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Powering E-Learning In the New Millennium: An Overview of E-Learning and Enabling Technology

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Abstract. *In today's new economy characterized by industrial change, globalization, increased intensive competition, knowledge sharing and transfer, and information technology revolution, traditional classroom education or training does not always satisfy all the needs of the new world of lifelong learning. Learning is shifting from instructor-centered to learner-centered, and is undertaken anywhere, from classrooms to homes and offices. E-Learning, referring to learning via the Internet, provides people with a flexible and personalized way to learn. It offers learning-on-demand opportunities and reduces learning cost. This paper describes the demands for e-Learning and related research, and presents a variety of enabling technologies that can facilitate the design and implementation of e-Learning systems. Armed with the advanced information and communication technologies, e-Learning is having a far-reaching impact on learning in the new millennium.*

Key Words. *e-Learning, internet, information technology, lifelong learning*

1. Introduction

Learning is perhaps the most indispensable activity in the current knowledge-based new economy characterized by industrial change, globalization, increased intensive competition, knowledge sharing and transfer, and information technology revolution. Education and training worldwide is becoming a huge business. It is estimated that education and training from pre-school to retirement is a US$2 trillion marketplace (Khirallah, 2000).

With the increasing use of networked computers and achievement of telecommunication technology, the Internet has been widely recognized as a medium for network-enabled transfer of skills, information, and knowledge in various areas (Carswell, 1997). The traditional context of learning is experiencing a radical change. People change careers and relocate several times throughout their lives. The concept of traditional education does not fit well with the new world of lifelong learning, in which the roles of instructor, students, and curriculum are changing. Teaching and learning are no longer restricted within traditional classrooms (McAllister and McAllister, 1996; Marold, Larsen, and Moreno, 2000). Learning methods need to become more portable and flexible.

E-Learning has been crucial to meet this new challenge. There are a variety of definitions of this term. In this paper, e-Learning refers to any type of learning situation when instructional content is delivered electronically via the Internet when and where people need it. It is an inescapable element of business in the new economy. It is estimated that 50% of all employees' skills become outdated within 3–5 years. 'Time-to-competency' is a major factor of determining competitiveness of all companies. In 1999, companies in United States spent $62.5 billion on training and educating their employees, with more than $3 billion spent on technology-delivered training (Khirallah, 2000). Effective and efficient training methods are greatly required by companies to ensure that employees and channel partners are timely equipped with the latest information and advanced skills. It is a daunting task to maintain a well-educated and high-performance workforce in the global economy of today.

As a promising solution, e-Learning technology has been widely adopted by many companies to expand their training market to previously out-of-reach employees. It eliminates the barriers of time and geographical distance, so continuing staff development can accommodate diverse learning environments such as

homes, offices, and offsite conference rooms. It also offers learning-on-demand opportunities to individual employees while reducing training time and cost. The market for Web-based corporate learning in US is expected to reach $11.4 billion by 2003, up from $550 million in 1998 (Kerrey and Isakson, 2000).

In academics, e-Learning has supported significant improvement in interactivity, collaboration, and delivery of online education. The educational opportunities have been carried to many remote corners of the earth via the Internet. The new focus of distance learning is to build a cost-effective learning infrastructure that enables anytime, anywhere, self-paced, and interactive learning.

This paper gives an overview of e-Learning from both research and enabling technology perspectives. It shows that with the growing awareness of the need for moving into a lifelong learning era, with the desire for time and cost savings, and with the need of remote education, e-Learning is playing an increasingly important role. The rest of this paper is organized as follows. Section 2 introduces distance learning history and e-Learning concepts. Section 3 describes synchronous and asynchronous e-Learning. The benefits of e-Learning are illustrated in Section 4. Then, in Section 5, we introduce previous research on e-Learning and enabling information technologies. Section 6 discusses a few existing problems and potential research issues in this field. Finally, we conclude in Section 7.

2. Learning

2.1. Learner-centric learning

Generally, there are three learning theories (Ertmer and Newby, 1993; Merrill, 1991)—Behaviorism theory focuses on behavioral changes as a result of learning in which a new behavioral pattern is repeated until it becomes automatic; Cognitive theory is concerned with changes in a student's understanding that result from learning. The theory is based on schemata structures organized by students about a perceived environment; Constructivism theory emphasizes the active participation and reflection by learners. A learner can choose his/her own best way of learning.

Traditional face-to-face learning has advantages of being familiar, close, and comfortable for both instructors and students. However, it may necessitate travel and disruption of work, causing time and expense to be prohibitive. In some situations, sending an instructor to a site may be impractical. When too much learning material is exposed in a classroom, learners' retention will be negatively affected. Moreover, teaching in a traditional classroom is instructor-centric, in which instructors mainly control class contents, including topic, course material, discussion, and progress (Baloian, Pino, and Hoppe, 2000).

At present, learning is shifting from instructor-centric to learner-centric, which emphasizes relevance, personalization (learning according to individual's interest, previous knowledge, and style, etc) and learning flexibility (time and location) (Adam, Slonim, and Yesha, 1997). A transition is occurring from "teaching by telling" to "learning-on-demand" or "learning by asking or doing."

2.2. E-Learning

E-Learning is a revolution that is currently emerging. Rather than replacing traditional classroom teaching, e-Learning serves as a complementary mechanism to lifelong or remote learning. People access multimedia instructional contents on the Internet that are prepared by experts.

Today, thousands of courses, including degree and certificate programs, are now being offered by universities worldwide. Among the biggest of those in United States is the University of Phoenix, which boasts an online student body of more than 30,000. Some programs offer comprehensive online courses for degrees, while others only provide a limited number of online courses to meet some of degree requirements (See Table 1).

One of the possible reasons is that e-Learning in universities is still in the early stage. There are many theoretical and technological issues that need to be explored.

