixing and matching different learning technologies that have different strengths to achieve the desired result
- Work-arounds to make existing technology more functional
- Introducing easy Web 2.0 tools such as blogs and wikis to provide missing communication elements
- Doing away with strict IT policies that do not allow any flexibility concerning the introduction of new learning technologies (or having them hosted externally. (M. Nehrling, 2006)

4.3.2 Designing the Learning Environment of the Future

Joanne Jacobs and Deb Polson of the Australasian CRC for Interaction Design published a paper on mobile learning and social learning in 2006. They have developed a model for evaluating the experiences and needs of stakeholders in the design of mobile and social learning for various technology-driven devices. They call their model "experience design" and say that case studies in mobile and social learning demonstrate that experience design, rather than education and technology design need to be given priority to ensure active and engaged learners. Jacobs and Polson say that such Web 2.0 services as MySpace, flickr, and user-led information platforms collectively demonstrate users' desire to have control over their engagement with ideas, players who want to become authors and actors in learning experiences. (Jacobs & Polson, 2006)

4.3.3 Portable Personal Learning Environments

Marcus Ragus in his discussion of the future of m-learning identifies several innovations he says will impact m-learning in the years to come. They are:

- Portable Personal Learning Environments (PPLEs)
- Radio Frequency Tags (RFIDs)
- Global Positioning Service (GPS)
- SMS Casting Service
- Gaming
- Mobile administration and documentation systems

Each one will be discussed in **Section 4**, but let's consider portable personal learning environments first. Ragus says Portable Personal Learning Environments are "environments made up of one or more portable applications that can be loaded onto a number of varying mobile devices for example, from memory sticks and to personal digital assistants (PDA) and mobile phones." This concept is taken from current research whose premise is that standard

college-based Virtual Learning Systems (VLEs) are not providing learners with what they need. If a user moves to an organization with a different VLE he or she will probably have to adapt to another system.

The primary goal of a PPLE would be to have a completely secure mobile system that could run from a remotely centralized standard VLE. This system would consist of tools, resources, and activities that could be accessed through a simple user interface. In theory, these systems could be loaded onto memory card devices and configured to run on specific computers. An example Ragus mentions are the interactive logbook for the Centre of Educational Technology in Birmingham, UK. (Corlett et al, 2005). (M. Ragus, 2006).

4.4 Mobile Administration and Documentation Systems

Remember the "paperless office" that was predicted eliminate the massive amounts of paperwork all organizations must cope with? Since the advent of the personal computer the amount of paperwork we accumulate has increased dramatically instead of decreasing. Ragus points out that educators spend much of their time managing paperwork.

He says that with mobile technology we are one step closer to the paperless office. For example, we can carry around a whole library of books on one portable device. Some progressive schools in the United States are running mobile software programs such as PAAM™, which allow students to access resources and then send completed material such as assessments back to a server where the teacher can access it for evaluation. Ragus also mentions similar projects that are underway in the Australian educational system. (Ragus, 2006)

4.5 Mobile Learning Networks of the Future

Today's cutting-edge networking technology, such as 3G, will bring about vast improvements in our mobile learning networks. In this section we will take a brief look at some of these new developments.

4.5.1 Tomorrow's Ubiquitous Network

Researchers at the AT & T Laboratories at Cambridge University are designing a ubiquitous networking system that will allow a person to take their software applications with them (virtually) wherever they are. A transmitter and special sensors will allow a user's workstation to be anywhere he or she is, not just at the physical workstation location.

Bills, et al, say that we should not think in terms of specific devices, but as components of the same integrated network. Ideally all the devices (storage

media, cell phones, printers, etc.) will work together seamlessly to the point where the user does not have to be concerned with the individual devices, but only with how they can collectively be used in conducting research and scholarship. As Norman (2002) said, "After all, what is the difference between machines that scan, copy, manipulate, combine, compose, fax, or print in a world where everything is networked: answer, there is no difference." (Bills, et al, 2006).

4.5.2 Tomorrow's 3G Network

Richard Oloruntoba in his study of mobile learning environments writes about the third generation networks (3G) that network operators are launching. Third generation networks promise faster broadband connections, enhanced multimedia, and advanced services such as video conferencing. Many organizations are still using equipment designed for 2G and 2.5G networks, so it will probably be several years before 3G networks are widely adopted. New EDGE technology is being introduced that will improve the performance of 2.5G networks. EDGE stands for Enhanced Data Rates for GSM Evolution. This technology increases capacity, improves quality, and allows the use of advanced services over the existing GSM network. Oloruntoba reminds his readers that network infrastructure has not quite kept up with handset development, users' expectations, or industry hype, resulting in bandwidth that is inadequate for substantial online learning and coverage. Also, many areas still have signal problems and travelers still experience signal problems, resulting in the necessity for a mixture of online learning as well as materials downloaded onto handheld devices for later offline use. (Oloruntoba, 2006).

4.5.3 "Micro Mobile" Networks

Marcus Ragus says the global move towards wireless networks will greatly impact the way we use mobile devices for learning, with communications and collaborative associations playing a larger and larger role in the way learning is carried out. He uses the term "micro mobile" networks to describe networks within campuses and organizations. He says access through these small local networks will predominate, allowing learners to be accessible whenever they wish to be. In this situation learning does not have to be online at all times, and learning materials can be chunked into accessible bites of information, so resources can be interchanged with existing management systems over networks. These "micro mobile" networks will all have access to the World Wide Web and "more web centered learning will open up collaborative networks from a local to a truly international level." (Ragus, 2006).

4.6 Future Developments in Technology and Devices

We have already discussed the mobile learning environment of the future, with some of the technologies that will make it possible, such as PLEs, 3G networks, and "micro mobile" networks. In this section we will briefly look into some future developments in the technologies and devices that will take advantage of the new mobile networks.

4.6.1 Visions of Tomorrow's m-Learning

Matthew Nehrling, in a blog posted in August 2006, wrote about various mobile learning devices, such as mobile phones, PDAS, and iPods. He says that what separates them from previous mobile learning devices such as books and cassette players, is the fact that our new mobile devices:

- Support a digital, connected learning environment
- Provide information in a compact and convenient format
- Give learners remote and instant access to a range of people and resources
- Give learners the ability to process data

that was not possible in the past.

Nehrling has developed what he calls a learner-centric "Four R's model" of mobile learning activities. He believes that mobile digital devices will become "increasingly affordable, accessible, and predictable platforms for facilitating learning." He envisions the learning device of the future as a personal, connected tool that will provide the learner with a full range of connected information and communications services, providing him/her with contextualized learning opportunities through a real-world interface. (Nehrling, 2006).

