An Internet-Based Framework For Supplementing Engineering Curricula

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Abstract

This paper describes a novel approach for meeting some of the needs of students and faculty in the rapidly evolving Engineering Programs at the University of Tennessee at Chattanooga. The concept involves the development, and delivery over the Worldwide Web, of a series of Micro eCourses, or MeCs. Initially, three broad areas were considered as the focal point for the design of the eCourses. Two of these areas are common to all engineering students. The third is aimed squarely at students enrolled in the Engineering Management Program. The three broad areas are: Freshmen Engineering Seminars and Computational Methods; Senior Engineering Design; and Technology Entrepreneurship, Leadership and Management. Each eCourse, or MeC, consists of a collection of essays or lectures, handouts and self-study guides, which supplement one or more courses offered in the area.

The concept of eCourses, its relevance and value to evolving engineering education is discussed. The paper describes how eCourses are being in developed for the Engineering Programs, at the University of Tennessee at Chattanooga.

Introduction

Faculty, in most university engineering programs, recognize that some of the knowledge that students will benefit by, or even require, in order to be competitive in the marketplace, cannot be imparted within the structure of most conventional engineering curricula. What, then, can or should be done about this need?

At the College of Engineering at the University of Tennessee at Chattanooga, faculty are addressing this need in several ways. One of the approaches involves a framework for the development, and delivery over the Worldwide Web, of a series of Micro eCourses, or MeCs.

The concept of Micro eCourses evolved out of the needs and opportunity, uncovered by collaborating faculty, while teaching different categories of courses in the undergraduate and graduate engineering programs. Some of these courses, which pointed to the need and the value of special topical materials, are Freshmen Engineering Seminar, Introduction of Computational Methods, Engineering Economics, Senior Engineering Design, Technology Entrepreneurship and Leadership, and Ethical and Legal Perspectives.

Rapid Changes in Engineering Programs

The ABET-accredited Engineering Programs at the University of Tennessee at Chattanooga, which include BS and MS Programs in Engineering Management, are evolving rapidly. Changes are being driven largely by the needs and the anticipated requirements of present and future students and of their current and prospective employers. The latter, in turn,

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must position themselves to respond to, or better still, to anticipate and prepare for rapid changes that are occurring in our
global economy.

Increasingly, businesses - the employers of our students - are dominated by the many currents of change generated across
the world and felt everywhere faster than ever before. Our focus is upon three of these currents, which are generated by:

• continuing advances in computer technologies and software, fuelled by faster and smarter microprocessors, higher
  storage capacities, and lower hardware costs;

• accelerating advances in communications technologies, including networking and communications at local, wide area and
  global levels, using and interfacing between wireless, cable, and satellite technologies as never before imagined by the
  lay person;

• and accelerated use of personal computers as a tool to access the Internet and the Worldwide Web for information,
  entertainment and education and, in the case of businesses, more significantly for eCommerce.

**How Can Engineering Programs Respond to Technological Changes?**

A university engineering program, with appropriate funding and administrative support, can respond readily to the first two
currents, generated by the surging computer and communications technologies. This can be accomplished by directly
delivering relevant curricula to students choosing to study in those areas.

Students who choose these new areas of studies, then, would be expected to be equipped to meet the business challenges
and to take advantage of technological advancements in these areas. That is to say, they would be expected to “ride the
waves” of technological changes on behalf of their employers or the businesses they represent.

Unfortunately, the effect of enabling the graduate to ride the technological wave, if that indeed is an objective of engineering
education, does not always follow from the cause of having completed an engineering curriculum rich in relevant technology.
A major reason for this is the magnitude of the influence exerted upon performance and success by the third set of currents -
those that are generated by the application of the changes caused by advancing technology. That is to say, if the graduate
is unable to utilize the ubiquitous results produced by the technological changes in a practical and effective manner, it will be
difficult to see, much less ride, the wave. How, then, should we equip our students for such challenges?

The obvious solution may appear to be the addition of one or more timely courses to rectify this deficiency. These new
courses may cover topics such as: Introduction to the Internet and the Web, Web Authoring, Principals of eCommerce, etc..
One does not have to look beyond the local technical community colleges and continuing education programs at universities,
to see a wide variety of such courses being offered. Such course come and go like the waves in an ocean.

Does a university engineering program seek to ride such waves, or metaphorically speaking, to join the parade through this
revolving door? On the other hand, does the university program accept its inability to respond effectively and completely to
observed changes?

The answer to both questions is no.

How, then, can the university engineering program equip its graduates to ride the swelling waves, or to hit the ground
running, so to speak - fully equipped and familiar with how business is conducted in the world?