On April 4, 2001, MIT announced its commitment to make materials from virtually all of its courses freely available on the Web for non-commercial use (http://web.mit.edu/newsoffice/nr/2001/ocw.html). This new initiative, called **MIT OpenCourseWare (OCW)**, reflects MIT's institutional commitment to disseminate knowledge not only to its own students, but also others across the globe. According to a recent U.S. government report, the demand for e-Learning is likely to leap from 5 percent of all students in higher education in 1998 to 15 percent in 2002.

In the meanwhile, many companies have adopted e-Learning solutions for their corporate training, such as Dell Learning, CISCO E-Learning, and HP Virtual

Table 1. *A list of U.S. universities offering online courses*

School	Courses or programs
University of Phoenix (http://www.phoenix.edu/index_open.html)	Business, Accounting, Management, Technology, etc.
Stanford University (http://scpd.stanford.edu/scpd/students/onlineclass.htm)	Aeronautics and Astronautics, Computer Science, Electrical Engineering, etc.
University of California, Berkeley (http://explore.berkeley.edu)	Computer Information Systems, Digital Communications, E-Commerce, etc.
Georgia Institute of Technology (http://www.conted.gatech.edu)	Digital Signal Processing, Mechanical Engineering
University of Illinois Online, Urbana (http://www.online.uillinois.edu)	Expert Systems, Microelectronic Processing, etc.
New Jersey Institute of Technology (NJIT) (http://www.njit.edu/DL)	Computer Network Design, Software Development, etc.
University of Maryland University College, Adelphi (http://www.umuc.edu)	Computer Systems Management, Software Engineering, etc.
University of Wisconsin, Madison (http://www.uwex.edu)	Engineering Economics

Classroom (Zhang, 2002). There are also many companies such as Ninth House, Thomson Learning, KeepSmart.com, and eMind.com available that provide e-Learning services (Moe and Blodget, 2000).

3. *Synchronous vs. Asynchronous E-Learning*

E-Learning can be either synchronous or asynchronous. Synchronous e-Learning requires simultaneous participation of all learners and instructors at different locations. It indicates any learning event delivered in real-time to remote learners, which includes immediate, two-way communication among participants. It can also be considered as scheduled delivery of learning. Synchronous e-Learning takes a variety of forms such as multicast and real-time interactive conferencing using MOO systems or IRC.

Asynchronous e-Learning does not require simultaneous participation of learners and instructors. It refers to a learning situation where the learning event does not take place in real-time. People can learn at any time. Therefore, asynchronous e-Learning is "on- demand delivery" of learning, which gives learners more control over the learning process and content. It usually takes forms such as: (1) electronic mail and listserv (delivering learning materials, sending/receiving assignments, and getting/giving feedback); (2) public electronic bulletin boards/newsgroups or collaborative systems for discussion; (3) downloading learning materials from knowledge repositories via the Internet; (4) company Intranets that distribute training to its employees; (5) the use of online databases and websites to acquire information and pursue research; and (6) interactive tutorials on the Web (Wulf, 1996; Hiltz and Wellman, 1997).

Synchronous e-Learning enables individuals to feel more like they are members of a learning society than asynchronous learning, and interaction among students and instructors is done in real-time. However, it loses time flexibility. Currently, the majority of e-Learning systems use asynchronous communication technologies because they are simpler to develop and not too expensive compared to the synchronous ones.

4. *Benefits of E-Learning*

A considerable amount of research has been conducted on e-Learning. In contrast with traditional classroom learning, the following section highlights several important benefits of e-Learning (Hiltz and Wellman, 1997; Beam and Cameron, 1998; Carswell, 1997; Burgstahler, 1997; McCloskey, Antonucci, and Schug, 1998):

- Time and location flexibility: E-Learning eliminates the barriers of time and distance by offering "just-in-time, on- the-job" learning, and has potential to reach a global audience, including disabled, part-time, and non-traditional people.
- Cost and time savings: As much as 40% of money spent on in-person corporate learning is eaten up by travel cost. Since e-Learners do not have to travel to a specific location, e-Learning can result in significant cost savings on indirect expenses. It is reported that companies using online training can expect an average of 50% in time savings and 40% to 60% in cost savings, compared with conventional face-to-face training (Khirallah, 2000). For example, Hewlett

Packard saved $150,000 in outside testing costs alone through online learning (Moe and Blodget, 2000).

- Self-paced and just-for-me learning: E-Learning fosters self-directed and self-paced learning by structuring learner-centric activities. Each e-learner can select learning activities that best fit his or her own background, interest, and career at that moment, rather than being a passive receptor of information. Researchers have reported that e-Learning can be as effective as traditional instruction methods and leads to more active participation of learners (Beam and Cameron, 1998; Burgstahler, 1997).
- Collaborative learning environment: E-Learning links physically separated learners and experts together to form an online collaborative learning community (Hiltz and Benbunan-Fich, 1997). By electronic means, an e-Learning system encourages learners to ask questions that they may not be able to ask in conventional classrooms, to elicit their personal opinions without inhibition, and to share different ideas with each other more easily through online forums.
- Better access to the instructors: In an e-Learning environment, learners obtain online guidance and help from instructors. They usually perceive greater opportunities for communication than those in a traditional classroom (Hiltz and Wellman, 1997; McCloskey, Antonucci, and Schug, 1998).
- Unlimited use of learning materials: E-Learning allows unlimited access and retrieval of electronic learning materials. Information and knowledge are available to learners 24 hours a day. People can review current or past information/knowledge stored in online knowledge repositories over and over again. An e-Learning system will never lose patience with learners, and those electronic materials can always keep high-quality and well-maintained.

5. *E-Learning Research and Enabling Technologies*

5.1. Effectiveness of e-Learning

The majority of research on Web-based learning focuses on its effectiveness compared with traditional classroom learning. The effectiveness is normally assessed by post-course questionnaires completed by students, direct observations of online activities, interviews with selected students, and comparisons of test/course grades or other objective measures of performance.

