AC 2003-179: HOW TO MAXIMIZE LABORATORY EXPERIENCE OF ENGINEERING TECHNOLOGY PROGRAMS USING ELECTRONIC MEDIUM

Albert McHenry,

John Robertson, Arizona State University

Lakshmi Munukutla, Arizona State University

Richard Newman,

How to Maximize Laboratory Experience of Engineering Technology Programs Using Electronic Media

Lakshmi Munukutla, Albert McHenry, John Robertson, and Richard Newman
Arizona State University East
College of Technology and Applied Sciences
Mesa, Arizona

Abstract

The embedded laboratory experience associated with engineering technology curricula is an added benefit to the engineering technology students and their preparation to immediately make an economic contribution upon employment after graduation. However, in the era of web enabled education, a challenge is posed by the need to replicate live laboratory experiences using electronic media processes. The Microelectronics program at Arizona State University East is sincerely attempting to deliver the laboratory courses through distance learning to accommodate compressed work schedule of students and to reach the students who must be at remote sites. The purpose of the paper is to survey the existing distance education formats that are currently in use to deliver laboratory courses and also cover the work-in-progress at ASU East. This paper will categorize and discuss various formats that are being used or tested in engineering technology programs nation wide. Goal one is to collect and present information that will help the reader to draw conclusions about the urgency of creating electronic laboratory workbooks that support comparable experiences for students, whether they are participating through distance learning or in live laboratories. Goal two is to provide and discuss the methods and best practices that are currently in use.

Introduction

Evolution of the World-Wide-Web has brought an incredible pedagogical shift in the delivery of higher education. As a result of this global revolution, higher education institutions are challenged to implement flexible delivery systems. A major factor is to use online delivery as a viable option to serve remotely located degree-seeking and life-long learning students. The use of electronic content delivery methods provides flexible learning environments and removes many barriers associated with location, time and many other stumbling blocks pertinent to students. Integration of laboratory experience into the course work is the major differentiation factor of engineering technology programs from other program types across the Nation. The educational principle associated with laboratory experience is to motivate students and create a better learning environment where they can conduct experiments, compare reality with simulations, collaborate with each other and explore following their curiosity. The rapidly evolving technological landscape often challenges educators to devise innovative pedagogical approaches to enhance students' educational experiences irrespective of where they reside (on campus or remotely located). Therefore, there is a compelling need to explore and implement either a single model or amalgamation of best practices to enhance laboratory experience of students.

Background

Many higher education institutions, both public and private are aggressively pursuing outreach to students without regard to geographical boundaries. These efforts are making available degree and non-degree program offerings using electronic media. The institutions use instructional delivery methods that do not require the student to be physically located at the same site as the instructor, which is called distance learning. Distance learning has its genesis in the delivery of content through correspondence courses. Consequently, distance learning is not a new concept to higher education. However, the World -Wide -Web through technological innovation made distance education more popular and attractive than ever. In addition, today's college students are very different; they are computer literate, mature, and prefer to integrate their studies with work and family to achieve their career goals.

Today, almost every higher education institution is engaged in educational program content delivery over the web at some level. However, the survey conducted for this paper only includes those institutions that are engaged in distance delivery of laboratory courses (Table 1).

Table 1

Institution	Course
MIT	Microelectronics WebLab.
Rochester Institute of Technology	On-campus laboratory.
University of North Texas	Circuits laboratory accessible by Internet.
Northwestern State University of Louisiana	Electronics Engineering Technology Laboratory course on the World-Wide-Web.
Kentucky Technical College System	Two-way interactive classrooms with video distributing network.

Arizona State University uses Blackboard as the enabling software for web delivery of courses. Traditionally, lecture based courses are more amenable to web delivery compared to laboratory courses. Blackboard, along with most of the enabling software is best at supporting the lecture format. However, the authors of this paper are interested in exploring ideas and methods to maximize the engineering technology students' laboratory experience through distance delivery. In general, faculty in engineering and science based disciplines are significantly challenged to deliver high quality laboratory experiences at a distance. Hence it is paramount that better techniques are created to deliver laboratory oriented courses through web delivery, where the student's remote laboratory skill development comes close to replicating that of live laboratory experience.

