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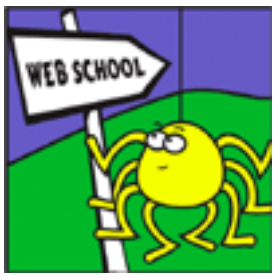

Using the Web to Enhance and Transform Education

by ***Michael Hulme*** and ***Michael Locasto***

Introduction

With the aid of the Internet and web technology, today's classrooms and learning environments are undergoing a major transformation. There is a massive effort to utilize the Internet as an effective communications and storage medium for education, research, and corporate training.

The impact of the Internet on the mechanics and culture of education and research is only beginning to manifest itself. There are a great number of open problems and challenges in this area. This article reviews some of the current trends in classroom computing and the use of Web technology in education. The article also explores how the strengths of technology have successfully been applied to the needs of education in both academic and business environments.

Classroom Technology

The classroom is no stranger to technology. It may be unusual to think of traditional classroom tools (blackboards, slide rules, etc.) as technology, but it is important to realize that every successful classroom technology achieved success precisely because it addressed a need of the educational culture, and not because it possessed some ephemeral quality of uniqueness or novelty. The culture of learning and teaching

centers primarily on the sharing of knowledge in a group setting.

In addition, the majority of educational literature and pedagogy focuses on the "self-actualization" of the student: the theory that the educational process is not a one-way transfer of information, but rather a process of shared understanding and communication between student and teacher. In short, the educator should be helping the student learn how to learn. Technologies adopted on the basis of their novelty are likely to have failed miserably because they were the wrong tool for the task of conveying and exploring knowledge in this setting. It is clear that we must make use of the appropriate strengths of the Web if it is to have a positive impact and transformative effect on education.

The PC: A Classroom Revolution?

Much like the introduction of the television and powerful multi-function calculators, the advent of the PC had many education professionals examining ways to integrate a new technology platform into curriculum, courses, and the classroom. Classroom television had amounted to little more than a curiosity for showing supplemental material. Graphing and multi-function calculators from Texas Instruments and HP fared better, partly due to strong marketing, textbooks with calculator-specific exercises in them, and the general usefulness of the technology in addressing student needs. These calculators have done their part in making the use of computational devices in the classroom feasible.

Throughought the previous two decades, a growing number of classrooms had computers in them. For the most part, the computer was a mysterious and hulking piece of machinery that played simple games or sat collecting dust because instructors were not trained in its use. The computer enjoyed only partial success until reliable and ubiquitous networking became widely available.

The addition of networking technology to the consumer operating system sparked an almost immediate rush to capitalize on the diverse and improved communication abilities offered by this powerful medium. Indeed, one of the first uses of networked computers and HTTP was to directly support academic research and communication. Since then, the use of computers and Internet technology in the classroom, research institutions and libraries, and the corporate world has grown exponentially. This trend has been helped by the almost universal adoption of the personal computer; now, even educators with no formal computer training feel reasonably confident opening a web

browser and downloading slide presentations or searching the Internet for material to support a lecture or to answer a question.

Uses of the Web in Education

What are people doing with the web? The web is both a communications and computation medium supporting both direct asynchronous and synchronous communications (e-mail and instant messaging), data storage and indexing (digital libraries and search engines), and a vast array of other multimedia, client-server, or peer-to-peer interactions. Frequently, the Internet is used for course web pages, electronic message boards, e-mail distribution lists, on-line grading, support web sites for textbooks, and lecture note distribution.

Our challenge is to construct applications and methodologies that take advantage of these strengths. We must also be prepared to thoroughly analyze and assess the efficacy of networking's role in education. Educators are exploring a number of ways to incorporate Web technology, and we discuss both unique and representative ones here. Brusilovsky [**3**] presents a good overview of the current approaches and problems with web-based education systems for the interested reader.

Digital Libraries

Digital libraries are a growing and important technology for storing many types of electronic media and transferring traditional media to electronic storage formats.