Many studies reported that students in an e-Learning environment could do as well as those in a conventional classroom, and online students perceived greater flexibility (Hiltz, 1995; Carswell, 1997; Wade and Power, 1998; Amir, Iqbal, and Yasin, 1999; Hadidi and Sung, 2000; Fallah, How, and Ubell, 2000). For example, Hadidi and Sung (2000) compared online and face-to-face pedagogy for different subject matters at different educational levels. There was no significant difference in both self-reported motivation and grades found between face-to- face classes and online classes. A few studies revealed that online learning could even be better than classroom learning under certain circumstances (Thompson, 1996; Zhang, 2002). Based on a review of comparative studies, Thompson (1996) found that online distance education was better in regard to students' acquisition of information technology skills and increased familiarity with technology.

Some research examined student engagement in e-Learning or impacts of students' personal characteristics on learning effectiveness. In Arbaugh (2000)'s study, student engagement in online courses was measured by calculating the amount of time students spent on the course Web-site. Students generally showed a fairly high level of perceived learning. A Web learning study conducted by Makkonen showed some interesting results. For example, females benefited from online courses significantly more than males; online coursework was beneficial to students who had less prior training; students who were not very experienced with personal computers and the Internet benefited slightly more from online coursework (Makkonen, 2001).

On the other hand, some other researchers found negative effects of e-Learning. For example, in Rivera and McAlister's study (Rivera and McAlister, 2001), they compared the efficacy of three class formats: a traditional section, a Web-based section, and a hybrid section. The study showed that there was no significant difference in exam scores of three sections. However, the students enrolled in the Web-based section were somewhat less satisfied with the course than others.

5.2. Multimedia-based e-Learning

Multimedia technology carries multimedia learning contents over increasing network bandwidth. It has a dramatic impact on both the process and product of learning because the multi-sensory learning environments can help maximize learners' ability to

retain information (Syed, 2001). Research has shown that multimedia instructions can enhance an individual's problem-solving skills, and entice learners to focus full attention on a task through the vividness of the presentation—more actively, intriguing, or fascinating (Corbett and Anderson, 1995; Senn, 1997; Zhang, 1995; Weston and Barker, 2001; Agius and Angelides, 1999). It is appealing to combine lectures and dialogue with visual presentation, animation and other multimedia effects.

Video is by far one of the most powerful and expressive non-textual media that can capture and present information (Hampapur and Jain, 1998). Exploration of video-based learning environments has indicated that students find video materials very compelling (William et al., 1992). In recent years, many video-on-demand (VoD) systems have been developed to deliver any of a large selection of movies to multiple users per requests through the network (Freedman and DeWitt, 1995; Aggarwal, Wolf, and Yu, 1996; Wactlar, 2000). There is a new trend to apply interactive video technology to learning. It integrates speech recognition, natural language understanding, image processing, Human Computer Interaction (HCI), and information retrieval techniques to create a new class of multimedia information access system. The basic premise is that information or knowledge of experts can be represented in the form of videos. For example, a Spanish chef can be videotaped when he is introducing how to make a delicious dish. These videos are segmented into video clips according to their contents and are stored in a video repository on a Web server. Appropriate video clips will be identified and retrieved from the repository to respond to users' interests. They will then be delivered to users' computers via the Internet and are played as if the users were interacting with an expert in real-time (Marinelli and Stevens, 1998; Wactlar, 2000).

Like CD-ROMs, the Internet can present video, audio, and animated materials. Unlike CD-ROMs, multimedia e-Learning materials can be regularly updated or revised easily. In recent years, video technology has been adopted in e-Learning to enhance learners' perception of live interaction with virtual instructors. A number of e-Learning systems present integrated and synchronized instructional materials in different media such as video, presentation slides, and lecture notes to users (Dorai, Kermani, and Stewart, 2001; Chen et al., 1999; Morales, Cory, and Bozell, 2001; Bargeron et al., 2001). For example, Morales, Cory, and Bozell (2001) probed students' learning effectiveness in a Web environment by comparing performance between traditional face-to-face delivered instruction and instruction delivered by an asynchronous live-switched video and accompanying PowerPoint presentation stream via the Web. There was no significant difference in learning effectiveness measured by students' exam grades between the Web-learning group and classroom group.

5.3. Enabling technologies in e-Learning

Technology is constantly changing how we learn and what we can learn. Technology-delivered learning is projected to grow rapidly with an annual growth rate of nearly 40% (Moe and Blodget, 2000). The advancement of the Internet and information technologies makes e-Learning more prevalent (Fig. 1). In the past decade, multimedia technologies and electronic distribution through the Internet or Intranet are changing the way learning takes place. In this section, we would like to illustrate various information technologies that are used to develop e-Learning systems.

5.4. Internet technology

Since 1994, when the graphical Web browsers Mosaic and Netscape Navigator were introduced and spread through the Internet community, the Internet has been offering both information access and a fast and inexpensive means of communication to the public. It is "perhaps the most transformative technology in history, reshaping business, media, entertainment, and society in astonishing ways. But for all its power, it is just now being tapped to transform education (Kerrey and Isakson, 2000)."

The explosion in Internet usage pushing the unprecedented technological adoption ever experienced in education and training will continue. The number of online users is expected to skyrocket from nearly 14 million at the end of 1995 to 638 million by 2004 worldwide (Moe and Blodget, 2000). The majority of Internet users in a survey indicate that they use the Internet to do research, to collect product information, and to access news. In other words, they use it to learn. The growth of e-Learning is driven by both compelling economics and the potential for effective education.

The Internet is helping us move toward a new frontier of learning. It prompts the concept of "anytime, anywhere" to a higher level as far as learning is concerned. Not only can instruction materials such as syllabi, lecture notes, and assignments be made available online, but collaboration and discussion can also occur via the Internet.

