

FROM THE CLASSROOM TO THE BOARDROOM: DISTANCE LEARNING UNDERGRADUATE AND GRADUATE ENGINEERING PROGRAMS A *GLOBAL PARTNERSHIP OF INDUSTRY AND ACADEMIA*

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Abstract -- Michigan Technological University (MTU) has a unique portfolio of distance learning engineering degree programs. Bachelor of Science (BS), Master of Science (MS) and doctoral (PhD) degrees in engineering have been developed. The primary client of the BS program is General Motors Corporation and Ford Motor Company sponsors the PhD. The MS program is a global partnership between Ford, the University of Bradford, England, and MTU. Industrial partners for all degree programs have expanded since their inception. A unique characteristic of the graduate degree programs is the requirement of a research-based thesis or dissertation. Emphasis is placed on student-faculty interaction methods, course delivery methods, and lessons learned. The PhD program involves a three to six month residence at the student's industrial site by the faculty advisor.

A recently developed twenty-five (25) semester credit certificate program will be briefly presented. This was created to enhance the education of designers in the automotive industry and is a partnership between General Motors University, Purdue, the University of Michigan and host, Michigan Tech.

Degree program structures, delivery methods, and financial models will be presented. The genesis and outcomes of these degree programs will be summarized.

INTRODUCTION

If change is constant, then learning must be continuous. Distance Learning has emerged as a means to provide continuing education in the form of courses, certificates and degrees. More and more students are logging on to e-learning. According to International Data Corporation, in Farmington, Massachusetts, students enrolled in distance learning courses will reach 2.2 million by next year and the number of distance learners will represent 15 percent of

higher education students [1]. The Internet and other new-media technologies have the potential to change distance learning into a force that could alter the face of higher education.

In this paper, we describe a portfolio of unique distance learning engineering degree programs. These include Bachelor of Science, global Master of Science, and Ph.D. degrees in engineering. In addition a newly developed Designing Engineer Certificate program is presented. The academic programs, delivery methods, program management, funding model development, and future directions are presented. Documentation of the development process for these programs may be useful to other groups in establishing distance learning engineering degree and certificate programs.

HISTORY

Michigan Technological University (MTU or Michigan Tech) was one of the first universities to offer an accredited distance learning engineering degree program in the U.S. In 1989 Michigan Tech began offering the Bachelor of Science in Engineering (BSE) degree program to General Motors (GM). At that time it was the first accredited distance learning engineering degree program in the U.S. Currently there are only two.

GM offers this degree program through their Technical Education Program (TEP) at 19 sites in North America. GM recognized three graduates of the class of 2001 with a TEP Value-Add Recognition Award for their senior design project. The Value-Add Award recognizes contributions resulting in improvement in GM's competitive advantage.

GM has many designers in their North American operations that do not have B.S. engineering degrees and the distance learning BSE program was developed to address the need for their talented designers to obtain this educational background. However, as successful as the program has been, the number of designers graduating each year from the

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program is not sufficient to ensure that the design workforce will be adequately prepared to meet future expectations. Consequently, the Designing Engineer Certificate (DEC) program was launched as a pilot in 2000 and will be fully implemented by the 2001-2002 academic year.

The distance learning Ph.D. in Mechanical Engineering-Engineering Mechanics (ME-EM) degree was established in 1995 in partnership with Ford Motor Company. In addition to the program in ME-EM, a Ph.D. in Electrical Engineering is now available to Ford employees. Also the distance learning Ph.D. program is available to other companies and government laboratories. Currently a Ph.D. student from the U.S. Army Tank and Automotive Laboratory is enrolled in the ME-EM program.

A global distance learning Master of Science in Mechanical Engineering (MSME) degree was established in 1998 as a partnership between Ford Motor Company, the University of Bradford, England, and Michigan Technological University. Designed with common general requirements but some local differences to meet specific university requirements, the degree program provides for seamless transfer of projects and courses between MTU, Bradford and job locations. Students are admitted in cohorts of 10-15 in August of each year. Beginning last year Ford opened this M.S. program to their suppliers. Currently three cohorts have been admitted and another is planned for August 2001.

DEGREE PROGRAM DESCRIPTIONS

Bachelor of Science in Engineering

The Department of Mechanical Engineering-Engineering Mechanics offers a 120-semester credit Bachelor of Science in Engineering (BSE) degree via distance learning [2]. The curriculum for the BSE program emphasizes design and a strong computer-aided-design (CAD) experience. The program is designed to provide a sound foundation in mathematics, basic sciences, engineering science, design, communications, humanities, and social sciences, with an emphasis in the concentration areas of mechanical design or manufacturing in the senior year.