The Engineering Program at the University of Tennessee at Chattanooga has responded to this dilemma in at least four broad
ways:
• New courses are designed and added, and courses and curricula are modified and enhanced, while increasing the use of computer and Internet applications throughout the Program, even in "non-computer" courses. These responses are, of course, expected of, and are evident in, all well-run engineering program.

• The Senior Engineering Design Project was redesigned to use the Internet as the key communications and research vehicle. This provided students with many of the experiences that they would gain during their employment (Chopra, et. al., 1997 and Thomason and Chopra, 1998, 1999a and 1999b).

• Courses are being selected, from those presently offered, for partial or full delivery over the Web. In addition, new courses are being designed especially for Web-based delivery. These enhancements will provide the flexible and extended learning experience that many working students now desire.

• A novel concept of Micro eCourses, or MeCs, has been introduced for the delivery of special topical materials over the Worldwide Web. MeCs are a series of short courses, or a group of lectures that are aimed at special areas that "fill the gaps between the bricks," so to speak, of formal courses.

The Concept of Micro eCourses

MeCs differ conceptually from other forms of Internet based learning to supplement classroom instruction. Examples of the latter include class notes posted on the Web, "timely" Web-based courses offered by technical and community colleges or continuing engineering departments, or so even the so called "distance earning” courses and symposia.

The differences are evident from the five basic requirements for MeCs, which are listed below:

• A MeC is not, can not, and should not be offered as a formal course in the degree program.

• A MeC should be useful to students enrolled in more than one formal course in the program.

• A MeC should be focused upon one issue, problem, or question.

• A sacred rule for all MeCs is that they should represent the best thinking on the subject to date. On a technical topic, for example, the MeC must represent the latest developments. This is a quality requirement that all MeCs should be subjected to, with no less vigor that any accredited academic course.

• An important measure of the value of a MeC is the range of its applicability or usefulness. That is to say, a MeC that is useful widely across courses and disciplines would be considered of higher value than one whose usefulness is limited to one or two courses, all other factors remaining the same, of course.

Metaphorically speaking, MeCs provide the mortar to complete the building, where the stones and bricks do not properly match or overlay. Clearly, if we could construct the building by interfacing the stones directly, as did the Incas of Andean Peru, no mortar would be required (see Figure 1 and Chopra, 1999a).

MeCs characterize, and in some ways emulate, the ways in which future graduates will continue to learn and contribute to their professions, throughout their careers, using both stones and mortar.
Selection of Topics and Content for Micro eCourses

The need for the mortar of topical and inter-disciplinary materials, to support and enhance our formal curriculum-based education, became evident during in our Senior Engineering Design Project (Chopra, et. al., 1997 and Thomason and Chopra, 1998, 1999a and 1999b). In recent years, the Project has been re-designed to run as a corporate entity, highly dependent upon the Internet as a communications and research tool (Thomason and Chopra, 1999b). Knowledge and training related to many of the "skills" that the students were expected to learn, via the Project experience, had not been offered in any other course in the Program. In addition, there was not readily available any single source, or a small collection of sources, which the instructors and students could refer to.

The faculty and students spent considerable time and effort to collect relevant information, and took pains to organize and edit the materials for use by current and future Project participants. The initial format selected for delivering the information to the class was slide presentations on a particular topic, posted in a Senior Engineering Design Web Site (Thomason and Chopra, 1999a). Other formats that are being tried to present these information resources. These range from essays or lectures posted on the Web and Web-based training games or tests, to complete special topic mini-courses, using fully integrated course management and delivery systems such as "Web Course in a Box."

Figure 1: Inca stone architecture in Cusco, Peru, showing complex interfaces matched without mortar.
In another example, computational methods, involving simple analysis using calculators and software programs using languages such as C++ could use a common resource with real examples from engineering economics - similar to those used in the later junior class. At the same time, juniors who needed to brush up on computational methods, or those that do not know C++ could share the same common resource. This resource may be provided in the form of a series of lectures, presentations, articles, problems with quizzes and solutions, or as other cohesive and organized instructional material. The resource could be made readily accessible to students enrolled in both classes.

A third example of a shared resource, suitable for transformation into a MeC, is provided by the common thread of discussions and essays utilized in freshman seminars and in advanced courses in management, leadership, ethics and legal perspectives. MeCs covering special topics in each of these areas can be accessed by any of the students enrolled in these classes.

This principle can be broadened further by stating that any MeC may be used, at any time, by any student enrolled in the Program. Or, even further, by stating any faculty, student, or alumnae of the university should have open and free access to MeCs. Taking this idea further, MeCs may be considered as a flexible "global electronic format," for organizing and delivering learning resources, including widely used materials such as handouts, class notes, assignments and practice tests. Thus, MeCs could include "sub-categories" of resources, which one may choose to call eNotes, eAssignments, eQuizzes, eTests, etc. MeCs also may be used for the purpose of satisfying Professional Development Hours (PDHs) for continuing professional registration.