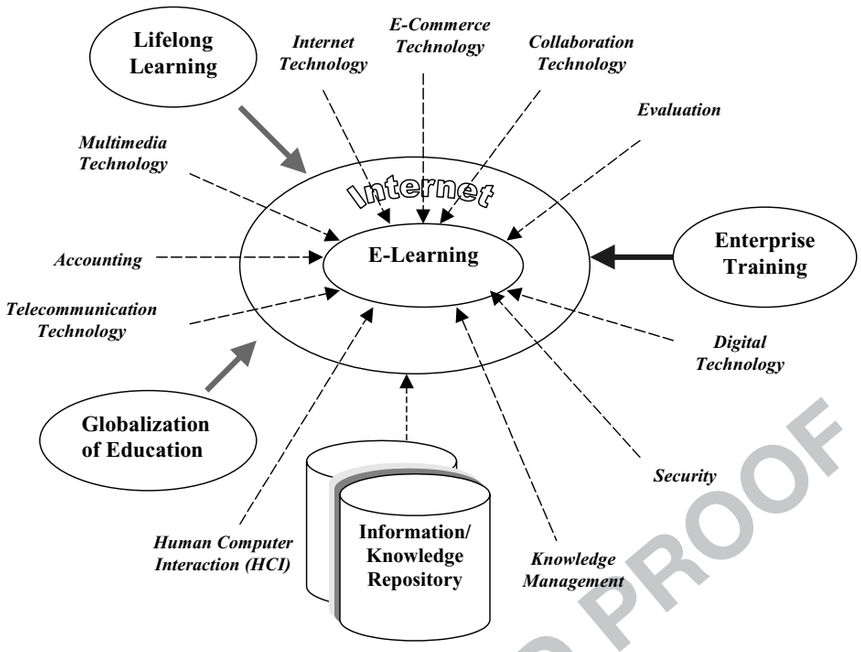

Fig. 1. A framework of enabling technologies in e-Learning.

5.5. Multimedia technologies

With the achievement of multimedia technology such as audio/video encoding and decoding algorithms, compression and decompression techniques, computer representation of sound, sampling rate, MIDI devices and WAV Files, multimedia technology has become one of the most attractive and promising technologies in learning. Hofstetter (1995) explains interactive multimedia as "the use of a computer to present and combine text, graphics, audio, and video, with links and tools that let the user navigate, interact, create and communicate..."

Today, the Internet supports the delivery of full-motion audio and video to personal computers. Thus, interactive video technology can be adopted in e-Learning to enhance perception of live interaction between virtual instructors and learners, and to provide additional visual and audio cues that may increase learners' engagement. In order to reduce video transmission delay, video streaming technology is often used to compress a video file and play it while it is downloading. To use interactive video technology in e-Learning, we need to maximize network bandwidth efficiency, explore efficient video indexing and retrieval mechanisms, and design an easy-to-use GUI for learners. As broadband capacity increases, online instructional materials will be enriched to include various multimedia contents.

5.6. Knowledge management

The strength of information technology is its ability to collect and interpret huge amount of information to facilitate people's learning and decision-making. The term of "Knowledge Management (KM)" originates from business organization context, aiming to provide instruments to employees of professional organizations who need to optimize the control and management of their most critical production factors. KM involves collecting, managing and sharing knowledge, helps people determine what knowledge is needed, and oversees acquisition and distribution of knowledge.

In e-Learning, there is a need to collect, store, sort, index, retrieve, update, and reuse knowledge that are eventually provided to learners. Most of current infrastructures in e-Learning systems are built upon a knowledge base that is accessible through the Internet. The use of database technologies for storing

and manipulating e-Learning materials (knowledge) provides scalability necessary to support learner community.

Nowadays, there is a transition from education and training to knowledge management and transfer. At least a few factors are driving the convergence of knowledge management and e-Learning. First, both knowledge management and e-Learning are essentially about knowledge acquisition and sharing, including equivalent technology infrastructures employed and similar investment of time and discipline. Second, both require efficiently organizing, manipulating, and maintaining knowledge for better use. Finally, both allow users to access knowledge and contribute new pieces of knowledge, although they may be generated in different ways. Scalability, knowledge reuse, efficient searching and retrieval, and effective management of knowledge are critical issues to the success of e-Learning systems.

One of the biggest knowledge management challenges in e-Learning is how to efficiently manage and access highly distributed information and knowledge to meet individual learning needs. Imaging in a company, there are over thousands of presentations, training videos, and text documents that are stored at separate locations. It is critical to provide online learners with appropriate content in a quick and accurate manner to enable learning-on-demand. Therefore, distributed computing techniques should be used.

5.7. E-Commerce technology

The technology of E-Commerce can also potentially facilitate just-in-time, on-demand education approach to delivering its electronic products by way of the Internet. E-Commerce technology plays an important role in the reengineering of academic education and corporate training by providing value-adding services and by enabling efficient integration of different types of learning (Lang and Zhao, 2000; Hämäläinen, Whinston, and Vishik, 1996). Hämäläinen, Whinston, and Vishik (1996) presented an electronic commerce framework for education and prototype implementation of an education brokerage. They argued that education brokerages would "draw on the standard E-Commerce methods to deliver information or knowledge over the networks, ensure the security of this information, carry out transaction processing and electronic payments, and route the traffic to the appropriate Internet Services." It is very helpful to identify indispensable services that e-Learning systems should provide and how to provide.

5.8. Collaboration technology

A few learning theories emphasize learning's social genesis and suggest the view that learning is a social process occurring more effectively through interpersonal interactions in a cooperative context. Collaborative learning can serve as a way of creating a virtual class in which a group of remote learners are learning together. Substantial research has shown that groupware supported collaborative learning leads to better student involvement, better performance, and higher participation and productivity than individual learning (Nunamaker et al., 1996; Alavi, 1994). Furthermore, individual learners' exposure to alternative points of view can challenge their initial understanding (Glaser and Bassok, 1989).