G-Portal [**14**] is a unique approach to categorizing knowledge that is geospatial and georeferenced. Each discrete piece of knowledge is literally located on a map. The designers feel that this method of organizing the massive amount of knowledge in a digital library or portal provides the user an intuitive interface for locating information. MiBiblio [**6**] is a recent effort to provide "personal spaces" in a digital library. These personal spaces adapt to the user's actions and attempt to organize knowledge based on user preferences.

Of course, digital document repositories like the ACM's Digital Library [**1**] and NEC's Citeseer website [**5**] have become extremely important tools for students, researchers, and information technology professionals. The ACM Digital Library is a storage medium for a wide variety of collected works, many taken from the conferences sponsored by the ACM. The Citeseer repository and website aims to catalog a wide collection of

science-related literature. Citeseer's unique indexing and correlation system makes searching for related documents easy. For example, after finding a document, Citeseer returns a page full of useful information, including a citation in Bibtex format, a list of works that cite the current paper, and a list of similar papers.

Online Assessment

Perhaps one of the biggest areas that the Internet has transformed is test taking and the assessment of student knowledge. Since the Internet allows both asynchronous and synchronous communication, material that is published can potentially reach a wider audience. In the case of test-taking, this access can be coordinated; however, the distributed organization of the web makes possible new methods of academic dishonesty, thereby presenting many new challenges to educators assessing student performance on-line.

Gouveia [**7**,**9**,**10**,**11**] and Gouveia et al. [**8**] have performed a number of experiments and analysis of networked educational environments, and proposed a generalized system [**8**] to support education, learning, and training via the Internet. Gouveia [**9**,**10**] relates personal experience with the University Fernando Pessoa's policy of requiring students to have laptops and describes a unique restructuring of the traditional testing environment. The experiment was conducted as a three member 'team' final exam. One team member was in the library, another in the test room, and the last in a social environment. Each had a laptop and was able to communicate via the University's network. During the two hour course of the exam, the team members collaborated on researching and answering the exam questions based on their unique access to diverse information. This experiment demonstrates the ways the Web can help prepare students for real-world team collaboration.

Pathak and Brusilovsky [**16**] present another means of assessing student performance by building a system that can create web-based parameterized quizzes. They applied the system to an introductory programming course. Given the general form of a series of code snippets and a valid range of parameter values for each, the system can dynamically generate both test questions and answers. The system addresses the demands on the instructor's time (by reducing the number of valid problems the instructor must generate) and inhibits academic dishonesty (by producing a fresh problem set for each quiz).

More recently, at the 2003 SIGSCE conference, Zachary and Jensen [**20**] described an

ongoing five year experience with a course in HTML and Javascript taught completely on-line. Their system deals with well-defined subsets of both HTML and Javascript. The system is an interactive web-based series of tutorials, lessons, and assessments. They conclude that the course is wildly popular with students, noting that most students cite the support and feedback system as key in forming their opinion.

Supporting Academic Integrity

Assessment of both student and instructor performance is critical, as is assessment of the new methods of education. As Popyack et al. [**17**] notes, the Web and current technology provide a diverse set of ways for students to undermine the integrity of the educational process. Woit and Mason [**18**] present an empirical analysis of a long term study in using on-line evaluations to reduce cheating. They show that most approaches to using on-line tests, quizzes, and other evaluations suffer from increased student willingness to cheat. Clearly, preventing academic dishonesty is an important challenge.

Equally important is assessing the performance of educators in the classroom. Many websites have appeared which invite students to rate teacher performance. This information is useful for both students and the educators themselves. While most systems are generally susceptible to skewed voting and overly negative or positive comments, they do provide a general sense of the educator's ability to assist student learning for a particular course.

Laptops in the Classroom

Laptops, palmtops, and other gadgetry are quickly taking over many campuses. Students may use them to play games, take notes, look at the provided lecture slides online, or access the campus servers to try example code the instructor is demonstrating. Many colleges are requiring their students to purchase a laptop. Laptops are becoming a familiar part of the course landscape, and professors will do well to integrate the laptop into the lecture. Yet, educators must also prepare for the possibility of the technology failing and be able to adapt.

