A Master of Engineering Degree Designed for Distance Learning

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Abstract: The three state universities in Arizona (Arizona State University, Northern Arizona University, and University of Arizona) have collaborated to offer a Master of Engineering degree program that is primarily intended to serve the advanced technical educational needs of practicing engineers. Through close partnerships with employers, the universities are developing curricula and courses that address the enhancement and/or development of new skills and knowledge pertinent to engineering practice. Given the assumption that Master of Engineering students in the program will be employment-bound to some extent, the goal of the program is to provide distributed access to a variety of courses via distance delivery and flexible course formats. Thus, Master of Engineering students will have the flexibility to design programs of study that take advantage of the breadth of course offerings reflecting the diversity of strengths across the three universities. While campus courses are accepted and many video courses are available, new development is concentrating on web based courses.

Keywords: collaboration, degree, distance learning, Master of Engineering, web.

Engineers work in technical fields that change so rapidly that careers cannot survive without continuous learning and/or periodic re-education. They are employed in a widely dispersed, global market where extensive travel is a common job-related requirement. Moreover, throughout the course of a career, engineers typically undergo a significant number of career changes. Insofar as the graduate education of practicing engineers is concerned, career changes and job-related travel make these prospective students something of a "moving target." Workplace- or campus-oriented programs cannot suffice; the web is the only medium that can realistically be used to accommodate the educational needs of practicing engineers. As a group, this audience has been underserved. Indeed, companies across the nation have called for the development of advanced engineering educational programs designed for working professionals [1-4], programs that can be delivered:

- *anywhere*, so that students are not bound to a particular campus and classroom environment, and
- *anytime*, so that job-related deadlines and travel schedules can be accommodated.

Individual students, who recognize the need for educational programs that accommodate their personal and professional lives, have also called for the development of such programs [5,6].

In collaboration, the three state universities in Arizona offer a practice oriented Master of Engineering (M.Eng.) degree program intended to serve the advanced educational needs of employment-bound professionals and residential students. The resulting educational program is intended to serve a target population that is best described as technically sophisticated part-time students in full-time employment. Many of these students can be characterized as "returning" or "nontraditional" students, in that several years have passed since the completion of their previous degree programs. Moreover, they are geographically dispersed and while their employment requires them to continuously update their technical knowledge, it does not typically afford them the opportunity to do so "on-campus".

Individual universities are beginning to offer fully on-line masters degrees in engineering that are typically of limited scope [8-10]. Because the Arizona tri-university collaboration involves three entire colleges of engineering, a broader spectrum of engineering programs is available to M.Eng. students than is currently available at any one of the affiliated universities. The M.Eng. degree program has been specifically designed to promote educational flexibility so that nontraditional programs can be offered. Thus, in addition to traditional programs such as electrical engineering, industrial engineering, and mechanical engineering, more specialized programs such as transportation

engineering, communications engineering, semi-conductor processing, and financial engineering are possible within the degree framework.

The Tri-University collaboration almost offers anytime, anyplace graduate education. Courses are offered in several formats for flexible scheduling. Students in the program have the opportunity to take courses on- and off-campus. Some courses might even be offered at the employer's site. They can select traditional three-unit courses or one-unit modules, some of which are self-paced courses. Additionally, the schools are considering condensed workshop/weekend offerings. Numerous courses are now available in distance delivery formats, including on-line web delivery, video tape and/or satellite delivery. Some courses are even available through metropolitan broadcast. The major emphasis for current and future development is toward on-line web courses.

Faculty support for the anytime-anywhere delivery of curricular programs is, perhaps, the single-most important factor influencing its success. The faculty have overwhelmingly embraced the notion of a multi-university collaborative program designed to meet the advanced technical education needs of practicing engineers. Moreover, the need for anywhere course delivery is easily recognized and accepted. However, the collective experience with designing web-based courses and any-time offerings is best described as limited.

The graduation requirements for the M.Eng. degree include: a total of 30 units of coursework (which may include up to six units of an applied project); three units are required in each of two areas (engineering business/management and engineering mathematics); and a final examination as determined by the faculty advisory committee. In contrast to normal M.S. degree requirements, there is no university residency requirement associated with the M.Eng. degree so it can be earned completely through distance learning if a student so desires.

The admissions requirements include: transcripts; a statement of career objectives; three letters of recommendation, minimum GPA of 3.00; as well as the graduate college requirements (e.g. TOEFL) for the home institution chosen by the student (ASU, NAU, or UA). To apply, prospective students choose a home institution and submit two application packets: one is an institutional application form that goes to the graduate college and the second is a M.Eng. application form that goes to the campus director of the home institution. The home institution has right of first acceptance, that is they have the first opportunity to admit the student. If they are not able to do so, they will refer the application on to the other two schools for possible acceptance. The institution that accepts a student's application provides at least one advisor, approves a plan of study, assures satisfactory progress, provides students with a sense of belonging, maintains student records, and confers the degree in collaboration with the other two universities.

With approval of the faculty advisory committee, course work may be taken at any of the three universities. A limited number of credits from institutions other than the three state universities may also be used.