Incorporating a new generation of communication and collaboration tools can enhance e-Learning effectiveness. These tools and technologies gear toward knowledge sharing and group discussion, and bring distinct benefits to both online instructors and learners. Instructors benefit from sharing new resources and discussing issues with other instructors virtually across the globe. The collaboration can, on the other side, also facilitate learners to perceive a learning community, gain a better understanding of problems based on other people's opinions, and exchange their knowledge with others.

There are a variety of collaboration tools that are used on the Internet. Some of them are electronic bulletin boards, online chat rooms, newsgroups, NetMeeting, and Web-based GroupSystems. Currently, text-based online collaboration tools are prevalent for supporting e-Learning. However, it has been well recognized that new tools supporting multimedia materials are highly demanded in e-Learning systems (Schreiber and Berge, 1998).

5.9. Digital and telecommunication technology

Digital technology is coming of age. The entire world seems in the process of converting analog data into digital forms in order to improve the quality of data transferred over the network. Today, digital technology has exerted a significant impact on the evolution of learning. It enables access to reliable digital resources and allows instructors and learners to build distributed learning communities (Marchionini et al., 1997). High-quality digital videos are being introduced into e-Learning with the advance of high speed networking.

Telecommunication technologies enable learners to communicate with others and make effective use of

P1: Techbooks/ P2: g/g Tally: g/g QC: GKW/RKP T1: GKW
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databases or other information sources throughout the world. Currently, the analog 56K modem is still the primary modem used to connect to the Internet from PC. However, if multimedia learning materials are used, faster transmission speeds are highly desired. DSL (Digital Subscriber Line) is a much more effective way to utilize existing copper telephone lines and provide secure, reliable, high-speed Internet access. With DSL service, users can benefit from Internet speeds that are up to 25 times faster than a traditional 56 Kbps modem. In the LBA project (Zhang and Nunamaker, 2000), while DSL was used, a multimedia-based e-Learning system only took about $3 \sim 4$ seconds to start playing a streaming video delivered from a remote video server after submitting a query. The next goal is gigabit networking that is able to transfer data via Internet much faster.

5.10. Human-computer interaction (HCI)

An easy-to-use and user-friendly interface is one important feature of an e-Learning system. HCI (Human-Computer Interaction) is "a discipline concerned about the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them. (ACM SIGCHI, 1992)." One important HCI factor is that different users have different conceptions about interactions with computers. Users may be different in terms of culture. Their interface preference may change over time. Generally, there are five aspects of HCI studies: the nature of HCI, human characteristics, the use and context of computers, computer system and interface architecture, and development process (ACM SIGCHI, 1992).

An ideal e-Learning system should have a Web user interface that supports all potential activities related to learning process. HCI research facilitates the design of easy-to-use interfaces that precisely present learning materials in a large variety of formats and enable learners to use embedded tools whenever necessary without any technical difficulty. For example, an interface may provide a direct link to an online forum so that learners can participate in online discussions very easily.

5.11. Evaluation of learning

Evaluation of e-Learning contains two perspectives: assessment of learners' progress during a learning process, and evaluation of system performance.

Keeping track of learning progress of individual learners facilitates instructors or systems to provide an appropriate level of materials to learners, enabling education and training to be effectively managed and appropriately tailored to meet individual needs. Assessment of a learner's progress in an e-learning system can be achieved by establishing a dynamic, personalized learning model or profile that contains his/her learning procedures, interests, problems encountered, and so on (Whitehurst, Powell, and Izatt, 1998).

In addition, an overall evaluation of effectiveness and efficiency of an e-Learning system is important, especially its effectiveness. Many different methods have been applied to gather information about the effectiveness of distance learning, including pre- and post- course questionnaires completed by students to elicit subject rankings, records of learners' online activities (records of system use and access), test/exam grades, direct observations, and learner-instructor and learner-learner communications through learning process (Hiltz and Wellman, 1997; Beam and Cameron, 1998). For a company that provides online education or training to its employees, it is essential to measure effectiveness, competency, impacts on business objectives, and profits and ROI of e-Learning. In the future, effective Web-based assessment tools for e-Learning systems should be developed.

5.12. Security and accounting

Knowledge is an intellectual property. In e-Learning, knowledge is placed on the Internet and can be accessed by individual learners. Thus, security and payment issues become essential and complex, and must be addressed properly.

First, an e-Learning system must be secure enough against malicious access or misuse of data in order to protect the privacy of learners. The system should be able to support verification of authorized users. Second, copyright and license agreements about electronic learning materials must be considered to avoid illegal use. For example, some encryption techniques and digital signature methods have been adopted to protect knowledge on the Internet. Third, owners of intellectual property should be compensated when their knowledge (electronic learning materials) is distributed to learners via the Internet. Therefore, e-Learning systems must support creation and management of learners' accounts, record learners' charges, and receive online payments. The Internet accounting and billing services should be well designed and established.

6. Discussions and Future Research Directions

There are many e-Learning systems available today. However, many of them have various limitations. As a result, higher effectiveness and greater societal potential of e-Learning are hindered. Some of the problems in current e-Learning systems are as follows.