Microelectronics Curriculum layout

The Microelectronics Teaching Factory (MTF) at Arizona State University East is a 15,000-sq.ft class 100 cleanroom equipped with late generation semiconductor device fabrication tools. The Electronic Engineering Technology (EET) curriculum with a microelectronics concentration integrates an intensive laboratory component into the course work in this special environment. In order to accommodate the schedules of working students, the courses are offered using flexible schedules. Figure 1, shows a typical course delivery design to accommodate the working student population. The course development strategy is based on the following outcomes.

Graduates should be able to:

- Adapt easily to new technologies
- Be capable of independent thinking
- Communicate quantitatively thru 360°
- Operate in multi-disciplinary teams
- Troubleshoot and design
- Be effective project managers
- Understand limitations

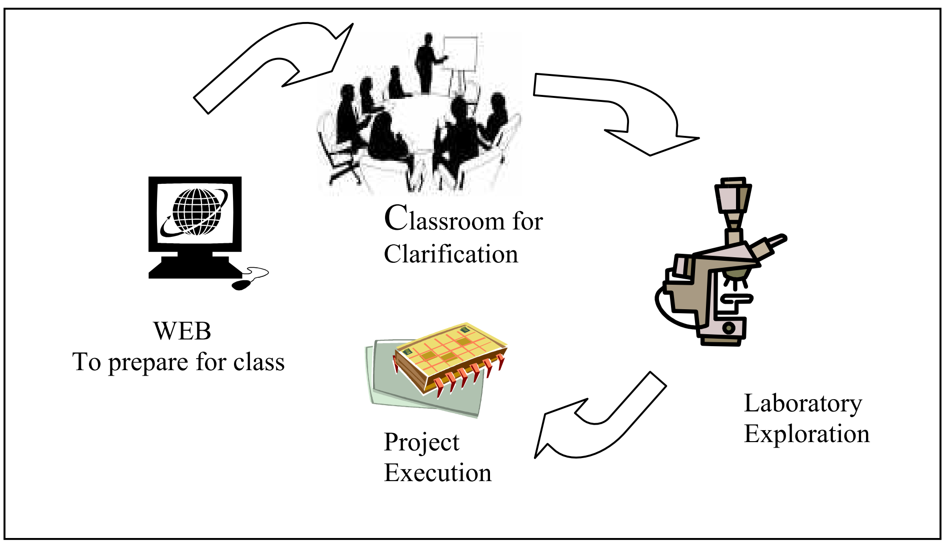

Figure 1
Microelectronics Curriculum Delivery Format at Arizona State University East

The content delivery plan that is being tested in the microelectronics curriculum is a hybrid model that consists of a combination of web enabled course material available for students to prepare ahead for the class followed by in class discussion facilitated by the instructor. The laboratory component of the course provides the environment that enables the student's exploration application of the target knowledge and skill. The interaction of the student and the environment is crucial for learning construction into useable knowledge. Then through execution of a project, the student tests the knowledge acquired and the ability to apply it. The capstone experience also allows the student to build a better understanding of the target knowledge and to acquire and improve the skill to apply this knowledge.

There are institutions that have a head start in offering online laboratories. MIT [1] is one such institution. It has developed a microelectronics WebLab, which can be accessed from student's dorm rooms, remote students located in another country such as Singapore or any other convenient location, 24 hours and 7 days a week. The MIT professor says, "If you can't come to the lab… the lab will come to you!" [1]. Among engineering technology programs, Rochester Institute of Technology [2] is offering online degrees with requirement of on-campus laboratories, which is closer to the model at Arizona State University East (ASU East). The only differentiation is that ASU East does not offer the entire degree program online yet. Other Engineering Technology programs are offering individual courses such as Circuits Laboratory and some introductory AC/DC circuits with a reasonable success [3-4].

