e-Technology Must Enable Big Education Goals

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Abstract

E-learning technology in engineering education must enable big education goals. Too often technology is an unevaluated adjunct to what is an old and ineffective curriculum. Instead a set of aggressive education reform goals must be established, focusing on the engineering profession of the future and today's student learner. Then e-learning technology can help satisfy these goals. Conversely knowledge of e-learning technology allows the educator to consider goals that are otherwise unreachable without the technology. Today's e-learning technology is in its infancy. This is the time to try bold experiments and to carefully measure (evaluate) the outcomes of these experiments. In this way new models can emerge as the preferred engineering education models of the future.

TEE 2002
A UNITED ENGINEERING FOUNDATION CONFERENCE
Davos, Switzerland 11-16 August 2002
http://www.coe.gatech.edu/eTEE

I. Introduction

With e-learning technology in its infancy (the World Wide Web is less than 10 years old) this is the time to try bold experiments in its use. These bold experiments must be carefully constructed to achieve student-learning objectives and not be simple-minded "stunts" that demonstrate technology with no measurable improvement in student learning. A synergy must appear between the advance of technology and the aggressiveness of education goals. Evaluation (measurement) of outcomes is essential. In this paper we will explore what these goals might be and how e-learning technology might enable them.

At the simplest level, ubiquitous information technology in the form of office productivity software, e-mail and now the World Wide Web offer opportunities to improve education just as they have influenced all aspects of modern life. In this paper, these will be characterized as "low hanging fruit", meaning that education is not special in its particular use of them. Educators simply take advantage of what is available at low price due to the immense volume sales of this software.

At the infrastructure level, e-learning technology has the potential of changing the educational institution venue. Certainly distance learning has had some success in particular niches. However, there is significant uncharted territory with regard to the use of e-learning technology to define what is done in the classroom, what is done out of the classroom, what is done on-campus and what can be done off-campus. Often times e-learning technology enables access to education that is otherwise inaccessible. Yet this same technology can be used to improve learning in the conventional setting by redefining roles.

In Section II we briefly look at the use of ubiquitous software in the engineering education. In Section III we discuss the effects of e-learning technology on institutional infrastructure. In Section IV we review an example of e-learning technology applied to a large enrollment computer sciences class. This is a modest example of big reform at the individual course level. Section V contains our conclusions.

II. Ubiquitous Software-Picking the Low Hanging Fruit

Engineer education has aggressively adopted the conventional ubiquitous software for its needs. Word processors now have built-in mathematical equation editors, as do presentation-authoring programs such as PowerPoint. Complex figures and graphs can be easily included in documents. The dominance of Microsoft in this office productivity software has led to de facto standards of information interchange that has greatly influenced student and faculty access to common information. It is important to recall that this productivity software took on its current role in the 1980's before the widespread advent of networking. The World Wide Web and the killer application of the 1990's, the Web browser, have had an equally great influence on engineering education as the office productivity software. Seamless access to information over computer networks through the use of standards such as HTML (the language of the Web) has been the major influence. And finally, conventional e-mail has long been a standard communications mode between engineering faculty and students. The engineering education model of today is shaped by all of these software innovations.

However, in all of these cases, the ubiquitous software has only improved upon or amplified conventional educational practices of the past. The course Web site has replaced the mimeograph machine and the reserve desk. E-mail has amplified office hours to anytime queries and answers. Documents are more professionally prepared with very little effort and at very low cost, however, the basic textual and graphic content is the same as in the past.

Nevertheless in its entirety ubiquitous software has had a profoundly positive influence on engineering education and its use will continue to provide improvements.

III. E-Learning Technology Impact on Infrastructure

If the overarching goal is improved learning experience for undergraduate engineering students through the use of e-learning technology, then many major realignments of the infrastructure must occur. Some of the most notable of these are outlined below.