4.6.2. The Future Technology of Mobile Learning is already Here

Mike Sharples, Josie Taylor, and Giasemi Vavoula in their article, *Towards a Theory of Mobile Learning,* write about the convergence of learning and technology. (See Table 1, Page 2 of this report). Leadbetter (2005) says that learning is being re-conceived as a personalized and learner-centered activity. The new digital technologies offer personalized services such as music play-lists (iTunes and other digital "juke box" software) and digital calendars (www.shutterfly.com for example).

Brown, Collins & Duguid (1989) have written about how learning is now considered as a situated and collaborative activity, that occurs wherever people, working alone or in groups, have problems to solve or knowledge to share.

Following that trend, mobile networked technology enables people to communicate regardless of their location. At the beginning of the 21st century both learning and computer technology are ubiquitous. Devices such as photocopiers and televisions, even kitchen appliances, have computers embedded in them. We are witnessing the ever-evolving of software programs and storage formats (Adobe© Acrobat 8 for example); many of these programs are backward compatible. Now people can preserve and organize the digital records of their learning over a lifetime (Banks, 2004) (Sharples, et al, 2005).

4.6.2.1 The Need to Understand Technology Tools

Marcus Ragus makes reference to an article by Hirsch (2005) who believes that the education sector should try harder to understand the technological tools that today's learners use in their everyday lives. Ragus asks learning researches why they continue to focus on "what m-learning is, is it really happening, and is it of any benefit?" He says we need to move past this point and start producing complete working models of mobile learning for organizations, staff members, and learners. He says these models should allow for "automated, systematic solutions for day to day operations and delivery, from automated mobile data recording, such as roll and enrollment, through to resource and learning pathways." (Ragus, 2006)

Ellen Wagner in her article *Enabling Mobile Learning* (***Educause***, May/June 2005) discusses her vision of the future mobile landscape. She makes reference to Clayton Christiansen who, writing in 1997, said that innovations, although they are initially not as reliable as the tools they supplant, do bring about significant change when they are widely adopted. She notes that Penny Wilson (2005) in describing mobile wireless devices such as cell phones, handheld computers, and notebook computers, called them "tools of mass disruption" that are going to spark a period of innovation in learning technology. Wagner says that the ultimate success of mobile learning will revolve around a montage of rich converged experiences, which will rest upon a foundation of converged network and device technologies. some of these technologies that will converge to assure the success of mobile learning are:

- Wireless services
- Rights management
- Content management
- Search management
- Transactional processing power

Wagner concludes that successful mobile learning will demand a rich presentation layer (or interface) that runs efficiently on a variety of platforms and in many forms. She also notes that "effective mobile learning will require new digital communication skills, new pedagogies, and new practices." She says

we still have time to prepare for the oncoming wave of learning innovation before the arrival of 3G and 4G technologies. (Wagner, 2005).

4.6.2.2 The Technology Infrastructure of the Future

Ragus says we should blend our fixed technology infrastructure with the technology of the flexible mobile spectrum, connected through associated telecommunication infrastructure and wireless networks.

Today's learners must still use our fixed technology infrastructure, such as computer labs, in their learning, but they should be able to access learning technologies whenever and wherever they need it in their daily learning. Technology will have to become an ever-present component of day to day learning for this to happen. When this happens, we can move beyond learning about technology to learning with technology. (Hirsch, 2006:para.13)(Ragus, 2006).

4.6.3 Mobile Learning Devices of the Future

In this section we will look at some of the mobile learning devices that will be used in the near future. Actually, all of the devices we will cover are already on the market, but they will all be significantly improved in the very near future. No doubt, learning devices that have not even been envisioned will be in use in the following decades.

4.6.3.1 The Mobile Learning Interface of the Future

Ragus says the mobile learning world needs simple interface development that would enable users to get what they need with one or two taps of the stylus (Authors Note: It will be interesting to see if touch screen interfaces such as the one featured by the new Apple iPhone which goes on sale in June 2007, will be used on tomorrow's mobile learning devices). He says that so far, the Palm operating system has been the only one that works this way. Ragus says Microsoft's new Mobile 5.0 operating system is a good first step, but that it still has some work to do if it is to satisfy the education market.

He mentions that organizations have to rely upon information found in research articles and mobile learning projects to learn about mobile technologies that might fit their needs. Many schools and colleges have adopted a 'wait and see' approach until the learning device market stabilizes, but this attitude might delay their progress in the emerging field of mobile learning. (Ragus, 2006)

4.6.3.2 Global Positioning Satellite Service (GPS)

GPS systems are not really new; many of them are already in use, in automobiles and as portable devices carried by travelers. Marcus Ragus wrote an article in 2004 exploring their potential in contextualized and situated learning. IN 2005 the CAERUS project (Context Aware Educational Resource System), hosted at the University of Birmingham in the UK, developed a prototype of a GPS interpretative device to be used in the University Botanical Garden. He also mentions the Virtual Tour™, developed by Daniel Dacey of New England Computer Solutions in Australia. The goal of this project is to provide a user-friendly interface that allows trainers to develop virtual tours based around any outdoor location. The system can support voice, video, and other multimedia, and has a database in which an enormous amount of information about tours and data can be stored. So far it has been used in field study such as science and the fishing industry, and allows the learner to engage in a range of real-world type situations. The device lets the teacher track students individually and students can complete assessments through it. (Ragus 2006).

4.6.3.3 PDA or Smartphone?

In 2003, TechLearn made the following predictions for the next three years:

1. As smartphones become more inexpensive when students upgrade their systems they will buy them rather than the much more expensive and battery-hungry phone-enabled PDAs. It is unlikely that students will purchase both a PDA **and** a smart phone.
2. Students studying for professions such as medicine and law where PDAs are widely used will likely purchase PDAs.
3. Most students will not purchase tablet PCs.