Online delivery of Microelectronics courses using Hybrid Model:

The Microelectronics Teaching Factory at ASU East offers a *New Approach to Education* by offering a learning environment which includes: flexible class schedule; web-delivered courses; industry mentoring and industry-like infrastructure aimed at preparing a work ready graduate. In order to achieve this mandate, the hybrid model has been selected as the best fit.

The hybrid model mixes the content delivery processes. Fig. 1 shows the mixed methods of delivery used to take full advantage of the laboratory content in the courses. The primary goal of this microelectronics program is to prepare work ready graduates for the semiconductor industry, therefore the authors believe touch and feel experience in the laboratory and face-to-face interaction among students and between student and the instructor has to be included as part of the learning environment. However, the component elements and events do not have to occur on a uniform basis for a fixed length of time. In order to provide flexibility to the face-to-face students, remote students and working students, the gatherings can be set after polling the members of the class and time duration can vary anywhere from 1-3 days. Therefore the majority of the lecture and laboratory preparation can be accomplished online. In order to make this model friendlier to students, both lecture and laboratory material need to be accessible to students on demand from their desktops both synchronously and asynchronously. Having student access to remote laboratory with video streaming capability and distributing this video to remote sites where students are located makes this task more feasible and minimizes the face to face meetings. However, this approach demands more self-discipline from students to maximize their learning experience.

Recently Kentucky Technical College system, which includes five Community Colleges, built a full-blown television studio with a powerful video distribution network using

VBrick products to provide two-way interactive classrooms at their campuses [5]. The VBrick system provides access to plug in a camera and microphone system to create a television studio across the interactive TV network. Instructors having access to this portable system in their classroom or laboratory can convert any classroom into a TV studio and then distribute the output across the interactive network. A typical system is shown in Figure 2. [6]. This is one example to implement distance delivery in a cost effective manner in any laboratory or lecture environment.

The tools in MTF are complex so having this capability in the laboratory provides tool access to the students on demand as many times as they require, followed by conventional touch and feel experience to enhance their total learning experience.

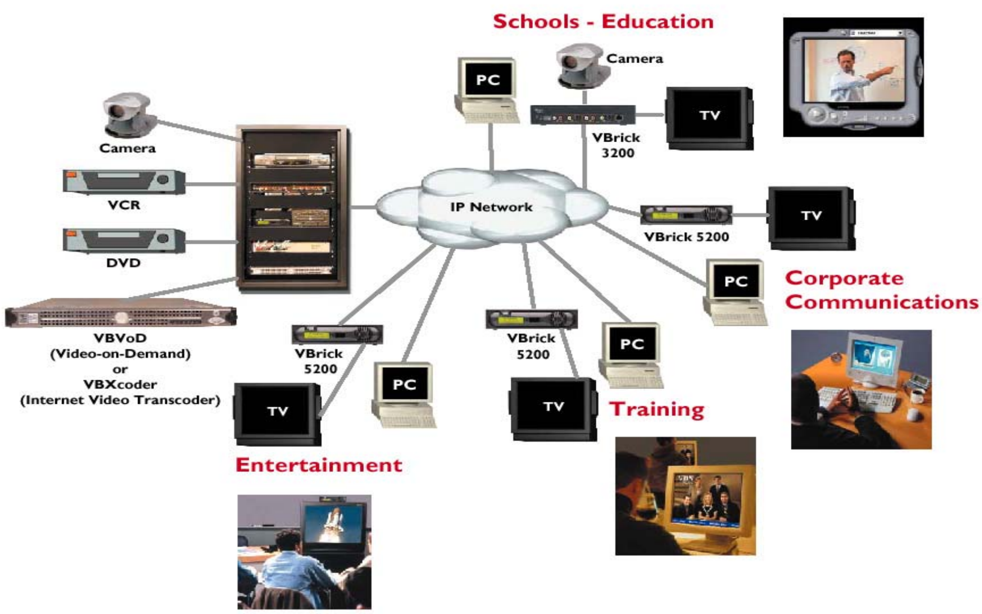

Figure 2, Source: Vbrick.com
Two-way Interactive Classroom model set-up with Vbrick products