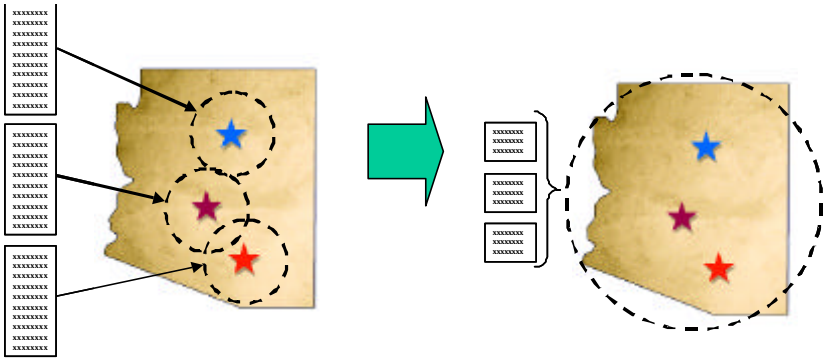
There are two formats for the curricula that will support the M.Eng. degree. The first is student centered. Students using this format prepare curricula that meet their personal needs and submit them. Their faculty advisory committees will then review and approve them if they are appropriate. The second format is faculty centered. For this format faculty prepare curricula that express their expertise and resources. Then students can choose to apply for a M.Eng. degree based on one of these formats if it meets their personal needs.

The program's administrative structure consists of a director at each campus, a tri-university coordinating board, and an industrial advisory board. The three campus directors are the lifeblood of the program. Their main responsibilities are to recommend students for admission and to coordinate local campus activities. The local activities include coordinating the development of curricula and new courses. The coordinating board is made up of three members from each university and has oversight responsibility for admissions, policies and procedures. The three members from each university include the campus director, and representatives of the dean and the faculty. This body coordinates distance offerings, facilitates the exchange of information across campuses and assures cross-campus academic and student services. A tri-campus administrative director is being hired. This person will report to the coordinating board and be responsible for coordination of the day to day activities associated with cross-campus academic and student services. The industrial advisory board has only recently been formed and includes ten representatives of industry and other constituents within the state. They provide strategic advice regarding the advanced technical educational needs of practicing engineers.

It is the goal of the collaboration that students experience seamless student services as they interact with the three somewhat autonomous campuses. Much progress toward this goal has been accomplished, but many issues remain. The admissions and financial aid offices of the three campuses are presently communicating and will soon solve problems relative to their areas of responsibility. A common database has been implemented as a temporary solution to the need for seamless transcripts. While the campus directors carefully monitor registration, it is not yet automatic and thus far the need to transfer fees between campuses has not been addressed. On the other hand, library access and career placement have proven themselves to be non-issues in their present formats.

The program is moving forward as quickly as possible. Present limitations include a modest number of course offerings, resource issues, infrastructure issues, and limited industry involvement. Soon; however: there will be a significant number of course offerings specially designed for the M.Eng program; the infrastructure will be in place for seamless admission, financial aid, registration, and transcripts; and significant collaboration with industry is being developed.

Technical specialization is the hallmark of graduate level engineering education. This means that a rather broad spectrum of courses must be available to meet student needs. By offering a nonresidential degree program, the partnership will depend heavily upon web-based delivery of these courses. In order to reconcile the economies of scale necessary to justify this delivery mode with the specialization required [11], the collaborating institutions will have to coordinate course development efforts. The efficiency of a tri-university collaboration becomes apparent when one considers the need to develop new web courses for each of the many curricula required to support a masters degree in engineering. For on-campus offerings each school supports a geographic region of the state with complete sets of courses for each curricula offered. The M.Eng. degree collaboration; however, requires each school to develop only one-third of the courses for a degree to have it offered to all three populations. This is almost a ten-fold increase in efficiency. In fact, when the degree becomes available out of state, the increase will be even more significant. Because of the expense of course development, this is a very important efficiency.



Issues currently being faced by the M.Eng. program include the cost to develop a web course, determining which web course formats are most effective; a movement from developing courses to a focus on developing curricula; and restraining growth until curricula are in place, the needed courses have been developed, and seamless student services are realities. Intellectual property issues that must be ameliorated in the near future involve course ownership and teaching credit for web courses. The collaboration is also wrestling with issues regarding special fees for distance learning.

Following are lists of the courses that are currently available for offering and those that are now under development:

During spring 1999 the Tri-University partnership offered seven web courses:

- Circuit simulation algorithms
- Finite elements for engineers
- Linear algebra in engineering
- Rapid prototyping and fabrication
- Semiconductor materials processing
- Strategic technology management
- Wet weather flow management

Fifteen additional courses were added during fall 1999:and spring 2000

- Analog circuits
- Analog integrated circuits
- Capability assessment for decision making
- Data converters
- Finite element analysis w/ANSYS
- Fundamentals of solid-state devices
- Integrating the manufacturing enterprise
- Introduction to optoelectronics
- Introduction to feedback systems

- Introduction to SIE methods
- Knowledge systems engineering
- Modern control theory
- Partial differential equations
- Wireless digital communications
- Wood and masonry design

At the present time twenty-two new courses are in various degrees of completion and additional courses have been contracted for by faculty at the three schools. The courses now under development include:

- Advanced engineering dynamics
- Applied fluid dynamics
- Applied thermal analysis
- Combustion
- Conduction and radiation heat transfer
- Convective heat transfer
- Analysis & design of mechanical systems
- Design, fabrication, and repair of polymer composite materials
- Design for environment
- Engineering statistics
- Fiber optics
- Indoor environmental control
- Onsite decentralized wastewater treatment and recycling
- Operations research modeling
- Principles of environmental transport
- Geomechanics with a virtual rock laboratory
- Introduction to visual computing
- Image processing
- Matlab for digital signal processing
- Product design
- Software project, process & quality management
- Vehicle dynamics

The assessment and evaluation of program outcomes is critical to the continuous improvement of this program. This activity has been initiated and will be reported at a future date.

For additional up-to-date information visit the web site located at: http://triuniv.engr.arizona.edu.

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