TechLearn also predicted that by the end of 2005:

- All students will own a mobile phone that will be able to receive text graphics. It will be possible for teachers to communicate text and simple graphics with all students.
- All students will be able to use their mobile phones to maintain an electronic calendar and task list that can be synchronized with a central server or desktop or laptop computer. Teachers may transmit timetable and course information to students' mobile phones.
- In spite of the popularity of PDAs in education, many students will not own one, therefore, if schools want all students enrolled in a course to have one, they must either furnish PDAs to students or require students to buy them. (Ted Smith, 2003)

4.6.3.4 RFID Tags

Marcus Ragus says smart tags such as RFIDs (Radio Frequency Identification tags) have the potential to revolutionize the way trainers deliver both workplace and college learning. RFID tags contain tiny microchips that can hold electronic information. Devices such as mobile phones, PDAs, or pocket PCs can read can read the information in the tags. Up to 1 megabyte (MB) of information can be stored on each tag. Nokia is marketing a series of RFID-enabled phones that can read these tags and write information to them. In the near future RFIDs may be used to deliver 'just in time' information for learners in bite sized chunks. Ragus says the infrastructure required for RFID systems is relatively cost effective and can easily be updated and contextualized by a staff with little experience. We will probably see more complex systems that incorporate voice or other multimedia formats in the very near future. (Ragus, 2006).

4.6.3.5 SMS Casting Service

SMS stands for Short Messaging Service. Mobile phone users have been sending short text messages to each other for years, but now educators and technologists are developing content that can be delivered to learners via their mobile phones. Alan Munro is the founding director of 5th Digit Mobile Concepts, a South African company that is developing applications that can deliver information across mobile networks. Munro's company has developed a method of sending the text component of language courses (English, Zulu, Xhosa) to students' mobile phones using SMS. The audio component is delivered as a podcast, which students can listen to on their MP3 players. The MP3 files are delivered over the Internet, but new software has been developed that lets users download MP3 files directly to their mobile phones. Munro says that.. "what makes this product unique is that it allows the learner to decide when and how frequently they receive their lessons." (Munro 2005).

An Australian company named Fifth Finger has launched a product called aircast™ Self Serve. This product is a "web interface which clients use to instantaneously create and launch a range of SMS services upon a predefined set of business rules." (Fifth Finger 2006:para.2).

The aircast™ interface is easy to set up and has options that allow users to set it up as a student survey tool, formative assessment area, etc. The information the learner needs is added by the teacher or trainer to an SMS generating database via the user's computer. Learners can then

access the information through most mobile phones using a trigger code that is sent to an assigned phone number.

When the 3G platform is available we will be able to transmit television and video through mobile phones. (Ragus, 2006)

4.7 The Social Learning Environments of the Future

Researchers in the field of learning have been writing about the benefits of social and collaborative learning for decades (see Vygotsky, Dewey. etc.), but now our young learners are learning in social groups with unfamiliar names such as "learning swarms" and "smart mobs." In this section of the report we will investigate these new learning environments.

4.7.1 Smart Mobs

Howard Rheingold is one of the true pioneers of the digital age. In 1985 he published *Tools for Thought*, a history of the people who developed the personal computer. He was one of the first people to research online communities, leading to his best-known book, *The Virtual Community*. His current interest is smart mobs. In 2002 he published a book titled *Smart Mobs*. There is a website dedicated to discussing the issues explored in this book at: www.smartmobs.com.

Based on his research on smart mobs, Rheingold foresees a future in which mobile and distributed networking devices could become "platforms for technical and entrepreneurial innovation, foundations for industries that don't exist yet, [and] enablers of social and political change" (Rheingold, 2005. Mobile and open: A manifesto). Rheingold promotes openly accessible systems for information exchange, because he believes they give people the opportunity to playfully exchange ideas and create connections between "similar minds and expertise, and that these connections will facilitate innovation, activism and new business opportunities." (Jacobs & Polson, 2006).

Pat Kane (www.patkane.com) is a musician, writer, consultant, and activist. He is the author of *The Play Ethic: A Manifesto for a Different Way of Living.* He feels that a digitally connected culture fosters idea generation and innovation more effectively than a hierarchical culture that enforces a puritan work ethic. Kane says that active members of a digital culture are "life-long learners as well as educators, keen to use the functional aspects of blogging and other social software tools to plan, to forge identities and to constantly innovate." (Jacobs, 2006). (Jacobs & Polson, 2006).

4.7.2 Learning Swarms

The origins of "learning swarms" can be traced to the "flashmobs" of the summer of 2003. Wikipedia defines a flash mob as "a large group of people who assemble suddenly in a public place, do something unusual for a brief period of time, and then quickly disperse." (Wikipedia, 2007) Young people would contact each other on their cell phones and agree to meet at a certain time and place. It could be a restaurant, movie theater, shopping mall, or any other place where large numbers of people could congregate.

Learning was not the goal of the first flashmobs, but what the National Science Foundation has called the *cyberinfrastructure* can be accessed by any learner, at any place and time. Bryan Alexander, in an article published in *Educause* in 2004, says that if the cyberinfrastructure is the place where learning is going to occur, then new forms of learning are emerging all around us. Alexander thinks that "information literacy may change as students expand their multitasking, mobile, learning-on-demand ethos. (Alexander, 2004).

Alexander asks his readers in higher education if they are ready to respond to groups of students organized into smartmobs or flashmobs. More than a response to these groups is needed in educators wish to take advantage of the learning potential they afford. How much do we know about social software such as Meetup, which has been developed in part to cater to these groups? Do we know how to use social software to meet our educational goals?

He believes we may be seeing the beginning of *learning swarms*. Students have been gathering at restaurants, libraries, movie theaters, etc., for years to discuss a new film, book, and so on. Alexander says that now with the widespread use of wireless networking and student mobility and the socializing influences of these technologies, these gatherings could become collaborative learning experiences. A school network or website could be equipped with learning objects, digitally tagged materials, instructors, etc, and students could contact it for learning experiences. Alexander mentions MIT's OpenCourseWare project (http://ocw.mit.edu/index.html) which makes hundreds of its course available free over the Internet to learners around the world.

Alexander gives the example of a student who sees the movie *Master and Commander* and becomes interested in the world of eighteenth sailing. If the student were acting on his own, he might go to Amazon.com and search for other novels by Patrick O'Brian, or watch a

program on the History Channel, or do a Google search for more information on it. Suppose his college sets up an environment in which the student could find a history professor who teaches classes on "the great age of sail," has resources on the topic posted on his/her website, and informs the student about library resources he might find useful. Then, the student and other students might chat on IM about eighteenth century sailing.

As Bryan Alexander points out, if our colleges and universities are to support this new learning phenomenon they will have to find ways our sedentary campuses can work with today's students who will want to learn in learning swarms. (Alexander, 2004)

4.8 The Learning Resources of Tomorrow's Mobile Learning Environment

In this section of the report we will look at standards-based portable content and digital storytelling, which will be important resources for mobile learning in the near future.