The mechanical design concentration provides an emphasis in developing virtual models of mechanical systems using state of the art solid modeling software, and applying finite element methods to analyze mechanical systems for stress and deflection. Students also complete a major design project working in teams. The manufacturing option includes courses that develop a systems approach to problem solving, the ability to apply knowledge of production systems to manufacturing, and the ability to integrate manufacturing into business concepts.

The BSE degree program is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET). The BSE

program is offered through corporations who have at least five employees at the same educational level who will pursue the degree as a group.

Michigan Tech delivers the required engineering courses via videotape delay or streamed video. The courses are taped as they are taught live on campus at MTU and are sent to distant sites with accompanying course materials. The foundation mathematics, basic sciences, and general education courses are usually taken at a local educational institution and the upper division courses taken from Michigan Tech.

Master of Science in Mechanical Engineering

The distance learning Master of Science degree in Mechanical Engineering (MSME) is unique in that it offers technical employees an opportunity to earn a work-based research degree. There are many coursework only M.S. degrees but very few research M.S. degrees. Another unique feature of the degree is that students may take courses from universities around the world, with approval from the student's advisory committee.

The distance learning MSME program has its roots as a global masters program that was conceived in partnership with the Ford Motor Company and the University of Bradford, England. During the early stages of development of this degree program it became clear that there were significant philosophical differences between the traditional Master of Science programs in the U.K. and the U.S. In the U.K. the overwhelming majority of their MSc program is spent in one-on-one interactions between the student and the faculty advisor. Areas where the student has knowledge gaps are generally addressed by the study of pertinent literature because no formal course program exists in the traditional U.K. MSc program. This structure is in stark contrast to U.S. M.S. programs that are at least two-thirds coursework with the balance associated with research credits. The difference between the Master of Science programs at Bradford and MTU were bridged by the creation of a degree program with roughly equal course and thesis/research credits. In a global degree the advantage of common requirements is that students can begin the degree program at one university, and if they are transferred overseas as part of their job, they can seamlessly transition to another university.

The MSME degree program is comprised of an individually tailored academic course of study delivered through distance learning technologies and a major work-based, job-related project, which culminates in a project thesis. Three additional credits may be transferred from the Ford Technical Education Program (FTEP) modules or other corporation programs subject to approval from MTU. The program requirements are at least three years experience within Ford, a B.S. degree in an engineering or related field, completion of the FTEP modules, a two and a half-year commitment and, most importantly, management support.

Because this is a work-based research program, company supervisors work closely with the employees to identify an appropriate research project. Employees then attend a required induction week at MTU where they meet their cohort group, participate in modules about the conduct of research, select a faculty advisor, define their course project proposal, and identify their course of study. This is a critical first step in this distance learning M.S. degree.

Progress toward degree completion is reported at scheduled videoconferences with their thesis advisor during each semester of the program. Each entering class is called a cohort to promote “bonding” and for networking and collaboration when away from MTU. Students are required to attend an additional study week at MTU at the midway point, which is during the Induction Week of the next Cohort, for intense faculty advising and to promote cross-fertilization between students in different cohort groups. The program culminates in a final review, an oral thesis presentation, and the submission of a project thesis deposited in the MTU library.

Doctor of Philosophy in Mechanical Engineering- Engineering Mechanics (Ph.D.)

Corporations have had a growing desire to have in-house subject area experts. These experts provide help in charting the path in an increasingly technology-oriented marketplace. In 1995 Ford Motor Company and Michigan Tech established a distance learning Ph.D. program in Mechanical Engineering-Engineering Mechanics (ME-EM) to serve the needs of highly motivated and exceptionally qualified employees. To the authors' knowledge it was the first distance learning engineering Ph.D. degree program in the U.S. The dissertation research topic is work-based and job-related. This Ph.D. program has several unique features. A key element of any student's Ph.D. program is the direct interaction between the student and their faculty advisor. This is uniquely addressed through a flexible residency requirement that is beneficial to both parties. The MTU faculty advisor spends up to six months with the student/employee at their Ford location and can be accomplished during a single block of time or over several visits. The faculty advisor can be available to Ford as a technical expert and a consultant. This is a valuable resource to the unit that is supporting the research and allows the faculty member to make contacts at the company for future research opportunities.

