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Abstract

Recent years have witnessed the rapid expansion of online technology and its use in education and training. The Internet and web technologies are used for courses of study as small as self-paced tutorials and as large as entire degree programs. Web technologies are currently used in many ways including distribution of traditional classroom materials, asynchronous and synchronous communication among students and instructors, multimedia presentation, and interactive simulation. Although the body of published research in web-based teaching and training is large, it is relatively young and incomplete. Existing theoretical and exploratory research needs further synthesis and empirical validation. Meanwhile, rapid technology changes have created opportunities for new theoretical and exploratory investigation. This paper points out some significant unanswered questions regarding web-based learning and training. We argue that only by answering those questions can the true power of the web to support learning and teaching be understood and, thus, fully exploited.

Introduction

The Internet and web technologies are changing the way in which students learn and professional training is conducted. In a web-based learning and training environment, the Internet is a means to distribute and exchange information across barriers of time and geographical location. The result is a virtual classroom where participants can communicate and collaborate without being present at the same time and place. The virtual classroom provides flexibility for participants to manage their own time and to study on their own pace.

Many profit and non-profit organizations are implementing the virtual classroom. Institutions of higher education as well as military and business organizations are shifting their interest from traditional blackboard instruction to web-based instruction. Across the country, credited and non-credited online courses have mushroomed as traditional and non-traditional educational institutions have rushed to stake a claim on the Internet frontier. International Data Corporation reported a prediction of 33 percent increase in the number of online learners between 1998-2000 (Barron 1999). In professional training, it is expected that the web-based training industry will be worth $15 billion a year by the year 2000 (Johan 1998).

It is expected that web-based learning and training will be increasingly acceptable in higher education and professional training as course material proliferates and instructors and students, become familiar with the new medium. Albernathy (1998) and Kearsley (1997) provide guidelines for instructors who want to move their classroom to the cyberspace. Increasing bandwidth and decreasing cost of the Internet and its technologies offer tremendous opportunities for students who live remotely from campus or who have busy schedules and personal commitment to pursue their degree or to enhance their skill. For example, an increasing number of students have received their degree via email (Gubernick and Ebeling 1997).

One of the future trends in web-based teaching and learning is an increasing effort from colleges and universities to market their online courses. The followings are a few recent examples.

- University of Maryland University College has founded a for-profit organization called UMUC Online.com Inc. to market university's online courses. UMUC hires the same person who developed NYUOnline for New York University's online programs (Carnevale 1999).

- Louisiana Colleges has recently received grants from the State's higher education management board to support courses delivered via the various electronic medium such as the Internet (Shuler 1999).

- Due to increased number of executive MBA (EMBA) programs offered (total of 61 programs in 1999, up from 37 five years ago), business schools are moving toward an online classroom that provides a flexible schedule to both students and teachers (Reingold and Schneider 1999).

- Recently a 75-page memo came from Rogers, S. at Harvard University proposed to enhance distance learning creating a full-blown Harvard.com business subsidiary to generate more revenue from the university's existing programs (Allis and Staff 1999).
• EMBA Net, a service provider that works with schools in developing distance learning infrastructures. Currently more than 200 universities have contracted with EMBA Net to incorporate online learning into their executive MBA and other continuing educational programs (Greco 1999).

Role of the Internet and the World Wide Web

The Internet has taken distance education to a new level. Distance education used to refer to correspondence courses offered first through postal mail, television, radio, then through video and CD-ROM. Now with the addition of Internet and its related technologies, distance education provides online courses where students and instructors communicate virtually and globally. Instructors who have struggled with choosing various teaching media for years may find web technologies offer the solution. Carver, et al. (1999) point out that using hypermedia (e.g., a set of text, audio, video materials linked together) in a virtual classroom can enhance richness of online presentation. Therefore, tailoring the presentation to different students’ learning styles can enhance learning outcomes (Carver, et al. 1999).

The World Wide Web (WWW) has had many impacts on education, two of which we focus on here:

• Standardization of web-browser capability and behaviors
• The WWW as a global information resource

The web browser has become a de facto standard for human interaction with software. In essence, a web browser is the VT100 or IBM 3270 computer terminal of the early 21st century. The universality of that interface has created an explosion in the availability of software applications. Applications of all types (including educational applications) are being migrated to browser-based interfaces. Widely adopted standards for web browsers, embedded applications, and document encoding have allowed application developers to focus all of their energies on a single universal interface. The result is a global market for any software application that bypasses many of the compatibility issues that once plagued software development and deployment. Intelligent computer-assisted education has finally found a universal platform.