4.8.1 Standards-Based Portable Content

Rob Reynolds wrote an article on the ideal package of digital content that publishers can market and sell to instructors and/or students in 2005 for Xplanazine.com. His research has convinced him that publishers are not meeting the needs of institutions and students for the digital content they need. Instead of meeting the needs of institutions and students, they expect them to adapt to publishers' offerings.

Reynolds says that, based on his research, the following important trends are emerging in the market place:

- "The increase in number of predominant LMS platforms in the market place
- The increase in standards-compliance for learning objects
- The increase of digital content created by instructors
- The increase in e-portfolio usage on major university campuses (Reynolds, 2005)

Reynolds says the developments listed above point to "an increased need for standards-based, that can be reused in multiple environments and for different pedagogical purposes." (Reynolds, 2005). Based on this information, he sees three opportunities for publishers to grab a bigger share of the market

and to make themselves the primary digital-content partners for instructors and colleges:

1. Focus on ***reusable*** content – Content that is granular (not produced to be used for a specific use)
2. Build ***cross-discipline pedagogical templates*** – In other words, we need "how-to" models that can be reused in multiple platforms.
3. Construct ***Portable Learning Environments*** (PLEs) – In relation to mobile learning, mobile learners need to be continuously connected to their educational resources, but sometimes they need to be able to learn without being physically connected to the network. (Reynolds, 2005)

4.8.2 The Potential of Digital Storytelling

Robyn Jay published an article in 2006 on using digital storytelling in VET (Vocational Education and Training). In this report I will not cover digital storytelling in much detail because my purpose here is to reflect on how it could be used in mobile education.

Jay says digital stories are, "multimodal presentations, combining images, voice, music and sometimes, written text using a number of suitable software programs. They are short and engaging, quick and easy to create, and offer a human element." (Jay, 2006).

Some of the educational benefits of digital storytelling are:

- They are very good learning tools in communication, literacy, and English courses.
- They have been used effectively with indigenous arts and general education students.
- They allow an intimate human collection and are proving to be a very successful medium for use with at risk students.

Jason Ohler said in a 2005 interview that by blending storytelling and critical thinking, digital storytelling can offer a 'powerful pedagogy.' Robyn Jay makes the observation that "Being literate in today's world must in part at least be about having skills in a wide range of communication styles and media, and knowing when to use a particular style to suit the desired purpose, audience and context." (Jay, 2006)

Marcus Ragus says in his article on mlearning that Microsoft's Photostory™ is being used in Australia for the creation of digital stories that can be transferred to an played on a Pocket PC. (Ragus, 2006). No doubt in the years to come with the greater acceptance of mobile learning, digital stories that can be downloaded to smartphones will be an important arrow in the quiver of the distance educator.

4.9 Conclusion – Moving Mobile Learning into the Mainstream

4.9.1 We Already Have the Technology

At last we come to the end of our long journey through the world of mobile learning – past, present, and future. The question today is not, "Shall we incorporate mobile learning into the educational mix?", but "When and how will we incorporate it into the educational mix?" Now we should focus on moving mobile learning into the mainstream of educational delivery. The good news is that the technology is already available and in demand by today's young learners. They grew up using personal computers in school, playing digital games, and now most of them own mobile phones and MP3 players.

Ragus says we often hear that there is too much emphasis on the technology and not enough on the learning. He goes on to say that we should make sure we as teachers and educators achieve our learning aims, but that we should not dismiss the potentials of the technologies of today because they are new and may be unproven for learning. Many people around the world enjoy the social benefits of technology (IM. blogs, wikis, MySpace, Facebook, etc.), but educators are still struggling with the basic issues of how to use technology to deliver education. Ragus asks the question…."are we still trying to 'educate' our learners based on old methods of delivery that are uncomfortably repackaged and delivered using the 'most trendy' technology of the day?" (Ragus, 2006)

The evolution of today's technology is being driven by the needs and desires of our society. Our users of technology are attracted to the capabilities, uniqueness, and convenience of our ever-changing technology. We as educators, designers, and administrators have the choice of sitting on the sidelines and observing the constant development and adaptation of new technologies, waiting until "the time is right" or until the technologies "mature," or being part of the technological revolution. Learning requires creative teaching that offers learners energy, inspiration, enjoyment, and excitement. In order to adapt today's technology to the learning environment, Marcus Ragus says "… we need a planned and structured system that incorporates this technology into the day to day operations of learning organizations, from administration to learning delivery and from staff to the learners." (Ragus, 2006).

4.10 Developing a Literature of Mobile Learning

Desmond Keegan (http://homepage.eircom.net/%257Edei/ICDERA/Board/D__Keegan/d__keegan.htm) says we need to develop the literature of mobile learning if it is ever going to move into the mainstream of education. One of the reasons is that educators

at universities will never accept the claims of mobile learning unless they can verify its claims by consulting the research literature. Keegan has been an active researcher and contributor to the literature of distance education since the 1980s and he is now contributing to the literature of mobile learning.

A search on amazon.com for books on mobile learning yielded only two books:

- *M-Learning: Mobile E-Learning*, by David Metcalf (January 2006)
- *Mobile Learning: A Handbook for Educators and Trainers*, by Agnes Kukulska-Hulme and John Traxler (2005)

Glossary

2G – Second-generation mobile telephone technology. 2G cannot normally transfer data, such as e-mail or software, other than the digital voice call itself. (Wikipedia, 2006)

3G - technology in the context of mobile phone standards. The services associated with 3G provide the ability to transfer simultaneously both voice data (a telephone call) and non-voice data (such as downloading information, exchanging email, and instant messaging). (Wikipedia, 2007)

Activity Theory – Learning is seen as a cultural-historical activity system, mediated by tools that both constrain and support the learners in their goals of transforming their knowledge and skills. (Sharples, et al, 2005). Activity Theory focuses attention on action, doing and practice, but within the 'activity' as the unit and content of analysis. (Savill-Smith & Kent, 2006)

Aggregation – Allows teachers to address the variation in understanding present in the classroom without having to address each individual student, but eliciting the patterns in variation across all students. (Roschelle, 2003)

Augmented reality - a field of computer research which deals with the combination of real world and computer generated data. (Wikipedia, 2007). For example, buildings on a campus, or objects in a museum will be able to 'talk' and offer information about themselves to the pocket computers of passers-by and museum visitors. (Savill-Smith & Kent, 2006)

Automatic electronic logs – Can record what or when knowledge or information was the learners consult for the benefit of the teacher. (Savill-Smith & Kent, 2006).