- Text-based learning materials: Some e-Learning systems present text-based content only, which may make users less engaged during online learning. Users dislike reading large volumes of text on screen (Carswell, 1998).
- Not enough content for good understanding: Many e-Learning systems do not necessarily provide sufficient materials for understanding a subject matter (Kohsaka et al., 1999). Some of them, for example, only provide PowerPoint slides of lectures and an online discussion forum, which are not enough for users to obtain a good understanding of content. It is not uncommon that when we read other people's slides, we may not understand what they really mean by just looking at those bullet points. Therefore, more and more e-Learning systems begin to provide an online environment similar to a traditional classroom setting by presenting synchronized instructional videos, PowerPoint slides, and lecture notes (Chen et al., 1999; Bargeron et al., 2001; Zhang, 2002).
- Less interaction and user flexibility: Unlike traditional classrooms, in which students have live interaction with instructors and classmates, an online learning environment separates students and instructors physically by time and location. Therefore, how to get online students more involved is an important issue. Currently, some e-Learning systems are not very interactive. Users do not have much flexibility and control over learning content and process in order to meet their individual needs. It is less likely to engage e-Learners (Hammond et al., 1995; Hiltz and Wellman, 1997).
- Unstructured and isolated multimedia content: In most current multimedia-based e-Learning systems, multimedia instructional materials are simply posted on the Web without any processing. They are usually presented in a static, passive, and unstructured manner without close association among relevant contents in various media.

The emergence of multimedia presenting technology presents an opportunity of both technological breakthrough and theoretical advancement in e-Learning. Technically, we need to engineer solutions for integration of multimedia contents. Theoretically, we need to understand how to control different factors in order to improve e-Learning effectiveness. In the literature, there has been little research towards building theoretical guidance for development of effective multimedia-based e-Learning systems (Zhang, 2002).

We are not claiming that e-Learning will replace traditional classroom learning. Naturally, not every student finds e-Learning to his or her liking. For one thing, it may require maturity and more discipline from students than conventional education. Nor do all instructors take to e-Learning. Kumar, Kumar, and Basu (2001) conducted a study to evaluate student perceptions of e-Learning and concluded that although students seem to be interested in virtual education, they are not willing to enroll in online education degree programs. Another study from Wilson and Mosher (1994) revealed that some users feel intimidated by the technology employed in delivering the course remotely. It is well recognized that total preparation time for an online course far exceeds the one for a traditional classroom course. Quite probably certain types of instruction may not be suitable to go online.

That being said, we believe that e-Learning will keep growing as an efficient and indispensable solution to remote and lifelong learning. It is especially beneficial when people cannot leave the duty and come to the campus to have face-to-face learning. To advance e-Learning, we also need to meet other challenges. First, as the number of Internet users increases, access time will increase as well; Second, the voluminous email messages or continuous online discussion can be overwhelming and cause information overload to learners. It can be alleviated by development of new software tools for standardizing and coordinating interaction. Information filtering techniques can also be applied to the selection of relevant information. Third, multimedia, along with its massive storage requirements, present research questions from a data management perspective, including how to store and manage multimedia and how to efficiently perform content-based multimedia retrieval. A few interesting research issues are:

- Examine the impacts of learner characteristics on e-Learning effectiveness.

- Explore how to provide powerful simulation or experimental opportunities to allow learners to practice newly acquired knowledge or skills. There is a lot of research on intelligent tutoring that can be applied to this area.
- Study how to efficiently assess learners' performance and make dynamic adjustment to instructional contents.
- Investigate the impacts of different learning contexts on e-Learning effectiveness. In other words, identify what type of content is more suitable for online learning and what is not.

7. Conclusion

E-Learning primarily gears toward lifelong and remote learning. With the advancement of information technology, we believe e-Learning will have a very promising future in the new millennium. In a report to the president and the Congress of the United States in December 2000, Senator Bok Kerrey and Representative Johnny Isakson urged to call upon federal and state governments to make an extension of broadband access for all e-Learners, create a comprehensive research, development, and innovation framework for e-Learning, remove all barriers that block the full access to online resources and courses, and develop high-quality content and applications for online learning (Kerrey and Isakson, 2000).

The future e-Learning will be featured with broadband and more reliable networks and high-quality multimedia learning materials. Constantly improved technologies will significantly boost the capacities, robustness, and speed of networks so that the transmission of multimedia-rich learning materials will be much faster than today. Streaming audio and video will be widely used. Knowledge will be better managed and reused. In the meantime, the cost of e-Learning will be reduced dramatically. As learning "anytime, anywhere" changes expectations and assumptions of our economy and society, e-Learning will become more and more important and pervasive in our lives.

References

ACM SIGCHI. Curricula for Human-Computer Interaction. *ACM Special Interest Group on Computer-Human Interaction Curriculum Development Group* [online]. 1992, Available: http://www1.acm.org:82/sigchi/cdg/index.html.

Adam A, Slonim W, Yesha Y. Globalizing business, education, culture through the Internet. *Communications of the ACM* 1997;40(2):115–121. Available: ACM digital library.

Agius HW, Angelides MC. Developing knowledge-based intelligent multimedia tutoring systems using semantic content-based modeling. *Artificial Intelligence Review* 1999;13:55–83.

Aggarwal C, Wolf J, Yu PS. On optimal piggyback merging policies for video-on-demand systems. In: *Proceedings of the ACM SIGMETRICS Conference on Measurement & Modeling of Computer Systems*, May 23–26, 1996, Philadelphia, PA USA, 1996:200–209. Available: ACM digital library.

Alavi M. Computer-mediated collaborative learning: An empirical evaluation. *MIS Quarterly* 1994:159–174.

Amir F, Iqbal SM, Yasin M. Effectiveness of cyber-learning. In: *29th ASEE/IEEE Frontiers in Education Conference*, Nov. 10–13, 1999, at San Juan, Puerto Rico.

Arbaugh JB. How classroom environment and student engagement affect learning in internet-based MBA courses. *Business Communication Quarterly* 2000;63(4):9–26.

Baloian NA, Pino JA, Hoppe HU. A teaching/learning approach to CSCL. In: *Proceedings of the 33rd Hawaii International Conference on Systems Sciences*, Available: IEEE Computer Society, 2000.

Bargeron D, Gupta A, Grudin J, Sanocki E, Li F. Asynchronous collaboration around multimedia and its application to on-demand training. In: *Proceedings of 34th Annual Hawaii International Conference on System Sciences*, 2001.

