The Feasibility of Online Laboratories

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Abstract – Higher education is a market economy in which students seek value. State universities and colleges have long been bargains. However, online/distance learning can be delivered from anywhere on the planet to everyone where they reside. The computer hardware, software, and communication infrastructure including fiber-optic cable and communication satellites provide fast communication between computers around the world. Thus, there is a powerful economic and convenience incentive to utilize online/distance learning. The effect on education is that many courses are now available online from virtually all educational institutions. However, there is a barrier to technical online/distance learning – laboratories.

Funding for laboratory equipment continues to be a problem for engineering and technology education. Replacing old lab equipment is difficult because it is often not research equipment. There are two general types of laboratories – skill labs and knowledge labs. Soldering an integrated circuit onto a circuit board requires hands-on motor skills and hand to eye coordination. Just knowledge of how to do it is insufficient. However, many technical labs do not require learning a skill and are information transfer experiences. If a student misses an “information transfer” lab, a good video tape of the lab would be a reasonable substitute. Could the video tape be used for all students? Economically, the benefit to cost ratio would be very large. Modern laboratory equipment at private labs or other institutions could be used and the experience could actually be better than a face-to-face laboratory on outdated equipment. In addition, labs could be presented using equipment not available at the institution. Thus, online/distance laboratory experiments using audio-video and other more sophisticated information transfer methods can substitute for some laboratories and improve the variety of available experiments.

Keywords: online, laboratories, distance, education.

INTRODUCTION

We began learning from each other on a one-to-one basis as apprentices with close supervision by the master. The master and apprentice often even lived together. This system made fine brick masons. It provided excellent knowledge transfer but was inefficient for the society and expensive for the subsistence-waged, live-in, apprentice. Later, group learning in lecture classes provided more efficient mass transfer of knowledge to the group and to society. However, a college education has become very expensive. College costs are outpacing inflation and a traditional college education obtained by attending face-to-face classes is becoming less available to high school graduates. Parents are urged to set aside college money using tax-deferred annuities for each child as soon as possible. Even for non-traditional commuting students, travel to classes is an expense and inconvenience. Fortunately, education is information transfer that is ideally suited to an information society. For an impressive perspective on modern information transfer, educators are encouraged read “The World Is Flat: A Brief History of the Twenty-first Century” by Thomas L. Friedman. He describes the impacts of the recent massive investment in technology (computers and software) and infrastructure (fiber optic cable and ISP’s). These innovations make the internet literally child’s play. Because of the large economic and convenience advantages of online learning, it will continue to grow quickly. Any English-speaking educator on earth with an internet computer can teach an online course at a time and place convenient to their students. There are many such educators in the US, Canada, Europe,

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India, and Australia. Fortunately, education works both ways; there are also many students in these countries. Online classes have been developed for most disciplines but engineering and technology are lagging behind because of problems with graphic communication and laboratory experiences. Unfortunately, for many non-traditional working students, unless all of the courses can be taken online, a diploma cannot be earned and thus not begun. The Southern Regional Education Board’s “Electronic Campus was launched in January, 1998 as an ‘electronic marketplace’ of online courses and programs from the South's colleges and universities. The Electronic Campus was designed to provide learning opportunities from accredited colleges and universities that offered courses and programs that exceed SREB's Principles of Good Practice. By doing this, learners could be assured of the quality and integrity of the courses and programs available on the Electronic Campus, that comparable information would be provided to help learners in making decisions that best met their needs, and that learners could quickly and easily search the large database of course and program offerings.” Regional mentors that are convenient to online students are used to administer face-to-face exams and return them to the online instructors. [1] A required laboratory can now be shared between institutions and instructors. Many instructors may be needed to teach this lab because of the limited number of students that can be managed by one instructor.

THE STATUS OF ONLINE TECHNICAL LABORATORIES

Both knowledge and skill can be imparted in face-to-face laboratories. Soldering, surveying, machining, and similar skills require dexterity that cannot be taught just online. However, the information learned in a lab experience can be presented online reasonably well. If high quality equipment is used and the experiment is supervised by the instructor with student assistants, a remote viewer would essentially be “present.” These types of laboratory presentations can be currently found on the internet as online labs. The benefit to cost ratio of these information transfer laboratories is large. Transferring information, particularly images and video online requires higher bandwidth. Streaming video performance is poor with a dial-up connection. However, the video file can be downloaded, even overnight, and viewed later. But, this is an inconvenience and the video quality is usually low. Video should only be used to show motion that is part of the experiment. A sequence of still photographs has the advantage of higher image quality and faster internet performance. We all have experienced a good self-paced power-point presentation with images, graphics, text, and perhaps sound. This can be a reasonable type of presentation for an online laboratory and is currently being used. Whether it can meet accreditation standards as a totally online laboratory is not fully understood. One nice set of experiments of this type is shown at the following website: http://www.uic.edu/classes/cemm/cemmlab/ [2]

The current ABET Engineering Technology Accreditation Criteria are as follows: An engineering technology program must demonstrate that graduates have:

a. an appropriate mastery of the knowledge, techniques, skills and modern tools of their disciplines,
b. an ability to apply current knowledge and adapt to emerging applications of mathematics, science, engineering, and technology,
c. an ability to conduct, analyze and interpret experiments and apply experimental results to improve processes,
d. an ability to apply creativity in the design of systems, components or processes appropriate to program objectives,
e. an ability to function effectively on teams,
f. an ability to identify, analyze and solve technical problems,
g. an ability to communicate effectively,
h. a recognition of the need for, and an ability to engage in lifelong learning,
i. an ability to understand professional, ethical, and social responsibilities,
j. a respect for diversity and a knowledge of contemporary professional, societal and global issues, and
k. a commitment to quality, timeliness, and continuous improvement. [3]
Many of these items relate to understanding and application of appropriate tools/experiments/systems that are appropriate to the discipline. The near future will determine whether online laboratory experiments can be designed to satisfy these ABET accreditation criteria.