Connectivism – Emphasizes the importance of the social context in the construction of learning and the connectedness of learners. (L. Low, 2006)

Convergence Learning Model – Founded upon cognitive sciences and operates upon three impulses: the psychology of learning, pedagogical change, and technological advancement. From a psychological view, the model addresses intrinsic motivation based on Csikszentmihalyi's flow theory. From a pedagogical view, the model provides a link between formal and informal learning to the benefit of each. Finally, the model is implemented using ubiquitous computing technologies. (mLearning-World, 2006).

Conventional education (**traditional education**, **face-to-face education**, **instructor-led-training**) – Takes place in schools, colleges and universities, training centers, laboratories, and workshops. (Keegan, undated)

Correspondence courses – A term that originated in nineteenth century vocational education programs that were conducted through postal mail. (Wikipedia, 2006).

Digital stories – Multimodal presentations, combining images, voice and sometimes, written text, using a number of suitable software programs. (Jay, 2006)

Distance learning (**education**) – Incorporates all forms of instruction in which instructor and student are physically removed from another by time or space from traditional correspondence courses to web-based instruction. (*Mobile Learning website*, 2006). The provision of education and training at a distance by Open Universities, distance education institutions, and distance education departments of conventional institutions. (Keegan, undated). A field of education that focuses on the pedagogy/andragogy, technology, and instructional systems design that are effectively incorporated in delivering education to students who are not physically "on site" to receive their education. Instead, teachers and students may communicate asynchronously by exchanging printed or electronic media, or through technology that allows them to communicate synchronously. (Wikipedia, 2006).

Education – The process of acquiring knowledge and skills through instruction or experience. (*Mobile Learning website*, 2006)

Electronic books (**e-books**) – Digitized versions of books that can be read on a desktop or laptop computer, handheld device, or with a dedicated e-book reader. (Savill-Smith & Kent, 2006).

Electronic learning (**e-learning**) – Incorporates all forms of online instruction using personal computers. (Mobile Learning, 2006). The provision of education and training via the World Wide Web for students who study mainly as individuals using LMSs (or VLEs) such as Blackboard. (Keegan, undated). "E-learning is the effective learning process created by combining digitally delivered content with (learning) support and services." (B. Little, Undated). Education delivered through electronic means. (Lee & Polat, 2006).

Flash mob – A large group of people who assemble suddenly in a public place, do something unusual for a brief period of time, and then quickly disperse. (Wikipedia, 2007)

Formalized context learning activities – Learning within a well-defined curriculum, being offered by some educational establishment, and led by a teacher, moderator, etc. (Frohberg, 2006).

Free context learning activities – Do explicitly not consider the particular context of the learner as relevant for the learning activity. (Frohberg, 2006).

Global Positioning Satellite (**GPS**) - A navigational system involving satellites and computers that can determine the latitude and longitude of a receiver on Earth by computing the time difference for signals from different satellites to reach the receiver. (The Free Dictionary, 2007)

Informal learning context – "Informal learning is any activity involving the pursuit of understanding, knowledge, or skill which occurs without the presence of externally imposed curricular criteria." (Frohberg, 2006).

Information literacy – "…an information-age problem-solving process, resulting in [the] productive use of information," which they consider to be at the heart of lifelong learning. (Pownell & Bailey, 200). Bailey and Lumley (1999) say: "In the coming century, the ability to identify, access, and apply and create information will be the equivalent of literacy."

Knowledge – Information in context. (Frohberg, 2006).

Learning – A change in behavior, thoughts, and/or attitudes resulting from education and/or experience. (Mobile Learning, 2006). A 'labile process' constantly open to change and adaptation, 'mediated' by knowledge in supportive teacher, learner, and peer relationships. (Sharples et al, 2005). "A process of coming to know, by which learners in cooperation with their peers and teachers, construct transiently stable interpretations of their world." (Laouris & Eteokleous, 2006).

Lifelong learning – The concept that "It's never too late for learning." It is attitudinal; one should be open to new ideas, decisions, skills, or behaviors. It sees citizens provided with learning opportunities at al ages and in numerous contexts; at work, at home and through leisure activities, not just through formal channels such as school and higher education. (Wikipedia, 2007).

Mash-up –A website or application that combines content from more than one source into an integrated experience. (Wikipedia, 2007)

Microlearning – Deals with relatively small learning units and short-term learning activities. It refers to micro-perspectives in the context of learning, education, and training. It is used in the domain of e-learning and related fields

in the sense of a new paradigmatic perspective on learning processes in mediated environments on micro levels. (mLearning World, 2006).

Micro Mobile networks – Those within campuses and organizations. (Ragus, 2006)

Mobile learning (**m-learning**) – Learning accomplished with the use of small, portable devices. (Mobile Learning, 2006). The provision of education and training on PDAs/palmtops/handhelds, smartphones, and mobile phones. (Keegan, undated). Merely un-tethered e-learning. (Bob Little, Undated). The delivery of training by means of mobile devices such as mobile phones, PDAs, and digital audio players, as well as digital cameras and voice recorders, pen scanners, etc. (Wikipedia, 2006). The delivery of learning to students who are not keeping a fixed location. (The Free Dictionary, 2006). E-learning that uses mobile devices. (Laouris & Eteokleous, 2006). "Learning that arises in the course of person-to-person mobile communication." (Nyiri, 2002).

Moblog – A blend of the words mobile and weblog. It consists of content posted to the Internet from a mobile or portable device, such as a cellular phone or PDA. (Wikipedia, 2006).

MP3 – An audio compression format capable of a great reduction in the amount of data required to reproduce audio while sounding like a faithful reproduction of the original uncompressed audio to most listeners. (Wikipedia, 2006)

Multimedia Messaging System (MMS) – The successor to SMS, this enables subscribers to compose and send messages with one or more multimedia. (Wikipedia, 2006)

Participatory simulations – Use the availability of a separate device for each student and the capability of simple data exchange among neighboring students. They enable students to act as agents in simulations in which overall patterns emerge from local decisions and information exchanges. (Roschelle, 2003)

PDAs – Small, handheld computers that are designed essentially to be personal information managers (PIMs).Most feature stylus input, and handwriting recognition, and are powerful enough to run cut-down versions of the popular office applications, including web browsing. (Ted Smith, 2003)

PDF – A portable digital format for sharing and storing digital images and documents. A number of Web 2.0 applications allow learners to take advantage of the wide acceptance and use of PDF files by converting paper documents into PDF files for sharing and storing. (L. Low, 2006).