Campbell and Pargus [**4**] explore the need for instructors to engage laptops as a valuable teaching tool, stating that the technology provides new avenues and methods for teaching various topics. Two primary benefits are quicker anonymous feedback on classroom events and new ways of interactively teaching the material. They argued convincingly that while much effort has gone into the design and support of many

institutions' networking infrastructure, relatively few efforts have been made to define pedagogical strategies incorporating the technology itself.

They point out that the presence of networked technology must contribute to a more effective learning process; otherwise, the networking infrastructure and students' laptops are merely an extravagant waste of money. The authors also present an interesting list of laptop classroom etiquette, including some rigid rules and penalties for breaking the acceptable behavior.

The Reach of the Web

Web technology is going to directly affect your learning experience. Many schools have started distance learning or video courses over the Internet. Large numbers of courses are being supported online. Middle schools and high schools across the world are being given technology grants or partnering with vendors to set up or support their networking efforts.

The web's role in education extends beyond the traditional institutional classroom and into the corporate world. Corporations and other organizations have a constant demand for more educated and versatile workers; employees of every company need to be exposed to new lessons ranging from how to work with associates to in-depth lessons on specialized equipment. Corporate training programs have improved the quality of training and saved both time and money due to the applications of the web to education.

Commercial Applications and Corporate Training

One way in which education in the corporate world differs from a traditional educational environment is the focus on training. Training is the way businesses ensure that each employee knows what needs to be done and how to do it. Unlike most academic education programs, abstract thinking skills are not the primary focus of the topics addressed in the training program; instead, discrete steps to accomplish a specific goal are learned.

Corporate training programs are important because they establish common guidelines for each employee and contribute to the specializations of job function we see in businesses today. Educated employees are a valuable and critical resource; they contribute to the growth of the organization and support the continued innovation that

is so key in staying ahead of the competition and winning market share.

The audience for corporate training programs is immense. The students for these programs may work in the private or public sector. They may be an entrepreneur, a company CEO, or an intern. They may be taught technical manuals, ethical decision-making procedures, how to satisfy a customer's needs, how to work in a team environment, or how to be a leader and commit to decisions. These students may or may not "learn" in the traditional sense of the word.

Guidelines for Good Training Programs

It is quite possible to set up good training programs without the use of current technology. A small company can hold meetings with individual departments to deliver instruction on company policies. Employees can take notes, ask questions, and interact with each other to learn. These sessions can be held with reinforcement questions and tests, and employees' progress can be tracked. Subsequent meetings may be held to learn an additional topics and progress through each session can be logged.

While this is an adequate process, it becomes a nightmare to manage with the addition of new employees, new business locations, and new company guidelines. In larger corporations, the cost of maintaining a staff to accomplish this becomes enormous; the cost is even greater in companies that need to train employees in more advanced skills. A 1998 study by the Information Technology Association of America found that high-tech companies -- in industries including computer systems, communications, biological and physical research, and drugs -- spend an average of $911 per employee per year on training, more than any other sector [**12**].

Can web technology improve training programs, or will it be a hindrance and fail both employee and employer? To answer this question, we should consider the qualities of traditional training programs and why they work. Most importantly, there must be good content. In particular, the subject at hand should be complete, accurate, and follow a logical progression through the course. Additionally, the content must be reusable so that a student can be successfully retrained if needed. The training programs should also have the ability to be adjusted based on future needs. This means that the course could easily be taught to employees speaking multiple languages, or additions to the content can be made without a complete reorganization of the subject.

Content delivery is critical. Students will learn more effectively by engaging in debate and collaboration with their student peers and by interacting with the subject matter

itself. Interactive learning improves on the quality of the course and the efficacy of the training itself. Finally, a course needs to be aware of its own successes and failures. This can be accomplished through student tracking and assessment. Analysis of the results of tests taken can contribute to improving the course for the future or improving the students' learning.