Beam P, Cameron B. "But what did we learn ...?": Evaluating online learning as process. In: *Proceedings on the Sixteenth Annual International Conference on Computer Documentation*, Sept. 24–26, 1998, Quebec, Canada, 258–264.

Burgstahler S. Teaching on the Net: What's the difference? *T.H.E. Journal* 1997;24(9):61–64.

Carswell L. Teaching via the Internet: The impact of the Internet as a communication medium on distance learning introductory computing students. In: *Proceedings of the Conference on Integrating Technology into Computer Science Education*, June 1–5, 1997, Uppsala, Sweden, 1–5.

Carswell L. The 'Virtual University': Toward an Internet paradigm? In: *Proceedings of 6th Annual Conference on the Teaching of Computing/3rd Annual Conference on Integrating Technology into Computer Science Education on Changing the Delivery of Computer Science Education*, 1998.

Chapman P, Selvarajah S, Webster J. Engagement in multimedia training systems. In: *Proceedings of the 32nd Hawaii International Conference on System Sciences*, Jan. 5–8, 1999, at Maui, HI, USA.

Chen H-Y, Chia Y-T, Chen G-Y, Hong J-S. An RTP-based synchronized hypermedia live lecture system for distance education. In: *Proceedings of the Seventh ACM International Conference on Multimedia*, Oct. 30–Nov. 5, 1999, Orlando, FL, US.

Corbett AT, Anderson JR. Knowledge decomposition and subgoal reification in the ACT programming tutor. In: *Proceedings of AI-ED 95: 7th World Conference on Artificial Intelligence in Education*, 1995.

Dorai C, Kermani P, Stewart A. ELM-N: E-Learning media navigator. In: *Proceedings of ACM International Multimedia Conference*, 2001, Ottawa, Canada.

Au: Pls. provide page range for the reference (Fallah, How, Ubell, 2002).

Au: Pls. provide "first name" for the author in the reference (Freedman and Dewitt, 1995)

Ertmer PA, Newby TJ. Behaviorism, cognivism, constructivism: Comparing critical features from an instructional design perspective. *Performance Improvement Quarterly* 1993;6(4):50–70.

Fallah MH, How WJ, Ubell R. Blind scores in a graduate test: Conventional compared with web-based outcomes. *ALN Magazine* 2000;4(2).

Freedman, DeWitt DJ. The SPIFFI scalable video-on-demand system. In: *Proceedings of the 1995 ACM SIGMOD International Conference on Management of Data*, 1995:352–363. Available: ACM digital library.

Glaser R, Bassok M. Learning theory and the study of instruction. *Annual Review of Psychology* 1989;40:631–666.

Hadidi R, Sung C. Pedagogy of online instruction—Can it be as good as face-to-face? In: *Proceedings of American Conference on Information Systems (AMCIS 2000)*, Aug. 2000, at Long Beach, California.

Hämäläinen M, Whinston AB, Vishik S. Electronic markets for learning: Education brokerages on the Internet. *Communications of the ACM* 1996;39(6):51–58.

Hammond N, McKendree J, Reader W, Trapp A, Scott P. The PsyCLE project: Educational multimedia for conceptual understanding. In: *Proceedings of ACM Multimedia 95*, Nov. 5–9, 1995, at San Francisco, California, USA.

Hampapur A, Jain R. Chapter 9: Video data management systems: Metadata and architecture. In: *Multimedia Data Management*, 1998, McGraw-Hill.

Hiltz SR. Teaching in a virtual classroom. In: *Proceedings of International Conference on Computer Assisted Instruction (ICCAI'95)*, March 7–10, 1995, at Hsinchu, Taiwan.

Hiltz SR, Benbunan-Fich R. Supporting collaborative learning in asynchronous learning networks: Software engineering or symbolic interactionism [online]. *Invited Keynote Address for the UNESCO/Open University Symposium on Virtual Learning Environments and the Role of the Teacher*, Milton Keynes, England, April 28, 1997. Available: http://eies.njit.edu/~hiltz.

Hiltz SR, Wellman B. Asynchronous learning networks as a virtual classroom. *Communications of the ACM* 1997;40(9):44–49. Available: ACM digital library.

Hodgins HW. Into the future—A vision paper. For National Governors' Association (NGA) and the American Society for Training & Development (ASTD)'s Joint Commission on Technology & Adult Learning [Online]. Available: http://www.selsius.com/warp/public/10/wwtraining/elearning/learn/whitepaper_docs/into-the-future.pdf, 2000.

Hofstetter F. *Multimedia Literacy*. New York: McGraw-Hill, 1995.

Kerrey B, Isakson J. The power of the Internet for learning: Moving from promise to practice. *Report of the Web-Based Education Commission to the President and the Congress of the United States*. Available: http://www.ed.gov/offices/AC/WBEC/FinalReport/WBECReport.pdf, 2000.

Khirallah DR. A new way to learn. *Informationweek* 22–23. Available: http://www.informationweek.com, 2000.

Kohsaka Y, Hashimoto K, Shibata Y, Katsumoto M. Flexible multimedia lecture supporting system based on extended virtual reality space. In: *Proceedings of 1999 International Workshops on Parallel Processing*, Sept. 21–24, 1999. Aizu-Wakamatsu, Japan.

Kumar A, Kumar P, Basu SC. Student perceptions of virtual education: An exploratory study. In: *Proceedings of 2001 Information Resources Management Association International Conference*, May 20–23, 2001, at Toronto, Ontario, Canada.

Lang KR, Zhao JL. The role of electronic commerce in the transformation of distance education. *Journal of Organizational Computing and Electronic Commerce* 2000;10(2):103–128.

Makkonen P. Who benefits from WWW-presentations in the basics of informatics? In: *Proceedings of 2001 Information Resources Management Association International Conference*, May 20–23, 2001, at Toronto, Ontario, Canada.