Personal Learning Environments (**PPLEs**) – Environments made up of one or more portable applications that can be loaded onto a number of varying mobile devices, for example, from memory sticks (flash drives, jump drives) and to PDAs and mobile phones. (Ragus, 2006)

Pervasive computing – Occurs when the entire environment becomes embedded with information accessed through devices that will range from desktop computers to items in development such as wearable computing devices. (Mobile Learning,2006). It is "always on" education that is available 24 hours a day, 7 days a week, anywhere, at any time. Pervasive learning is a social process that connects learners to communities of devices, people, and situations so that learners can construct relevant and meaningful learning experiences, that they author themselves, in locations and at times that they find meaningful and relevant. (Pervasive Learning website, 2007)

Pervasive learning – "Pervasive learning is a social process that connects learners to communities of devices, people, and situations so that learners can construct relevant and meaningful learning experiences, that they author themselves, in locations and at times that they find meaningful and relevant." (S. Thomas, 2005).

Podcasting – The process of creating an audio show of some sort that is available in MP3 format via an RSS 2.0 feed that supports enclosures. (Oloruntoba, 2006).

Radio Frequency Identification (**RFID**) – A method of remotely storing and retrieving data. An RFID tag is a small object, such as an adhesive sticker that can be attached to or incorporated into a product. RFID tags contain elements to enable them to receive and respond to radio-frequency queries from an RFID receiver. (Wikipedia, 2006)

Reflective logging – Using a handheld learning device to record students' observations in the learning situation they are working in. (Savill-Smith & Kent, 2006).

RSS - family of web feed formats used to publish frequently updated digital content, such as blogs, news feeds or podcasts. (Wikipedia, 2007). RSS is a methodology employed by a number of social software sites to aggregate content form many web-based information sources into a single place, or repurpose that content. (L. Low, 2006).

Screencast – A computer-based presentation tool that may be used online or offline, by individual learners, or with groups of any size. It may be viewed as a sequence of dynamic screenshots presented as something similar to a PowerPoint slideshow. (Oloruntoba, 2006).

Semiotic perspective on learning – Describes learning as a semiotic system in which the learner's object-oriented actions are mediated by cultural tools and signs. (Sharples, et al, 2005)

Short Message Service (**SMS**) – Available on most digital phones, a service that permits the sending of short messages between mobile phones and other handheld devices. (Wikipedia, 2006)

Smart mobs (**Learning swarms**) – Groups that spontaneously show up at sites around town, coordinate to perform an action and then disband as quickly as they formed, leaving no trace of their existence. (Mobile Learning, 2006). Smart mobs typically emerge when communication and computing technologies amplify human talents for cooperation. (J. Lester, 2003)

Smartphone (**smart phone**) – Any handheld device that integrates personal information management and mobile phone capabilities in the same device. The key feature of a smartphone is that one can install additional features to the device, such as internet access, e-mail access, scheduling software, built-in camera and, contact management. (Wikipedia, 2006). A wireless telephone set with special computer-enabled features not previously associated with telephones. (Bitpipe, 2007).

Social-constructivist approach to learning – Views learning as an active process of building knowledge and skills through practice within a supportive community. (Sharples, et al, 2005). It says that students learn best when given the opportunity to learn skills and theories in the context in which they are used. (Cobcroft, et al, 2006).

Tablet PCs – Fully-fledged PCs that are roughly the size of A4 paper, and come in two types: the pure-slate configuration (no keyboard) and the hybrid arrangement (with a fold-away keyboard). They feature stylus input with handwriting recognition. (Ted Smith, 2003).

Technology – Any tool that serves the purpose of enquiry, enabling people to address problems in context and to clarify and transform them into new understanding. (Sharples, et al, 2005)

Training – Instruction that emphasizes knowledge or skills for acquisition for job performance or improvement. (Mobile Learning, 2006).

Ubiquitous computing – An approach to human-computer interaction (Mark Weiser, 1991 at Xerox Parc) that describes the situation where technology becomes virtually invisible in our lives. For example, instead of having to use a desktop or laptop computer, we will use technology embedded in the

environment. The user will be the central focus in a computing environment. (Savill-Smith & Kent, 2006).

User-led education – Learners create their own content and collaborate with peers and communities within and beyond the classroom. (Cobcroft et al, 2006).

Web 2.0 (**Social Web**) – The network as platform, spanning all connected devices. (Jacobs & Polson, 2006). Web 2.0 refers to a philosophy of web development, rather than a change of technology. Web 2.0 sites are designed to be sources of content and functionality … facilitating the sharing, exchange of information, and the construction of networks of information and people. Social websites provide high levels of user interactivity, allowing users to contribute, create and modify content themselves and discover new and related content through informal (and more formal) relationships with other users. (L. Low, 2006)

Web 2.0 applications – Those that make the most of the intrinsic advantages of the Web 2.0 platform, delivering software as a continually-updated service that gets better the more people use it, consuming and remixing data from multiple sources, including individual users, while providing their own data and services in a form that allows remixing by others, creating network effects through an architecture of participation, and going beyond the page metaphor to deliver rich user experiences. (Mobile Learning, 2006)

WiFi - a brand originally licensed by the Wi-Fi Alliance to describe the embedded technology of wireless local area networks (WLAN) based on the IEEE 802.11 specifications. Wi-Fi was developed to be used for mobile computing devices, such as laptops in LANs, but is now increasingly used for more services, including Internet and VoIP phone access, gaming, and basic connectivity of consumer electronics such as televisions, DVD players, and digital cameras. (Wikipedia, 2007)

References

Alexander, Bryan (2004, September/October). Going nomadic: Mobile learning in higher education. *Educause Review*. Available at: http://www.educause.edu/pub/er/erm04/erm0451.asp.

Alexander, Bryan (2004, August 3, 2004). M-learning: Emergent pedagogical and campus issues in the mobile learning environment. *Educause Center for Applied Research – Research Bulletin*. Available at: http://www.educause.edu/ir/library/pdf/ERB0416.pdf.

Bailey, GD and Lumley D (1999). Fishing the net: Teach kids what to keep and what to throw back. *Electronic School* 1. Available at: http://coe.ksu.edu/bailey/infolit.art.pdf.

Bell, Ann. (2007, March 28). Rubric for podcasts. From University of Wisconsin-Stout website. Available at http://www.uwstout.edu/soe/profdev/faculty/abell.shtml.