A. Anytime and Anywhere Learning

E-learning technology breaks the time and place constraints of the classroom. This is true for distance education as well as for the conventional resident college experience. The power of breaking the time and place constraint is not yet fully understood. The idea of synchronous and asynchronous learning is important to this discussion. In the conventional setting, synchronous learning is associated with the classroom. What is best done in this synchronous format? Clearly one-way information transfer in lecture format is what is often accomplished. Historically this is what has been given highest priority because this is the only time that the professor has with the students to transfer his/her knowledge to them. We know that this is a flawed model. E-learning technology offers the opportunity to change this model. One example of this is explored in Section IV.

Today, a special distance education department in most colleges administers distance education. As e-learning technology blurs the lines between on-campus and distance students the role of conventional departments will change as they "take ownership" of both categories of learners. This will require a significant change in faculty attitudes and will likely demand a change in faculty incentives. It will also demand a change in department staffing to serve distance students.

B. Student Assessment and Credentialing

As the identity of on-campus and distance learners blurs there is the possibility that colleges will more explicitly become credentialing institutions. Students with a portfolio of courses will request that a degree be conferred upon them. The decision to confer the degree will depend upon not only the courses taken, but upon the "habits of mind" of the student. Habits of mind are defined as the way students come to know. This is quite different than what they know. It is habits of mind that engineering students carry with them throughout their careers and is the defining quality of an engineering education. The student knowledge base is generally the focus of faculty, students, and parents. Yet employers often say they are most interested in the habits of mind. They are quite confident that engineering colleges will adequately teach the students about thermodynamics and mechanics. They are instead more interested in problem solving skills, communications skills, and team building skills. These are often cited as defining factors in engineering leadership. Measurement of this will require very different techniques than those used today to assess students. This will likely demand a greater share of faculty time and skill than is currently the practice. The degree to which e-learning technology can contribute to this issue may in fact involve solving the conventional problem of assessment of the knowledge base, leaving the faculty with time to do the more difficult assessment of habits of mind.

C. Physical Infrastructure and Total Immersion

Physical infrastructure must change as e-learning technology replaces conventional lecture halls. This is already evident in engineering colleges. More group project labs will be required for active learning experiences between faculty and students. Access to these labs must be given to students "after hours". Access to computing hardware, software and networks is essential. Wireless networking must be commonplace anywhere that students choose to study. A total immersion environment must be provided to students—reducing the barriers to learning resources. Support systems such as course registration must be modified to accommodate new course delivery methods. The student portal will become an essential resource for all students.

D. Technical Staff

The extensive use of e-learning technology will cause a realignment of college staffing. Technical professionals in e-learning software and hardware must be in place in order to successfully use this technology. Otherwise the best faculty intention leads to chaos for the learners as systems to facilitate anywhere and anytime learning instead result in all-the-time frustration. A substantial change in motivation among administrators is required. Today the incentive is to hire as many research-oriented faculty as the budget will allow. In many colleges 90% of the budget is devoted to faculty salaries. Optimum e-learning enabled undergraduate education likely requires a different emphasis. Sorting out the optimum mix of faculty and technical staff constrained by fixed budgets is a challenge.

E. Curriculum Coherence versus Flexibility

Perhaps the largest infrastructure change enabled by e-learning technology is the concept of "just-in-time learning". The current situation sees freshman and sophomore engineering students spending much of their time in math, physics and chemistry courses, preparing them for later engineering science courses. The use of technology allows us to consider a curriculum where engineering students studying engineering science can conveniently reference background math, physics, and chemistry through on-line resources. This has both benefits and drawbacks. As course material becomes tightly interlinked, the learner will be benefited by a more cohesive and coherent curriculum. However, this same coherence could lead to a less flexible curriculum, requiring the learner to stay in lock step with the curriculum. This creates problems for students who cannot remain in lock step with the curriculum for a number of reasons. These could be transfer students, part time students, either on-campus or at a distance. Some on-campus programs use a lock step cohort model—particularly in professional schools such as medicine, pharmacy, and business. Some distance education curriculums use a lock step cohort model, but most emphasize flexibility. Meeting both of these needs with e-learning technology is challenging and there are no obvious solutions. The creation of content metadata standards such as SCORM offers the promise that coherence and flexibility can be simultaneously achieved using e-learning resources.