Very often the inability to get the courses needed/desired at the most convenient time can be an impediment to the timely and successful completion of any distance learning degree program. Another unique feature of this degree program is the ability to take courses from any university in the world. All that is needed is prior approval of the doctoral advisory committee. Other features of the program include an on-site Ford co-advisor, who must be qualified as an MTU adjunct faculty member and who then

is a member of the student's doctoral advisory committee. The doctoral student is expected to spend from one to two weeks in residence at MTU for each of the qualifying, comprehensive and final doctoral dissertation defense examinations. In addition to the successful completion of the above-referenced examinations a minimum of 20 semester credits of graduate courses beyond the M.S. degree is required.

MTU requires the candidates to have a M.S. in engineering or a closely allied field to be considered for the program. Once admitted to the program a doctoral advisory committee must be established for the student. The committee will consist of at least two MTU graduate faculty and two Ford adjunct faculty. All doctoral students must maintain a continuing enrollment of at least four credits per semester (course and research credits), one credit of which must be taken from MTU. In addition to the MTU requirements for the program, a candidate must receive approval in writing for program participation from their Ford supervisor. As of several years ago, this degree program is available to other companies worldwide.

Two of the Ford doctoral students have completed their Ph.D. requirements and graduated within three years. Although this was our hope, it is remarkable considering they were full-time employees.

Designing Engineer Certificate (DEC)

The goal of the Designing Engineer Certificate (DEC) program is to significantly enhance the skill base of the designer and engineering population with diverse educational and experiential backgrounds [3]. This creates a Designing Engineer with a uniform knowledge base. Addressing students' varied qualifications is a critical component of the DEC program.

The DEC program addresses the diverse credentials of designers as a group through modularized fundamental courses. The program emphasizes the use of modern solid modeling tools to build a virtual model of the system, and finite element programs for the evaluation of stress and deflection in the virtual model. Developed specifically for this program are four courses, which provide fundamentals in mathematics and engineering mechanics that will provide the student with an appropriate foundation for the core area. The core courses build on the fundamentals and encompass many of the mechanical design concepts included in the four year BSE program. An underlying concept of the program is the conviction that an engineering background in calculus can be substituted with algebraic concepts to understand basic finite element analysis and the application of the results. A select set of core courses of the DEC program is directly transferable into the MTU BSE program.

The certificate program draws from courses taught by a consortium of traditional universities and from the General Motors corporate university. GM teaches the solid modeling classes live in classrooms designed for computer instruction

on graphics workstations using the Unigraphics software. Purdue University teaches the course in Design for Manufacturability and the University of Michigan teaches Vehicle/Occupant Packaging. Michigan Tech hosts the program and teaches Integrated Design and Manufacturing, Introduction to Material Science and Engineering, Introduction to the Finite Element Method, and a design project course.

DELIVERY METHODS

MTU's distance learning classes are taught in the University's studio classroom to an on-campus section so the remote students receive the same lecture. The lecture is captured 'live' then distributed on videotape, 'on-demand' video streaming, and supplemented with web tools.

Studio Classroom

The broadcast quality studio has an instructor's console that includes an area for visuals, plus several television screens for monitoring graphics, program output, and the teleprompter. The instructor and the students are recorded with three cameras, and a fourth overhead camera records the visuals. Technical staff in a separate control room operates the audio and video controls so the instructor can concentrate on course content.

Computers can be integrated into the studio classroom presentation using high-resolution displays to show computer-aided-design models. The studio classroom is connected to MTU's computer network to allow Internet/Internet2 access.

Videotape continues to be a primary means of distribution as the technology is well established and readily available in world standard formats. Also this is currently the preferred mode by employees from industry simply because of the flexibility it affords. Along with web-enhancements, distance learning students usually meet at the corporate work sites with a site coordinator to view the lectures. Homework assignments may be distributed in both hard copy or on faculty web pages.

Course Management Tools and other Web Enhancements

Faculty use custom web pages to distribute course materials such as PowerPoint presentations, reference material, and homework problems. Use of course management tools, such as WebCT, continues to grow. WebCT (<http://www.webct.com/>) is a course management tool centrally supported by the University. It gives faculty members the pedagogical flexibility to teach their own way, provides tools to enhance interaction between students and faculty, and offers security of course material.

Videoconferencing

Videoconferencing has been deployed on campus and enables multi-institutional collaboration and resource sharing. Systems have been installed in many campus conference rooms plus on personal desktop computers allowing for real-time distance learning courses, advising sessions and test review meetings.

Streaming

Streaming media technologies can deliver live on-demand audio/video programming over the Internet. This meets the expectation of just-in-time, real-time delivery. Downloading is also an option so the students can put the file on a computer and watch the lecture at a more convenient time.

For streaming of distance learning courses, lectures are captured "live" in the studio classroom and simultaneously encoded for video streaming. With this process, courses are available on the Internet within a few hours after meeting on-campus.