Belshaw, Doug (2006, September 21). 20 ideas: Getting students to use their mobile phones as learning tools. *Doug Belshaw's Teaching-Related Blog website.* Available at: http://teaching.mrbelshaw.co.uk/index.php/2006/09/21/20-ideas-getting-students-to-use-their-mobile-phones-as-learning-tools.

Billis, D., Holliman, S., Lowe, L., Ochola, J., Park, S., Reed, E., Wolfe, C., and zieglowsky, L. (2006, April). The new mobile scholar and the effective use of information and communication technology. Available at: http://www.firstmonday.org/issues/issue11/issue11_4/bills/index.html.

Brown, Doug (2006). Personalised learning – the technology challenge. Global Summit 2006 Technology Connected Futures. Available at: http://www.groups.edna.edu.au/file.php/1030/GS2006_BROWN.pdf.

Cobcroft, R., Towers, S., Smith, J., and Bruns, A. (2006). Mobile learning in review. Opportunities for learners, teachers, and institutions. Available at: https://olt.qut.edu.au/udf/OLT2006/gen/static/papers/Cobcroft_OLT2006_paper.pdf.

Distance learning (2006, December 6). In *Wikipedia, The Free Encyclopedia*. Retrieved December 6, 2006, from http://en.wikipedia.org/wiki/Distance_learning.

E-learning (2006, December 5). In *Wikipedia, The Free Encyclopedia*. Retrieved December 6, 2006, from http://en.wikipedia.org/wiki/E-learning.

Flash mob (2007, April 11). In Wikipedia, *The Free Encyclopedia*. Retrieved April 18, 2007, from http://en.wikipedia.org/wiki/Flash_mob.

Flexible learning: Mobile learning objects. (2002, November 20). *Knowledge Anywhere*. Available at: http://whitepapers.techrepublic.com.com/whitepaper.aspx?docid=89037.

Frohberg, Dirk (2006). Mobile learning is coming of age – What we have and what we still miss. Available at: http://www.ifi.unizh.ch/im/imrg/fileadmin/publications/2006_DELFI_Darmstadt_MLearn_Framework.pdf.

History of distance education. (2007, January 6). From *University of Florida* website. Available at: http://iml.jou.ufl.edu/projects/Spring01/deClair/history.html .

Jacobs, Joanne and Polson, Deb (2006). Mobile learning, social learning. Available at: https://olt.qut.edu.au/udf/OLT2006/gen/static/papers/Jacobs_OLT2006_paper.pdf.

Jay, R. (2006). Using digital storytelling in *VET: experiences and reflections. Ezine, International Centre for VET Teaching and Learning*. Available at: http://www.icvet.tafensw.edu.au/ezine/year_2006/feb_apr/feature_digital_storytelling.htm.

Jeffries, Michael (undated). The history of distance education. *IPSE Research in Distance Education*. Available at: http://www.digitalschool.net/edu/DL_history_mJeffries.html.

Keegan, Desmond (Undated). The incorporation of mobile learning into mainstream education and training. Available at: http://www.mlearn.org.za/CD/papers/keegan1.pdf.

Keegan, Desmond (Undated). M-learning: How far has it come? Available at: http://learning.ericsson.net/mlearning2/files/conference/dkeegan.pdf.

Kukulska-Hulme, Agnes (2005). Current uses of wireless and mobile learning. *JISC website*. Available at: http://www.jisc.ac.uk/uploaded_documents/Current%20Uses%20FINAL%202005.doc .

Laouris, Y. and Eteokleous, N. (2006, October). We need an educationally relevant definition of mobile learning. Available at http://www.mlearn.org.za/CD/papers/Laouris%20&%20Eteokleous.pdf.

Lee, R. and Polat, E. (2006, March 15). Readiness assessment report for mobile-learning. Available at: http://bluehawk.monmouth.edu/~jwang/RitaErcan_MobileLearningReadinessReport_Revised.pdf.

Lester, J. (2003, June). Integrating and evolving a mob: The growth of a smart mob into a wireless community of practice. *Proceedings of 10th International Conference on Human-Computer Interaction, Crete, Greece, June 22-27, 2003. Lawrence Erlbaum Associates, Inc*. Available at: http://neuro-www.mgh.harvard.edu/lester_hci_2003.pdf.

Lifelong learning (2007, February 27). In *Wikipedia, The Free Encyclopedia*. Retrieved March 23, 2007, from http://en.wikipedia.org/wiki/Lifelong_learning#External_links.

Little, Bob. (Undated). M-learning– moveable feast or one-year wonder? *E-Learning Network*. Available at: http://www.elearningnetwork.org/reports/report17.doc .

Low, Leonard (2006, November). Connections: Social and mobile tools for enhancing learning. *The Knowledge Tree*. Available at: http://kt.flexiblelearning.net.au/edition-12-editorial-2/connections-social-and-mobile-tools-for-enhancing-learning-by-leonard-low/.

Low, Leonard and O'Connell (2006). Learner-centric design of digital mobile learning. Available at: **http://online.cit.act.edu.au/mlearning/lowoconnell2006.pdf**.
Low, Leonard (2006, September 30). Why mlearning is cheap. *mLearning World blog*. Available at: http://mlearningworld.blogspot.com/.

M-learning (2006, December 3). In *Wikipedia, The Free Encyclopedia*. Retrieved December 6, 2006, from http://en.wikipedia.org/wiki/M-learning.

M-learning. (2006). In *The Free Dictionary*. Retrieved December 3, 2006, from http://encyclopedia.thefreedictionary.com/mobile+learning.

McHugh, Josh (2002, October). Unplugged u. *Wired*. Available at: http://www.wired.com/wired/archive/10.10/dartmouth_pr.html.

Mammen, Anil. (2006, November 14). The future of instructional models. On *Tata Interactvie Blogsite.* Available at http://blog.tatainteractive.com/2006/11/the_future_of_i.html.

Moblog (2006, November 21). In *Wikipedia, The Free Encyclopedia*. Retrieved November 21, 2006, from http://en.wikipedia.org/wiki.Moblog.

Mobile learning and pervasive computing (2006). *Mobile Learning and Pervasive Computing website*. Available at: http://www3.telus.net/~kdeanna/mlearning/index.htm. Last accessed: 12/26/2006.