**Faculty Online Laboratory Resources**

The Massachusetts Institute of Technology (MIT) and Microsoft are currently developing the iLab to provide online engineering laboratories. Software is being developed for online experiments for use on a variety of PC platforms such as Windows, Apple, and UNIX at multiple institutions. The MIT iCampus will disseminate laboratory experiments for undergraduate and graduate curricula in the US, Europe, Africa, Asia, and Middle East. Other institutions are invited to participate in the development of the labs. [http://web.mit.edu/edtechfair/projects/ilab.html](http://web.mit.edu/edtechfair/projects/ilab.html) [4]


NEEDS “The National Engineering Education Delivery System is a digital library of learning resources for engineering education. NEEDS provides web-based access to a database of learning resources where the user (learners and instructors) can download and comment on resources to aid their learning or teaching process.” [http://www.needs.org/needs/](http://www.needs.org/needs/) [7]

The use of internet material is encouraged by the WebCT administrators at the University of Southern Mississippi. This greatly increases the amount of material that is available for online laboratory use. The web contains many high quality laboratory experiments that can be linked for presentation to students. This can be done without permission even if the document contains a copyright notice. Links are just addresses to the locations of documents and just linking to them, even for profit, is not copyright infringement.[8] Otherwise, Google would be in violation of copyright law. “Many people assume that everything posted on the Internet is public domain, probably because our law used to protect published works only if they displayed the proper copyright notice upon publication. The law, however, has changed: neither publication nor a notice of any kind is required to protect works today. Simply putting the pen to the paper or in the electronic medium, putting the fingers to the keyboard creates a copyrighted work. Once expression is committed to a tangible medium (and computer media is considered tangible), copyright protection is automatic. So, postings of all kinds are protected the same as published printed works.” [http://www.utsystem.edu/ogc/intellectualproperty/useofnet.htm](http://www.utsystem.edu/ogc/intellectualproperty/useofnet.htm) [9] For online course materials, the following website is useful. [http://www.utsystem.edu/ogc/intellectualproperty/copypol2.htm#distance](http://www.utsystem.edu/ogc/intellectualproperty/copypol2.htm#distance) [9] Manufacturer’s websites often contain good equipment images, descriptions, and specifications. Requests for permission to use such material by this author were replied with: “Please use all you want. We will send you higher resolution images if you would like them.” Manufacturers like free advertisement.

**The Future of Online Laboratories**

The internet technology will continue to evolve including innovations in home computers including video conferencing, connection access speeds and availability, communication software, virtual reality hardware and software, and lower costs. We can expect continuing improvements in the realism of online laboratories. Computer game developers use the term “immersion” to describe the experience of suspension of one’s personal reality and acceptance of the game’s reality. In the future, we can expect students to become “immersed” in their virtual laboratory experiments. Currently, sight and sound are commonly communicated over the internet. However, force feedback joysticks and steering wheels are now used to provide realistic tactile feelings in many online games. Flying an airplane online using force feedback is a realistic and a useful experience. The “experiment” of stalling the airplane looks right, sounds right, and feels right. Touch-sensitive displays can also make the human-computer interface more natural. Streaming video and downloaded video can provide almost the exact experience of watching a demonstrated experiment. Some experiments are too dangerous to do face-to-face -- such as runaway
DC electric motors. But, they can be done in a virtual laboratory. It is clear that we are just at the beginning of high quality virtual laboratories.

Remote control of actual testing equipment is on the horizon. We can expect laboratory equipment manufacturers or third party companies to develop computer interfaces for laboratory machines for worldwide training and for leasing to distant users for their own supervision of the remote testing. The transducers for such interfaces are present technology. These systems would be available for use by universities and education consortiums for laboratory course development. Computer Aided Manufacturing (CAM) is currently controlled through the internet. Remote control of laboratory equipment and virtual laboratories are competing technologies and the best value will probably prevail.

Although synchronous teaching/learning is not as convenient as non-synchronous teaching/learning, video conferencing is an important way for a class to participate in an online laboratory experiment. The students are able to ask questions and redirect the experiment if necessary. They can also view the equipment and take the readings.

**CONCLUSION**

Robert Ubell of the Stevens Institute of Technology stated that for his “WebCampus,” the future looks bright, with more programs, more courses, and more students entering online learning in greater numbers in those fields in which have earned Stevens an enviable reputation in science, engineering, and management. [10] The need for high quality online laboratory experiments is obvious. Whether online laboratories can satisfy accreditation probably depends on the sophistication of the online presentation. Students and faculty are becoming more familiar with online learning and teaching. This method of instruction can be expected to evolve and better satisfy both the learner and teacher. It is clear that virtual laboratories will eventually be developed to meet any reasonable ABET criteria for accreditation. Such a virtual lab would allow each student to do a one-on-one experiment that often does not occur now in face-to-face labs. Well-written virtual laboratory software would be much less expensive than purchasing the teaching laboratory equipment. Perhaps, only the virtual laboratories will prevail and be used for all students.

**REFERENCES**

[1] Southern Regional Education Board http://www.sreb.org/
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