Information of all types is increasingly placed on the web. Cheap hardware, easy to use web development software, and standardized web browsers have all made this possible. The impact on education has been profound and rapid. Finding information used to be a complex process of searching outdated paper-based indices and retrieving paper documents. Finding information has been transformed into a point and click exercise assisted by powerful search engines that continuously update their indices. The old problems of time-consuming search and difficult access have been replaced by information overload and the need to filter information sources for relevance and quality. Information accessibility is no longer an impediment to education.

Present and Future Research Themes

The body of research in web-based learning and training has grown nearly as rapidly as the web itself. That early research reflects the frenzied activity of the web’s youth. It is a wide-ranging and impulsive set of exploratory activities - strong on energy and initiative, but generally lacking rigor and a long-range outlook. Like any adolescent, the field now faces the prospect of having to prove its usefulness and its ability to contribute to society in a meaningful way. This will require a more focused set of activities and specific attention directed to honing skills and knowledge to achieve provably significant results.

As a framework to start describing present and future research themes we have chosen the old engineering maxim “better, faster, or cheaper – pick any two”. Each section in the remainder of this paper begins with a significant unanswered question about web-based learning and training. The questions are followed by a discussion of related current research and specific areas of future research. Only by answering those questions can the true power of the web to support learning and teaching be understood and, thus, fully exploited.

Better

Does web-based education produce better results than traditional education?

Most existing research directed to this question is based on personal experience or anecdotal evidence (e.g., Kearsley 1998; Ward and Newlands 1998; and Berger 1999). Authors present lessons learned from developing and delivering their online instruction via the Internet. In general, they are optimistic about web-based learning and training. For example, Berger (1999) found an online class to be a place where students can work collaboratively and share their knowledge freely.

We assume that the goals of education are to increase student knowledge (broadly defined) and the student’s ability to acquire new knowledge. We typically measure knowledge increases by pre- and post-testing (e.g., traditional exams and practical application problems that
require exercise of newly gained knowledge. We typically measure a student’s ability to acquire new knowledge by presenting them with a problem that requires knowledge acquisition (e.g., writing a term paper or implementing and experiment. We use the term learning outcome to describe the knowledge and skills gained and the student’s ability to recall, apply, and extend that knowledge.

A substantial body of literature describes the results of web-based education. But relatively few studies directly measure learning outcomes and even fewer do so with reliable empirical research methods. Common measures include results of student satisfaction surveys and analysis of comments from instructors. But such measures are a poor substitute for direct measurement of learning outcomes. There have also been few attempts to directly compare learning outcomes among web-based and traditional education methods. Research that systematically and comparatively assesses learning outcomes of traditional and web-based learning has been called the third generation of web-based education research (Schneiderman 2000).

A few studies have empirically investigated the impact of web-based technologies on learning outcomes. Stith (1999) developed an online biology course with Web CT. He measured the number of times students clicked on web pages and found that it did not correlate with students’ final grades. However, he discovered that the number of articles that a student read on the class bulletin board appeared to correlate with the final grades (Stith 1999).

Schulman and Sims (1999) adopted the same methodology used in an experimental study performed by Dr. Schutte at California State, Northridge (as quoted by McCollum 1997). They divided their classroom randomly into two groups. One attended the class on campus and the other accessed class’ materials via the Internet. Both studies conducted a test-retest study by giving each group of students a pre- and post-test. Dr. Schutte found that his online group performed significantly better than his on campus group (McCollum 1997). On the other hand, Schulman and Sims (1999) found no significant difference between two groups for their sample.

The area of web-based teaching and learning is relatively new. The question whether web-based education produces better results than traditional education is still unanswered. What makes answering this question difficult is that researchers must be sure that traditional and web-based educations are comparable; otherwise, we wind up comparing apples and oranges. Since the findings in previous studies are mixed, existing theoretical and exploratory research needs further synthesis and empirical validation. More studies regarding the effectiveness of web-based education and its impact on learning outcomes are needed.

**Faster**

Is web-based education faster (or more time-efficient) than traditional education?

Education is traditionally a time-consuming activity and there is a strong feeling among many educators that it should be so. That is, that true learning requires time for information gathering, assimilation, reorganization of paradigms and thought processes, reinforcement through review and exercise, and critical evaluation of what has and hasn’t been learned. But there are also many educators (and probably many more students) who feel that traditional education consumes their time inefficiently.

The typical organization of education into time units (e.g., semesters, three credit courses, and 75 minute class periods) is driven by historical precedent, scheduling convenience (primarily of instructors), and the logistical problems inherent in assembling dozens or hundreds of people in the same place at the same time. Once assembled, students are given a one-size-fits-all educational product that many of them find lacking. Teaching time is allocated based on averages of student background and ability to absorb new knowledge. But failure to customize the “product” to individual needs means that the majority of students have either too much or too little time devoted to specific topics and activities.