Munro, A. (2005). 5th Digit mobile language application. *Mlearn 2005: 4th World Conference on mLearning*. Available at: http://www.mlearn.org.za/CD/BOA_p.49.pdf

Naismith, L., Lonsdale, P., Vavoula, G., and Sharples, M. (2004). Futurelab series – Report 11: Literature review in mobile technologies and learning. *Future Lab website*. Available at: http://www.futurelab.org/uk/research/reviews/reviews_11_and12/11_07.htm.

Nash, Susan (eLearning Queen) (2006, September 26). Ethics and mobile learning: Should we worry?. *mLearning World blog*. Available at: http://mlearningworld.blogspot.com/.

Nash, Susan (eLearning Queen) (2006, September 18). Learning with mobile devices, what's the best way? *mLearning World blog*. Available at: http://mlearningworld.blogspot.com/.

Nasseh, Bizhan (1997). A brief history of distance education. On *SeniorNet* website. Available at http://www.seniornet.org/edu/art/history.html.

Nehrling, Matthew (2006, September 18). Book review-mLearning: Mobile learning and performance in the palm of your hand. *mLearning World blog*. Available at: http://mlearningworld.blogspot.com/.

Nehrling, Matthew (2006, August 30). Someone who truly gets it. *mLearning World blog*. Available at: http://mlearningworld.blogspot.com/.

Nehrling, Matthew (2006, February 14). Educational development for the gameboy generation. *mLearning World blog*. Available at: http://mlearningworld.blogspot.com/.

Nehrling, Matthew (2006, September 25). Gagne's 9 learning commandments? *mLearning World blog*. Available at: http://mlearningworld.blogspot.com/.

Nehrling, Matthew (2006, October 17). Choose the right door. *mLearning World blog*. Available at: http://mlearningworld.blogspot.com/. Last accessed:

11/22/2006. *mLearning World blog*. Available at: http://mlearningworld.blogspot.com/.

Nehrling, Matthew (2006, September 29). Save $$ using iPods instead of binders – by Jenna Sweeney. *mLearning World blog*. Available at: http://mlearningworld.blogspot.com/.

Nehrling, Matthew (2006, December 3). mLearn: The Perfect Ed Tech Device?. *mLearning World blog*. Available at: http://mlearningworld.blogspot.com/.

Nehrling, Matthew (2006, October 1).Break out of the box – from breakthrough eLearning. mLearning World blog. Available at: http://www.mlearningworld.blogspot.com/.

Oloruntoba, Richard (2006). Mobile learning environments: A conceptual overview. Available at: https://olt.qut.edu.au/udf/OLT2006/gen/static/papers/Oloruntoba_OLT2006_paper.pdf.

P*ervasive Learning website* (2007, March 23). Available at: http://www.pervasivelearning.org/index.php.

Pownell D and Bailey GD (2001). The next small thing – handheld computing for educational leaders. *Learning & Leading With Technology*. Available at: http://www.intel.com/education/articles/next_small_thing.htm.

Quinn, Clark. (2002, November 20). Flexible Learning: Mobile Learning Objects. *Knowledge Anywhere website*. Available at: http://www.knowledgeanywhere.com.

Ragus, Marcus (2006). Mlearning: A future of learning. From *The Knowledge Tree* website. Available at: http://kt.flexiblelearning.net.au/edition-9/mlearning-a-future-of-learning/.

Rawlinson, D. and Bartel, K. (2006, February). Implementing wireless pda technology. *Educause Quarterly*. Available at: http://www.educause.edu/ir/library/pdf/EQM0617.pdf.

Reynolds, R. (2005, March 14). The ideal publisher's digital content package for 2006-2006? – A portable learning environment. *Xplanazine*. Available at: http://www.xplanazine.com/archives/2005/03/the_ideal_publi.php.

Roschelle, J. (2003, September). Unlocking the learning value of wireless mobile devices. *Journal of Computer Assisted Learning*. Available at:

http://www.blackwell-synergy.com/doi/full/10.1046/j.0266-4909.2003.00028.x?cookieSet=1.

Ryder, M. What is activity theory? (2007, March 13, 2007). *University of Denver Health Sciences Center website.* Available at: http://carbon.cudenver.edu/~mryder/itc/act_dff.html.

Savill-Smith, C. and Smith, P. (2006). The use of palmtop computers in learning – A review of the literature. *Learning and Skills Development Agency Research Report*. Available at: http://www.blackwell-synergy.com/links/doi/10.1111/j.1467-8535.2005.00473.x/abs/. accessed:

Sharples, M., Taylor, J., Vavoula, G. (2005, September). Towards a theory of mobile learning. Available at: http://www.mlearn.org.za/CD/papers/Sharples.pdf. Last accessed 12/28/2006.

Short message service (2006, March 4). In Wikipedia , *The Free Encyclopedia*. Retrieved March 4, 2007, from, http://en.widipedia.org.wiki/SMS.

Smart phone (2007, February 8). On Bitpipe website. Retrieved February 8, 2007, from http://www.bitpipe.com/tlist/Smart-Phones.html.

Smith, Ted (2003). Personal digital assistants (PDAs) in further and higher education. *Joint Information Systems Committee (JISC).* Available at: http://www.ts-consulting.co.uk/DownloadDocuments/PDAsinFurther&HigherEducation.doc.

Stead, Geoff (2007, February 26). Mobile assessment? On *Moblearn blog on Blogspot.com website*. Available at: http://moblearn.blogspot.com/2007_02_01_archive.html.

Szuchman, Mark. Palm pilots and critical thinking skills in higher education. (2002) PDA Education website. Available at: http://www.pdaed.com/vertical/features/CriticalThink.xml

Thomas, Michael (2006, July). iPods in education: Innovations in the implementation of mobile learning. *The Knowledge Tree*. Available at: http://kt.flexiblelearning.net.au/edition-10/ipods-in-educationinnovations-in-the-implementation-of-mobile-learning/.

Thomas, Siobhan (2005). Conference: Research & development workshops on pervasive learning. *Knowledge Lab* website. Available at: http://www.knowledgelab.dk/now/pervasive-learning.

Ubiquitous computing: The case for handheld computers. (2006). On *CILT* website. Available at: http://www.cilt.org/themes/ubiquitous.html.

Wagner, Ellen (2005, May/June). Enabling mobile learning. *Educause*. Available at: http://www.educause.edu/apps/er/erm05/erm0532.asp.

Wheeler, Tony. (2007, March 17). Creative assessment with handhelds. Blog on *Handheld Learning website*. Available at: http://www.handheldlearning.co.uk/content/view/34/2.