The technology for video streaming is dynamically improving and we envision an increased use of new technologies to deliver MTU's distance learning programs worldwide. Michigan Tech is committed to research new technologies to offer the highest quality distance learning over the Internet and Internet2.

PROGRAM MANAGEMENT

The needs of distance learners are different than those of resident students. They require special policies and procedures and an infrastructure to meet these special needs. At Michigan Tech the Extended University Programs (EUP), was established for this sole purpose. EUP administers distance learning policies and procedures, distributes information to distance learning students and corporate clients, and assists in the development and promotion of distance learning programs. A very important function of EUP is to close the gap between the instructor and the distance learner in a manner transparent to both.

EUP works closely with academic units concerning the establishment of policies on intellectual property, residency, faculty compensation, course fees, etc.

EUP is responsible for student admission, transfer of credits, receiving and routing transcripts, registering students for courses, and providing a certain level of advising. They are responsible for the distribution and collection of course materials, homework and exams

FUNDING MODEL DEVELOPMENT

While each program has a funding model that has characteristics unique to the specific degree they all follow the same general guidelines. Tuition assessment for

individual programs was determined with a financial plan to encompass all aspects of the costs required to provide course and degree delivery to distance learners. The model is based on the minimum number of students required to offer a course and the minimum number of courses that can be offered annually (based on the number of students enrolled in a given program). The result of this model is that the university operates the degree programs with very little financial risk.

Bachelor of Science in Engineering (BSE)

The BSE was and continues to be the most difficult program to financially model. The variables associated with this program can change multiple times over the anticipated length of time for student degree completion and corporate contract agreement. Students spend from seven to ten years taking coursework and can start and stop the program at various times if their career warrants it, enrollment forecasting is difficult. Major components to this model include faculty compensation, course development, program management and personnel, course delivery costs per student, program delivery, studio expenses and overhead. Fixed and variable costs were identified and the per credit hour tuition level was based on the number of students in a course, number of sites viewing the course, and the number of courses offered during the academic year. This model has evolved since the program was initiated. Significant model changes include an increase in faculty compensation, technology infrastructure amortization, enhanced course development, and other changes to provide incentive for both faculty and departments to participate in distance learning.

Master of Science in Mechanical Engineering (MSME)

The MSME has two financial components to the degree. The first is the traditional coursework credits. Expenses were determined as described in the BSME model however, a two-year timeline to complete coursework assists in the determination of the total number of courses to offer annually. Each cohort of students is expected to take all of their coursework from Michigan Tech during this time period. The second component is the research credits necessary to conduct and complete the required thesis. The financial structure for this is different. Costs unique to the research component include compensation for the faculty advisor, an induction week, and a weeklong study period. This tuition rate is considerably higher than the coursework component but is competitive and necessary to complete the research activities and satisfy university residency requirements.

Doctor of Philosophy in Mechanical Engineering Mechanics-Engineering Mechanics (Ph.D.)

The Ph.D. funding model focused specifically on the expense associated with the faculty advisor's direct interaction with the student. A faculty member is expected to spend up to six months in residence at the corporate location advising the student. A research contract is created to cover the expenses associated with faculty compensation, travel, and living expenses. Included in the research budget is the cost for the doctoral candidate to spend two weeks in residence at Michigan Tech to complete each of the qualifying, comprehensive, and final oral dissertation defense examinations.

The most important consideration in all of the models was to view distance learning and the associated faculty compensation similar to the way research is funded. Faculty members may use their distance learning compensation to release themselves from one of their other teaching assignments utilizing an algorithm that adjusts for the number of distance learning students in each course. Alternatively they may take the compensation in the summer and teach the distance learning course as an overload.

CONCLUSIONS AND FUTURE DIRECTIONS

It is our experience that in order to have successful and sustainable distance learning degree programs, quality in all aspects of the program is essential, particularly in instruction. It is our belief that another reason for the success of our existing programs and the growth of new programs is that they have all been customer-driven. Areas that have and continue to create challenges for distance learning programs are intellectual property rights for the faculty, student and corporate sponsor, staffing, and faculty compensation.

In the future the course format will contain a mix of traditional and short intensive courses to allow for greater flexibility in offering courses on campus and at corporate sites. Future plans include a new studio to accommodate large on-campus courses which includes the latest in technological advances for distance learning, more faculty use of web-enhanced delivery modes, and instructional designers to work with faculty on course creation designed for distance learning.

A new Center for Integrated Learning and Information Technology is in the planning stages and will include distance learning classrooms and space for distance learning instructional designers. Lastly the university strategic plan now includes distance learning as one of its major goals.

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