

## **The Enterprise Program at Michigan Technological University**

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### **Abstract**

Michigan Technological University recently restructured its entire curricular offering in association with an academic calendar change from quarters to semesters. As part of this restructuring the university developed the Enterprise Program, a new and innovative experience that provides all students on campus, but especially engineering majors, an opportunity to start-up and operate their own business. Development and implementation of this program was made possible in large part through support from the National Science Foundation's Action Agenda Initiative for Systemic Engineering Education Reform. Program development has been a collaborative effort between faculty in the College of Engineering, the College of Sciences and Arts, and the School of Business and Economics. Within engineering programs the philosophy behind the Enterprise Program is to provide a flexible curricular structure that leads to a traditional engineering degree while at the same time enabling students to participate in the operation of a real enterprise over multiple years. During the first year of the program (AY2000-01) eleven enterprises have been established. More than 230 students from 19 disciplines are involved. Based on the interest and enthusiasm of both industry and the students, the program is expected to double in size during the second year. This paper presents the curricular structure of the Enterprise Program as well as the preliminary assessment during the first year of the program.

### **I. Introduction**

As part of the engineering curricular development at Michigan Technological University (MTU) associated with the calendar conversion from quarters to semesters each engineering department was required to construct their new curricula within several college prescribed boundary conditions. One of the constraints relevant to this paper was the required inclusion of a major design experience, preferably interdisciplinary in nature. As such, two options have been made available to all students. Within the 'traditional' path a year-long, 6-semester credit senior design sequence is available in each engineering degree program. This common structure facilitates the formation of interdisciplinary teams when needed. The second option available to students, still leading to the same engineering degree, is referred to as the 'Enterprise' path and includes a greater emphasis on communications and business aspects of the engineering profession.

The Enterprise Program includes an extensive multi-year, multi-disciplinary design experience. Within this option the college/university establishes a number of engineering/business entities, called enterprises, and students choose to join the company and work with other students and faculty to make the enterprise a successful venture. Each Enterprise, for the most part, operates much like a real company in the private sector. The employees (students) solve real-world problems, perform testing and analyses, make recommendations, build prototypes, manufacture parts, stay within budgets (real and imaginary), and manage multiple projects. The objectives of the Enterprise Program are to

- provide opportunities for students and faculty to develop entrepreneurial and innovative engineering skills,
- provide students with a multi-disciplinary design experience that involves other baccalaureate programs, such as Business and the Basic Sciences,
- provide a framework for faculty to mentor students in a learning setting that closely resembles an industrial or professional environment,
- include learning activities that arise from the approaches used to solve real-world problems provided by industrial and/or professional sponsors,
- utilize the students' fundamental background in science and engineering in the context of a problem when non-technical issues, such as cost or societal impacts, are of equal importance, and
- enable students to participate in activities that coincide with the stages of their professional development.

The genesis of the Enterprise Program at MTU was a direct result of industrial assessment of engineering degree programs across the nation. Survey after survey of university, college and departmental industrial advisory boards identified the same shortfalls in today's engineering education [1-3]. Technical competence is seldom an issue with industry and it is typically considered a 'given' for ABET accredited engineering programs. However, several other personal and professional attributes are consistently identified as critical to the success of an engineer, but generally lacking in new engineering graduates. These attributes include

- strong skills in communication and persuasion
- the ability to lead and work effectively as a member of a team
- a sound understanding of non-technical forces that affect engineering decisions
- an awareness of global markets and competition
- demonstrated management skills and a strong business sense

This list of attributes clearly identified the educational objectives defining the Enterprise Program. Many of these skills and expertise are not easily taught within a traditional classroom setting. In fact most, if not all, of these abilities are best developed in practice. The engineering programs at MTU took a 'giant leap of faith' and liberated some of the credits typically assigned technical/approved electives and created a new and different experience designed to educate and prepare graduating engineers for more productive and successful careers. This paper describes the

curricular structure of the Enterprise Program and our experience thus far during the first year of implementation.