Web-based education is capable of breaking through restrictions of time and place. An often unspoken assumption is that students will learn more efficiently at their own individualized pace via web-based instruction. But it is far from clear exactly how those benefits can be systematically achieved. Simply moving an existing course based on lecture and presentation onto the web and supplementing it with a virtual discussion forum (e.g., an electronic chat room or threaded email archive) does not guarantee that learning occurs with either greater efficiency of effectiveness.

Various aspects of computer-based and web-based technology have been proven effective in specific circumstances. For example, Pearce and Livett (1999) examine the use of interactive visual simulations in an introductory physics course. Many studies discuss the impact of computer-supported collaboration on course design and student satisfaction. Kemery (2000) reviews many studies on computer-supported collaboration and proposes a model to account for their effectiveness.
Small-scale successes in the application of specific technologies need to be scaled up to become comprehensive educational programs. Appropriate mixes of activities, technologies, and teaching and learning methodologies need to be defined for various areas of study. The mix will vary among study areas and among students as well. Thus, domain specific research is required to identify which technologies and techniques are best suited to each knowledge area and how those technologies and techniques may be synergistically combined into larger programs of study. Schank (1998) poses strong arguments about the need for web-based teaching to deliver highly personalized content and to embody learning principles such as guided self-discovery from a student’s own mistakes. The promise of increased learning efficiency can only be achieved by an educational “stew” customized to the “diner” and the “ingredients” at hand.

**Cheaper**

Is web-based education cheaper than traditional education (all other things being equal – if that’s even possible)?

The cost of delivering educational services has grown at a much faster rate than the general rate of inflation. Students, businesses, governments, the trustees of educational institutions, and society as a whole are justifiably concerned with rapidly rising costs. The cost of many other goods and services has decreased because of improved technology including the web. Thus, it is little wonder that there is so much pressure on educators and educational institutions to embrace web-based and other technologies in an attempt to control, slow, or reverse the rising trend in educational costs.

Relatively little research has examined the costs of web-based educational technology or compared them directly to traditional education methods and technologies. It is far from proven that web-based technology can currently deliver education at lower cost or quality. If we assume that web-based technology has some educational benefits and that Moore’s Law will continue to hold then there must come a time when web-based technologies will become cheap enough to be cost-effective. But has that time passed, have we just reached it, or will it be reached in the near or far future?

Some researchers have examined the economic landscape of web-based instruction and other new technology applied to education pursuits. Hämäläinen, et al (1996) describe an electronic market for educational services that delivers customized education. Tsichritzis (1999) provides a detailed description of the reengineering required for a traditional university to survive in world in which education content and services can be easily imported and exported. Both papers emphasize the economies of scale inherent in such an educational marketplace. But there is still far to go to make that marketplace a cost-effective reality. Questions that need to be answered include how educational and services will be packaged, how quality control will be implemented, and what infrastructure and standards will be required to service such a vast and diverse market. The answers to these questions are not the stuff of “big picture” research agendas. But they are necessary cogs in the larger machine of web-based education.

**Technology, Infrastructure, and Skills**

The technology and infrastructure requirements needed to support ubiquitous web-based education are substantial. For convenient discussion, we divide them into three classes – communications, hardware, and software requirements. A directly related issue is the skill set required to effectively exploit web-based technology and the roles of student and teacher in a web-based learning environment.

**Communication**

What communication network capabilities are required to deliver effective web-based education?

The common standard of computer communication in the majority of the developed world is an analog modem operating at 56 Kbps or less. Even this relatively modest standard is far from universal. Significant numbers of people in developed countries and the vast majority of people on the planet do not have access to such technology. Bandwidth continues to be a commodity in relatively short supply and will likely remain so for the near future.

Bandwidth is a significant constraint on the amount of raw information that can be delivered at a distance. Although this constraint is easy to measure in bits and bytes, it is much more difficult to measure in terms of education effectiveness. What is the practical upper bound of educational effectiveness that can be delivered within specific bandwidth constraints? And what specific technologies, techniques, and educational practices will use the available bandwidth for maximum educational effectiveness?

Bits and pieces of answers to these questions exist in the literature. For example, Parikh and Verma (1999) examine the use of push-pull technology to minimize bandwidth consumption using push technology to deliver updated course materials. Litecky, et al. (1999) examine the use of various telephony and video conferencing technologies. Similar studies are needed to address the
entire array of communication technologies including emerging broadcasting and multicasting technologies and their supporting Internet standards. In addition, the educational effectiveness of those technologies needs to be examined with rigorous empirical analysis.