Conclusions

MIT's Weblab is very close in meeting all the characteristics of online laboratory course. Other approaches delivering the online lab courses concur with the hybrid model that is discussed in this paper. Availability of resources at each institution is the primary determining factor in selecting a given method. Therefore, a best practice at one institution may not become a best practice at other institution. Hence, the hybrid model may be the best method that is available today through its greater flexibility.

Online laboratory course offerings are beginning to emerge and still there is long way to go before they become popular using electronic media as mainstream delivery system. The Microelectronics program at ASU East is at its beginning phase to provide online laboratory experience to our students along with traditional hands on laboratory using hybrid approach. The progress of our effort will be disseminated regularly and at the same time leave the door open to learn and implement best practices from others.

Bibliography

1. *MIT News*, http://web.mit.edu/newsoffice/nr/2001/weblab.html.
2. http://distancelearning.rit.edu
3. *A Circuits II Laboratory Accessible by Internet,* Mitty C. Plummer, Charles Bittle, and Victor Karani, Session 2248, Proceedings of the 2002 American Engineering Education Annual Conference & Exposition, Montreal, Canada, June 2002.
4. *EET Laboratory Courses: From the Classroom to the Web-From Research to Practice,* Session 2248, Proceedings of the 2002 American Engineering Education Annual Conference & Exposition, Montreal, Canada, June 2002.
5. *Vbrick,* AV Video Multimedia Producer, avvmmp.com, April 2002.
6. www.vbrick.com

Biographical Information

Lakshmi Munukutla received her Ph.D. degree in Solid State Physics from Ohio University, Athens, Ohio and M.Sc and B.Sc degrees from Andhra University, India. L.V. Munukutla developed an interest in semiconductor device processing technology and characterization while she was working at Motorola Inc. She has been active in research and published several journal articles. She holds an Associate Dean position in the College of Technology and Applied Sciences at Arizona State University East.

Dr. Albert L. McHenry is Professor and Dean of the College of Technology and Applied Sciences at Arizona State University East, Mesa, Arizona. He holds a BS Industrial Technology from Southern University of Baton Rouge, Louisiana, a MS Technology and a Ph.D. Technical Education from Arizona State University. His area of technical specialization is digital electronics. His current research interests include noise in digital systems design methodology and effective paradigms in engineering technology education. He is Co-director of The Western Alliance to Expand Student Opportunity, a National Science Foundation Alliance for Minority Participation project. He was the recipient of the 2002 James McGraw Award and the 1996 ASEE, Fredrick J. Berger Award.

John Robertson is a professor in the Department of Electronic and Computer Technology at ASU's East campus in Mesa, Arizona. From 1993 to 2001, he held a number of senior R & D positions in Motorola's Semiconductor Products Sector. His earlier academic experience was as Lothian Professor of Microelectronics in Edinburgh University, UK where he managed a national research center and developed continuing interests in process control and the global economics of semiconductor technology.

Richard L. Newman joined Arizona State University East (ASUE) in August of 2001 and currently serves as Director of Training Operations for the Microelectronics Teaching Factory. In this position Mr. Newman is responsible for the identification, development and delivery of education and training for the semiconductor manufacturing industry. Prior to joining Arizona State University, Richard served twenty years as a faculty member and administrator within the Division of Technology and Applied Sciences at Arizona Western College and the University of Arizona. He most recently held the position of Associate Director at the Maricopa Advanced Technology Education Center (MATEC). MATEC is a national center of excellence funded by the National Science Foundation (NSF) that focuses on workforce development for the semiconductor manufacturing industry.