## II. The Enterprise Curricular Structure

A key challenge in the development of the Enterprise curriculum was to provide a truly unique experience that addressed the educational outcomes previously defined while at the same time satisfy the degree requirements within any of the engineering degree programs. Fortunately, this could be accomplished more easily within the new EC-2000 ABET accreditation criteria that provides more flexibility within degree programs than in the past. Each engineering program in the college was able to design a curriculum and a corresponding assessment program in which the general and respective program educational outcomes defined by ABET could be evaluated within the 'required' courses for the degree programs. This, in effect, has to be the case since it is difficult to develop and implement an assessment plan that is strongly dependent on 'elective' courses, which may vary so dramatically from one student to another. As will be seen shortly, the entire Enterprise curriculum can be accommodated into any of the engineering (and non-engineering) degree programs through the appropriate use of the University General Education program, the major design requirement, and some of the technical, approved or free elective credits.

It is also worth noting here that another curricular boundary condition has facilitated the implementation of the Enterprise Program, namely the Common First-Year Engineering program recently adopted by the College. All engineering students participate in the same curriculum during the first year. Our experience with the pilot and implementation year of the First Year Engineering Program are described elsewhere in these proceedings [4,5]. Since the Enterprise Program is a 3 year experience beginning in the 2nd year, all students join their enterprise with the same course credentials. Students choosing the 'Enterprise' path select a company not based on their discipline, which is hardly established at this point, but on their own interests, and professional and career objectives.

As mentioned previously, the Enterprise Curriculum is a 3 year experience. The curriculum is two-pronged and consists of 1) participation in the operation of a business (project work) and 2) completion of concentrated course material (instructional modules) designed to provide key information, processes and skills required for effective management of a viable business. The requirements for completion of the 'Enterprise' path are 16 semester credits, or approximately 12.5% of the BS engineering degree requirements. Ideally, students enroll in the Enterprise Program for 6 continuous semesters (excluding co-op absences). Of the 16 semester credits, 7 credits result from working on real-world projects, i.e. operating the company. Each enterprise is required to address and complete at least one major project/product per year, although multiple projects are encouraged when appropriate and available. Consequently, each student will participate in a minimum of three different projects during their tenure in the enterprise. Their tasks and responsibilities on each of the project will be many and varied, since over the three year period they contribute to the projects in different ways due to changing levels of technical expertise, maturity and seniority.

The remaining 9 credits in the Enterprise path result from the student involvement in structured mini-courses or instructional modules, some of which are required and others elective. Over the three-year period, students are required to participate in 3 required and 6 elective modules. The subject matter of each module is highly specific and has been designed to mimic a workshop type environment commonly found in an industrial setting. Also, many of the modules have been designed such that logical streams or threads of modules will provide the student with a clearer understanding of the interconnection of subject matter and its application to their individual/team assignments within the projects.

In Table 1 a comparison between curricular requirements for the 'Traditional' and 'Enterprise' paths within a typical engineering degree program is provided. It can be seen from this table that the primary differences between the two curricula reside entirely within the realm of electives. For the students choosing the 'Traditional' path, more elective credits are available to pursue areas of technical interests, presumably to support the student's career goals. Within the 'Enterprise' path, some of the elective credits are now consumed with the specific purposes of enhancing communication skills and business acumen.

**Table 1: Comparison of Traditional and Enterprise Curricular Frameworks**

Typical Engineering Program	Traditional	Enterprise
Required Courses:		
Basic Mathematics	19	19
Basic Sciences	15	15
Engineering Science and Design	48	48
Core General Education	13	13
Major Design Requirement	6	7
Elective Courses:		
General Education-		
Distribution Courses	15	12
Required Enterprise Modules*	-	3*
Technical or Approved Electives	12	6-8
Elective Enterprise Modules	-	6
Free Electives	3	0-3
Total Credits	131	131
* Required modules satisfy MTU General Education		

In Table 2 the curricular framework of the Enterprise Program for engineering students is presented. For non-engineering degree programs the enterprise path can be accommodated in different ways and are not described here. Descriptions of the required and elective instructional modules are provided in the following section.

**Table 2: An Ideal Curricular Schedule for the Enterprise Program within an Engineering Degree Program**

	Fall Semester	Spring Semester
Year 2	Enterprise Orientation 1	Communication Contexts (required) 1
	Teamwork (required) 1	Project Work 1
Year 3	Elective Modules 2	Communication Strategies (required) 1
	Project Work 1	Elective Modules 1
		Project Work 1
Year 4	Elective Modules 1	Elective Modules 1
	Project Work 2	Project Work 2
		Total Semester Credits 16

## II. Instructional Modules

A critical component to the Enterprise curriculum are the instructional modules that supplement the project work (operation of the company). Each module is equivalent to 1 semester credit or 15 contact hours of instruction. Hence, these modules are very concentrated in their subject matter, providing students with only the most critical information and instruction to enable them to employ their new found knowledge directly in the operation of the enterprise. The philosophy behind this approach is that student will better master the subject matter through its immediate application and that further development and understanding of the material will come through both student interest and company needs. As described in the previous section some modules are required of all enterprise students and some are elective. The elective modules cover a broad range of subjects and, in theory, students select those modules that either match their professional interests or are required for successful execution of their particular responsibilities within the Enterprise.