**Hardware and Software**

*What are the hardware and software requirements of minimal/adequate/exceptional web-based education?*

The personal computer has become a ubiquitous presence in offices, schools, and many homes in the developed world. Many have predicted its eventual demise, transformation into a fundamentally new device, or replacement by an army of more specialized “smart” devices. But for the present, the personal computer is the primary hardware platform used to support web-based learning and teaching. Wide variations in the hardware and software configurations of personal computers available to students make it difficult to choose tools and technologies to support web-based education. Educators must often target instructional delivery to a lowest common denominator with concomitant reductions in instructional capability.

There has been little systematic evaluation of the relationship between hardware and software capability, instructional capability, and educational effectiveness. We all have an intuitive feeling that a student is missing something when he or she peers at the web through a 14-inch screen on a computer with a slow CPU, limited RAM, and an outdated browser. But exactly what is the student missing and what are learning outcomes compromised by missing it? The answer to this question is of paramount importance as schools rush to implement distance education using web-based technologies.

**The Roles and Skills of Teacher and Student**

*What is the role of student and teacher in a web-based learning environment?*

The roles of student and teacher have been honed by educational practice over a few thousand years. Until relatively recently, technology has been an infrequent intruder into educational practice. But the end of the twentieth century has seen traditional roles bent, broken, and redefined by new educational technology. The web appears to be the technology that will fundamentally rewrite the roles of student and teacher.

So how do roles change in a web-based educational environment? Do teachers become disembodied presenters in a multimedia show? Is presentation by a human even required? Can an automated tutoring program look students in the face and recognize the look of confusion or the “a ha” factor? Is the current amalgamation of teaching duties and skills destined to be sliced up into a set of more specialized roles similar to those of health care providers in a modern health maintenance organization?

There has been surprising little research directed toward these questions. Glimpses of the future for faculty members appear in Tsichritzis (1999) and Hämäläinen, et al (1996). But these glimpses are partly speculative and they are painted in broad brush strokes. Perhaps the direct impact of a web-based future on higher education faculty (who do much of the research in web-based education) explains the dearth of study in this area. Could it be that the future is less frightening when many of its details are unknown?

Schneider (1994) states that the role of an instructor in the virtual classroom is to be a coach, a catalyst, and a leader. In the traditional classroom, students are passive receivers who listen to knowledge passed through a teacher. On the contrary, the virtual classroom allows both parties to share knowledge and experience. On-line instructors can no longer use the traditional style of teaching (i.e., lecturing) in the virtual classroom. Leonard (1999) points out that a successful on-line education depends on ability of instructors to deliver their course via the Internet and facilitate the virtual classroom’s discussion and collaboration.

The effects of web-based education on the role of students have been reported in many studies. Online students need to possess both technical and non-technical skills. In the virtual classroom, they must be able to maneuver around courseware that contains lecture notes, PowerPoint slides, and online quizzes. Furthermore, the students must know how to use a variety of web-based tools such as file transfer protocol (FTP), search engine, listserv, e-mail, and any other tool used in their course.

Next, non-technical skills are critical for success of online students. These skills are time management, self-studying, and group collaboration skills. Although most course materials are available 24 hours/7 days, the students cannot wait until the last minute to study (Reid 1999). The online environment allows the students to study at their own pace, independently from their instructor. Thus, the students must know how to manage their time properly and how to study without an instructor sitting next to them. Finally, group collaboration skills are important aspect of the virtual classroom environment. Web-based learning is believed to increase critical thinking and problem solving abilities of students because it allows intensive interaction and coordination among students and the instructor (Kearsley 1998).
Sonner (1999, p. 247) states, "distance learning is an acceptable means" of teaching simply because it reaches a more motivated student population. On-line students need to possess a great level of motivation. When the students do not come to class, some may lose interest in the class. To keep them enthusiastic, an online instructor plays an important role to make sure that course materials are updated, class activities are interesting, and workloads are average. The instructor also needs to respond to his/her students in a timely fashion. Due to lack of face-to-face meeting, the online students seem to be very demanding in terms of feedback and grade.

Summary

The body of research in web-based learning and teaching is large and impressive. But there are important questions that remain unanswered. The most important of these concern educational effectiveness.

There is ample anecdotal and case-based evidence to support the effectiveness of web-based teaching and training. But complete proof can only arise from empirical studies that cover a wide array of technologies and educational domains, have valid and significant sample sizes, and stand up under repeated trials and the glare of critical analysis.

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