Technology For Corporate Education

The current capabilities of technology support a wide range of possibilities for delivering adequate training. Taking the content from a traditional training course and applying it to current technologies such as posting it on a website is obviously possible; however, it does not enhance the learning process. It does not introduce additional interaction with the material. Instead, the technology of today must be used to improve upon the existing courses. In particular, the features that will lend themselves to this are: constant connectivity, centralization of data, relational databases, search tools, expandability, portability, sever-client functionality, networking, and the application of multimedia.

Learning Management Systems

This list of features has enabled the development of Learning Management Systems (LMS), which are the center of today's corporate training. According to [**19**], an LMS is comprised of five basic components:

1. launching component (student interface)
2. course-development component (course administrator interface)
3. registration and enrollment component
4. assignment management component (manages student progress through assignments)
5. data collection component (to analyze performance)

The many available LMSs may emphasize different components. Some concentrate on managing employee tracking information, while others focus on maintaining the quality of the content. One such movement in the LMS world is the development of Sharable Content Object Reference Model (SCORM) based modules of knowledge. SCORM "includes aspects that affect learning management systems and content authoring tool vendors, instructional designers and content developers, training providers and others [**2**]." SCORM is based upon the idea that knowledge can be chunked into segments

that multiple vendors can draw from. In doing so, knowledge can be centralized and re-distributed. SCORM is based on technology which establishes a strict standard format so that it becomes the LMS's job to become SCORM-compliant.

While multiple companies will be able to share knowledge over the Web, each will probably have its own ways of applying the knowledge. Different authoring tools, LMSs, operating systems, and hardware create implementation challenges, but SCORM technology makes these differences transparent and supports interoperability [**13**].

SCORM is a relatively new application of content management. However, it is becoming more commonly used as a standard. It will provide large cost-savings to companies over a period of time as more and more adopt this new strategy. For instance, if the development of a single training program costs $20,000, and ten companies need this module, the companies will spend $200,000 in development combined before actually customizing the content and paying those additional costs. However, if there was a generic version that each company could base their specific implementation off of, less money is spent on the initial development of the content. Instead of $200,000, only $20,000 is needed for the development before customization [**13**]. Without the Web and connectivity of businesses not normally linked, the success of SCORM would not be possible.

While the content in modules of the future will be based on generic content chunks, this does not mean it can not be dynamic, flexible, and interesting. In fact, the development of the web has expanded how audio and video is brought to us. In particular, an advantage of the technology can allow for a company to buy a networked version of training modules to take advantage of the benefits of streaming media. With this type of setup, companies can stream single files to multiple employees, thereby reducing space on the server and cost to store bloated media formats. In addition, the applications of multimedia have made content more interactive and dynamic. Since each student will receive his or her own copy of the training module, they are able to individually work their way through courses. They can watch videos or listen to audio repeatedly as needed. Students can also work through simulations of high-priced equipment at a reduced cost, as opposed to working on the equipment itself.

In order to succeed in building effective training modules, elements of design, usability, and functionality must be considered. An understanding of how people learn and studies of the trade-offs between the cost and development of the module and the

actual effectiveness come into play. Interaction is important, but the module should hold the student's attention and force them to interact with a goal in mind [**15**]. They should come away from an exercise with a better understanding of the subject matter, and this can only be possible with good design, transparent delivery, and critical assessment.

The Future: Strengths, Needs, and Assessment

As we look to the future of education in a world with ubiquitous networking, we must realize that constantly assessing the performance of our solutions is paramount. We cannot be assured that the demands of teaching have been met or that the possibilities for educational professionals have been expanded without constant and rigorous assessment.

Applying the power of the Web to education draws from many different areas of Computer Science. Networking and system design provide the marvels of the communications infrastructure. Artificial intelligence and learning techniques provide models for interacting with content. Human-computer interface design and multimedia allow the student to engage the material in a meaningful way. The principles of good software engineering allow the content, lessons, and educational experience to be efficiently reused across wider audiences.

Ultimately, the task of enhancing our own educational processes and techniques requires a high degree of cooperation and coordination between a good many professionals in different fields, and we should be prepared to face the unique challenges posed by this new learning environment.

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