### *Required Modules:*

There are three required modules designed to enhance the communication skills of the students in team-like and professional environment. A brief description of each module is provided here.

**Teamwork** - This module develops group problem-solving skills and stresses interpersonal skills and skill assessment, communication, group process and teamwork, and action planning. Some of the team activities include setting expectations, developing Gantt Charts, designing an agenda, and role playing.

**Communication Contexts** - This course is designed to help members of enterprise teams study the communication contexts and practices of their teams. Students develop an understanding of concepts such as knowledge construction, discourse communities, socialization, genre, communication patterns, group hierarchies and audience. They develop competencies in observing, listening, giving feedback, interviewing, recording, analyzing, synthesizing, negotiating meaning, writing memos and analysis of reports, and giving oral presentations.

**Communication Strategies** - This course draws on the broad understanding of workplace communication. Students learn and practice strategies for effective oral, visual and written communication in technical and professional settings. Emphasis is on audience adaptation of technical information and on achieving clearly specified purposes.

### *Elective Modules:*

The Enterprise Orientation Module is designated as elective, although it is required of all students. However, it is the student's choice as to which enterprise she/he wishes to join at the beginning of her/his second year of study. The other modules are truly elective in nature. It would be unrealistic to describe in detail all of the elective modules available to students within the Enterprise Program. The majority of the modules fall into the category of business/economics, however, there are additional communication modules as well as some with a technical/engineering emphasis. Listed below are titles for modules currently approved. Other modules are under development.

Economic Decisions Analysis I, II and III	Design for Manufacturing
Enterprise Market Principles	Concept Design-Problem Solving
Strategic Leadership	Industrial Health and Safety
Project Management	Material Flow - Industrial Society
Budgeting - Intrapreneurial Engineering	Manufacturing Process Design I and II
Global Competition	Manufacturing Process Simulation
Project Phases in Design & Implementation	Complex Communication Practices
Writing about Engineering in a Societal Context	Entrepreneurship

Table 3 provides a summary of syllabus topics for those modules offered in the fall of 2000.

**Table 3: Syllabus Topics for Fall 2000 Instructional Modules**

<b>Course Name</b>	<b>Course Topics</b>
Economic Decision Analysis I	Time Value of Money, Simple and Compound Interest, Annuities, Gradients, Nominal and Effective Interest, Loans, Basic Decision Methods
Economic Decision Analysis II	Cash Flow Statements, Depreciation, Salvage Values, Taxes, Total and Relative Worth Decision Methods, Independent Project Selection
Economic Decision Analysis III	Economic Life, Retirement and Replacement, Incremental Analysis, Investments, Sources of Capital, Weighted Average Cost of Capital, Public Sector Project Evaluation, Risk and Uncertainty
Enterprise Market Principles	SWOT Analysis, Marketing Strategies, Marketing Mix, Product Life Cycle, Positioning, Market Research, Market Segmentation, Developing a Marketing Plan
Industrial Health and Safety	Hazards, Legal Issues, Regulations, Liability, OSHA, EMP, Workman's Compensation, ADA, Chemical Process Safety, Mechanical and Electrical Safety, FMEA, FTA Accident Investigation
Conceptual Design Using Creative Problem Solving	Creative Problem Solving Process, Planning and Analyzing, Idea Generation, Concept Development and Optimization, Concept Evaluation and Selection
Product and Process Design I	Product Realization Process, Project Management, IPPD, QFD, FMEA, Product Specifications, Quality, Process Flow, BOM, Cost Analysis, Environmentally Conscious Mfg
Budgeting for Intrapreneurial Engineering	Financial Planning and Budgeting, Preparation of Financial Plans and Budgets, Preparation of Enterprise and Project Budgets, Evaluation of Project Performance
Writing About Engineering in a Societal Context	Cultural Analysis Frameworks, Application of Frameworks to Specific Societies, Examination of Failed/Successful Engineering Projects, Determination of Reasons for Failure/Success, Engineering Project Site Proposals
Global Competition	Economic, Market, and Political Risk Factors, Country Risk Profiles, Entry Strategies for Global Competition