Marchionini G, Nolet V, Williams H, Ding W, Beale JR, Gordon A, Enomoto E, Harbinson L. Content + connectivity = community: Digital resources for a learning community. In: *Proceedings of the 2nd ACM International Conference on Digital Libraries* 1997:212–220. Available: ACM digital library.

Au: "Beale, J. Rose," has been set as "Beale JR" O.K. as set ?

Marinelli D, Stevens S. Synthetic interviews: The art of creating a "Dyad" between humans and machine-based characters. In: *Proceedings of Interactive Voice Technology for Telecommunications Applications'98 (IVTTA '98)* 1998:43–48. Available: IEEE digital library.

Marold KA, Larsen G, Moreno A. Web-based learning: Is it working? A comparison of student performance and achievement in Web-based courses and their in-classroom counterparts. *Challenges of Information Technology Management in the 21st Century* 2000:350–353. Available: Idea group publishing.

McAllister NC, McAllister DF. Providing education electronically to non-traditional sites: New delivery to a new audience. In: *Proceedings of the 14th Annual Int'l Conference on Marshaling New Technological Forces: Building a Corporate, Academic, and User-Oriented Triangle*, 1996:187–193.

McCloskey DW, Antonucci YL, Schug J. Web-based vs. traditional course development: Identifying differences in user characteristics and performance outcomes. In: *Proceedings of the International Business Schools Computing Association Annual Conference*. Denver, Colorado, 1998.

Merrill MD. Constructivism and instructional design. *Educational Technology* 1991:45–53.

Moe MT, Blodget H. E-Learning: The knowledge Web. Part 1: People power—Fuel for the new economy; Part 4: Corporate e-Learning—Feeding hungry minds. *A Report to United States Education & Training Services*. Merrill Lynch. 2000:73.

Morales C, Cory C, Bozell D. A comparative efficiency study between a live lecture and a Web-based live-switched multi-camera streaming video distance learning instructional unit. In: *Proceedings of 2001 Information Resources Management Association International Conference*, May 20–23, 2001, Toronto, Ontario, Canada.

Nunamaker JF, Briggs RO, Mittleman DD, Vogel DR, Balthazard PA. Lessons from a decade of group support systems research. In: *Proceedings of the 29th Hawaii International Conference on System Sciences*. Wailea, HI, USA: IEEE Comput. Soc. Press. 1996:418–427

Rivera JC, McAlister MK. A comparison of student outcomes & satisfaction between traditional & Web based course offerings. In: *Proceedings of 2001 Information Resources Management Association International Conference*, May 20–23, 2001, Ontario, Canada.

Schreiber DA, Berge ZL. *Distance Training*. San Francisco, Jossey-Bass Publishers, 1998.

Senn JA. Capitalising on interactive multimedia technologies in dynamic environments [online]. 1997. Available: http://crm.hct.ac.ae/021senn.html.

Stallings W. *Business Data Communications*. Upper Saddle River, N.J.: Prentice Hall, 1998.

Syed MR. Diminishing the distance in distance education. *IEEE Multimedia* July–Sept., 2001:18–21.

Thompson M. Distance delivery of graduate-level teacher education: Beyond parity claims. *Journal of Continuing Higher Education* 1996;44(3):29–34.

Ubell R. Engineers turn to e-Learning. *IEEE Spectrum* 2000;59–63.

USDLA (The United States Distance Learning Association). Research information and statistics [online]. Available: http://www.usdla.org/.

Wactlar HD. Informedia—Search and summarization in the video medium [online]. In: *Proceedings of Imagina 2000 Conference*, Monaco, Jan. 31–Feb. 2, 2000;1–10. Available: http://www.informedia.cs.cmu.edu/documents/imagina2000.pdf.

Au: Pls. provide volume number for the reference (Wade and Power,1998)

Wade VP, Power C. Evaluating the design and delivery of WWW based educational environments and courseware. *ACM ITICME* 1998;243–248.

Weston TJ, Barker L. Designing, implementing, and evaluating Web-based learning modules for university students. *Educational Technology* 2001;41(4):15–22.

Whitehurst RA, Powell CL, Izatt JS. Utilizing the student model in distance learning. In: *Proceedings of the 6th Annual Conference on the Teaching of Computing/3rd Annual Conference on Integrating Technology into Computer Science Education on Changing the Delivery of Computer Science Education*, 1998:254–256. Available: ACM digital library.

William F, Bareiss R, Birnbaum L, Osgood R. ASK systems: An approach to the realization of story-based teachers. *Technical Report*, No. 22, Institute for the Learning Sciences, 1992.

Wilson JM, Mosher DN. Interactive multimedia distance learning (IMDL): The prototype of the virtual classroom. In: *Proceedings of ED-MEDIA 94-World Conference on Educational Multimedia and Hypermedia*, June 25–30, 1994, at Vancouver, British Columbia, Canada.

Wulf K. Training via the Internet: Where are we? *Training and Development* 1996:50–55.

Au: Pls. provide 'volume number' for the reference Wulf (1999).

WWWebster Dictionary [online]. (1997). Available: http:// www.m-w.com/dictionary.htm.

Zhang D. Media structuration—Towards an integrated approach to interactive multimedia-based E-Learning. Ph.D. dissertation. The University of Arizona, 2002.

Zhang D, Nunamaker JF. A multimedia-enabled system for interactive self-paced learning. In: *Proceedings of IASTED International Conference on Internet and Multimedia Systems and Applications*, Nov. 19–23, 2000, at Las Vegas, Nevada, USA.

Zhang D, Zhao JL, Nunamaker JF. Media structuration theory: Towards a framework for effective multimedia-based e-Learning, 2002. Submitted to MIS Quarterly.

Zhang W. Chapter 8: Multimedia, technology, education and learning. *Technological Innovations in Literacy and Social Studies Education* [online], 1995. Available: http://tiger.coe.missouri.edu/~sslit95/.

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