IV. E-Learning Technology at Work—eTEACH

In recent years there has been awareness that the engineering curriculum is falling short of industry expectations and most curricula now include a number of key features: including freshman engineering practice courses and senior capstone design courses. However, the vast majority of engineering courses are taught in a lecture format—both early large enrollment introductory courses and advanced senior-level courses. The professor lectures, the teaching assistants run labs and grade homework. Furthermore, the courses are very loosely coupled to accommodate the variations of content selected by individual faculty.

One example of such a course was Computer Sciences 310 taught at the University of Wisconsin–Madison. This course in numerical methods with Malab and Maple applications is taken by 300 sophomore engineering students each semester. It was previously taught as two large enrollment lectures per week and one TA-monitored computer lab. Starting in Fall 2000 using the eTEACH streaming video presentation software [1] CS 310 was reformed to include: eTEACH lectures viewed at the students' convenience; a skills-based computer lab on either Monday or Tuesday; and a new faculty-taught student team-based computer lab for problem solving on Thursday or Friday. We describe this reform as reversing the lecture-homework paradigm. The students now view the lecture in their own time and the class time is spent on problem solving with the professor as the mentor. A professional evaluator evaluated this new format and the findngs were very positive [2]. Two-thirds of the students preferred the eTEACH presentations vs. the conventional large lecture format. Many other measures of student opinion were collected and reported. The course has been packaged using the WebCT course management system so that all of the lectures, notes, lab write-ups, and homework sets are available on the course homepage.

We can elucidate the impact of this reform using the seven principles for good practice in undergraduate education [3]. These principles were not designed specifically for engineering education but they serve this purpose well. Good practice in undergraduate education:

1) encourages student-faculty contact;
2) ncourages cooperation among students;
3) encourages active learning;
4) gives prompt feedback;
5) emphasizes time on task;
6) communicates high expectations; and
7) respects diverse talents and ways of learning.

The student – faculty contact is improved with the reform because faculty now teach the team labs and are face-to-face with the students, actively observing their problem solving strategies and offering advice and support. The team labs demand cooperation among the students. Students are only graded for attendance in the labs to emphasize cooperation and focusing on problem solving skills. The team labs encourage active learning. Everyone has a role to play so there is no opportunity to "tune out" during the lab as is so commonplace in large lectures. The team labs provide prompt feedback because students can observe others and know how they stand in their level of understanding of the material. The labs emphasize time on task because students are actively working on problems similar to the homework exercises. The course format is very well defined with on-line eTEACH presentations followed by an on-line quiz over the presented material, skills labs early in the week, and problem solving labs late in the week. This is repeated week after week throughout the semester. Finally, the on-line lectures follow the course notes. The labs connect to the lectures, building computer and problem solving skills. There is a rich set of learning modalities.

The infrastructure requirements for the reformed course are different than the conventional course. There is no need for a large lecture hall, but the team lab was specially constructed by the College of Engineering to accommodate three students at each computer in a work cell arrangement. Amusingly, our on-line course registration system does not allow for labs without a lecture section. Thus we have to use a "virtual lecture" for our timetable so students can successfully sign up for CS 310. This anecdotal example shows how innovation often runs into inflexible infrastructure. The students record their attendance in the team lab using WebCT by taking a one question – one answer quiz that is recorded in the WebCT grade database. For the quiz we restrict IP numbers to those in the lab so that students who oversleep cannot record their attendance from their dorm room.

Faculty time on task is increased in the reformed course because faculty teach four lab sections per week compared to two lectures per week.

V. Summary

Now is the time for bold e-learning technology experiments that challenge the conventional practices of engineering education. These experiments must be carefully conceived and undertaken and the outcomes must be carefully evaluated (measured). Only in this way can the motivation for lasting infrastructural changes be created.

Acknowledgments

This work was supported by the NSF through the EOT PACI program and by the University of Wisconsin - Madison.

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