**Micro eCourses for an Engineering Management Program**

Engineering Management, as an academic discipline, is relatively new. Consequently, it is experiencing growing pains upon which are superimposed the pains associated with the currents of technological change discussed earlier. Yet, most engineering management programs, following the basic "human" instincts of survival and progress (motivated by their key human element - the faculty), are evolving and growing to meet the challenges and opportunities that pain and change so often provide.

It is expected, and even customary, for faculty to modify and enhance course materials, based upon their research and consulting activities, and to supplement them extensively with reference materials and even with guest lecturers. However, despite these enhancements, it becomes necessary sometimes to make significant changes to a course, or even to revamp a curriculum, in order to meet the needs dictated by accelerating changes in the industry and in the marketplace.

Often, it becomes necessary to introduce new courses and to re-arrange or re-group sets or series of courses to serve various areas or "concentrations" within an academic program. Such major revisions can require a considerable length of time, often stretching to several academic years. In the meantime, the gaps can widen between what is taught and what should be taught.

Further compounding the dilemma is the realization that appropriate textbooks are not always available that address these evolving changes in a manner that can be useful for some of the new courses that are developed. One such area, in the Engineering Management Program at the University of Tennessee at Chattanooga, is Technology Entrepreneurship, Leadership and Management. Several questions arose with respect to this area.

For example, how is this area of practice impacted by the rapid globalization of the economy and the increasing influence of new information, telecommunications and Internet technologies and of e-commerce? Should there be a change in the way we view competitors, regional and national business environments, strategic alliances, and corporate, professional and personal ethics? If these changes are significant, then how should we prepare students to deal with them as they mature into productive and contributing citizens?
Examples of the Micro eCourses being developed for the Engineering Management Program are "Management Viewed as Action with a Purpose," "Relationship between Corporate, Professional and Personal Ethics," and "The Value of Intrapreneuring in an Innovative Organization."

**Administrative Issues Associated with the Development and Delivery of MeCs**

When the broad principles of open and free access to new instructional materials, be they in the form of MeCs or other vehicles, are stated, a new "reality" sets in. No sooner does one mention new courses and widespread delivery (distance learning is another popular new buzzword), that university administrators start raising such "show-stopper" issues as credit hours, tuition or registration fees, copyrights, degree requirements and accreditation.

As it turns out, there is a straightforward, though not necessarily the most effective, way out of this administrative maze. Just post the MeCs out on the Web as a new form of class notes, for the use of any and all students in your classes!

Though simple, and seemingly painless, this approach has several shortcomings, which preclude true MeCs from being offered in this manner. These shortcomings will become self-evident when we examine some of the requirements of a MeC in order for it to gain an air of respectability (Exhibit 1).

<table>
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From these few requirements, it evident that the simple approach of posting class notes on the Web will not suffice. One must tackle the thorny administrative issues.

Each university has its own, sometimes peculiar, sets of rules and guidelines governing the delivery, accounting and financing of the products of its faculty. Nevertheless, here are some common MeC principles that may apply to most:

• No separate tuition will be charged for a MeCs, to any student enrolled in the Program. Consequently, only students enrolled in the Program will have access to the MeC.

• Groups of associated MeCs may be approved and designated by the faculty or department as eligible for credit as a "Special Topics" course, if such a course is permitted by the appropriate accrediting body. In such cases, tuition would be charged at the standard credit hour rate.
Universities that have a continuing education arm may offer *MeCs* as stand-alone or as part of their continuing education offering by prior arrangement with the faculty author.

Students who have completed a series of *MeCs* through continuing education, or during their education in the Program, may petition for "Special Topics" credit, as stated earlier.

**Conclusion**

Supported, initially, by an Excellence in Engineering Award, a series of *MeCs* are being developed to serve the needs of undergraduate, and graduate students and faculty in Engineering Management (Chopra, 1999). Some of the materials for these *eCourses* has been presented over the Internet to students enrolled in undergraduate and graduate courses. These course include, Freshmen Engineering Seminars, Engineering Economy courses, Senior Engineering Design Projects and graduate courses in Engineering Management (Thomason and Chopra 1999a and Chopra 1998 and 1999b). Initial drafts have used Web essay formats and slide presentations and on-line "tests," posted on university Web sites. Current efforts are aimed at providing a uniform and systematic format for *MeCs*, using available Web course management and delivery systems.

It is expected that the new *Micro eCourses* being developed will benefit students and faculty in the Engineering Programs at the University of Tennessee at Chattanooga. In a broader sense, they may be of use to faculty, students and alumnae of the College of Engineering and of the University at large.

**References**


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