#### IV. Experience in the First Year of Implementation

The 2000-01 academic year marked the inauguration of the Enterprise Program at MTU. This also corresponded to the university calendar change from quarters to semesters. Considering the turmoil associated with such a transition, student and industrial participation in the program during the first year has been extremely enthusiastic. There are presently 11 Enterprises on campus, involving nearly 230 students from 19 disciplines within the College of Engineering, College of Sciences and Arts, School of Business and Economics and the School of Technology.

Industrial participation has also been more than gratifying. Sponsorship of an Enterprise takes several forms including

- designation of professionals within the company to serve as mentors who communicate with students about technical matters
- provision of materials relevant to the project
- visits to the campus from program planning and evaluation of student reports and presentations
- provision of testing and processing facilities not available on campus
- \$35K per year for a minimum of 3 years

To date all but one of the enterprises have full industrial support. Furthermore, we have commitments from another 6 companies for full support beginning in the fall of 2001. We anticipate having 20 enterprises involving over 400 students in the second year of the program.

The technical emphases of the eleven enterprises presently in operation range from natural resource utilization to information technology and everything in between. Listed below are the emphases and brief description of the activities for the existing enterprises.

*Future Truck* - Hybrid Electric Sports Utility Vehicle for national design competition

*Formula SAE Car* - Indy-style race car for national design competition

*Mini-Baja SAE* - Mini-baja car national design competition

*Clean Snowmobile Challenge* - noise and emission reduction national design competition

*Water Supply Evaluation* - ground water evaluation and planning for the Keweenaw Bay Indian Community

*Resource Engineering Associates* - mining engineering consulting services

*PrISM* - Program in Integrated Sustainable Manufacturing

*Wireless Communication* - test bed for wireless communication, hardware, and software development

*IT Oxygen* - Information Technology Consultants

*Consumer Products Manufacturing* - development & manufacturing of paper products

*Pavement Design and Construction* - consultants for construction aspects of the road pavement industry



The first semester of implementation has been a tremendous learning experience for both students and faculty as they strive to understand the key elements of a new business start-up and establish the framework around which their business will be run - namely, a sound business plan, organizational structure, mission, goals and objectives and the business processes and procedures that will support a sustainable organization. It has been determined that not only do the individual enterprises need to develop this framework, but the overall Enterprise Program also needs to do the same, but at a university level.

Assessment of the educational outcomes associated with the Enterprise Program are also underway. However, since we are only half way through our first year the data are limited to date. The instruments for evaluating both the business and communication outcomes are nearly developed and we will report on the assessment procedures, the data and its analyses in a future paper. One method for determining the level of success in achieving the desired business and communication outcomes will include use of an instrument designed to measure knowledge and awareness of economic and management aspects of engineering projects. This will be administered to first year students prior to selection of the Enterprise curricular option and again in the fourth year to both Enterprise and traditional students. Use of this instrument is intended to measure differences in learning across the enterprise and traditional curricula, convergence or divergence in awareness and interest in economic/management issues in the two paths, and an indication as to whether students are self-selecting the enterprise path on the basis of interest in these issues.

Additional methods of assessment will include a comparison of work completed by enterprise students to that of traditional students using several different techniques such as interviewing, videotaping of team working sessions, skills inventories determined through use of surveys/questionnaires and a review of portfolios developed by the students showing the progression of their work over the course of their educational experience.

## V. Summary

In summary, the Enterprise Program, in its first year of implementation, is already showing promise of successful delivery of its educational objectives. By working together in a business-like setting, teams of students are not only enhancing their technical skills through the application of engineering concepts and practices, but are also developing a working understanding of the issues surrounding start-up and operation of a business.

Support from industry has been overwhelmingly positive with numerous private and government organizations seeking involvement in this innovative program which they believe will enhance the quality of engineering education and produce engineering graduates who are able to be immediately productive upon entering the workforce.

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Mark Plichta received his BS, MS and Ph.D. in Metallurgical Engineering from Michigan Technological University. He joined the Department of Materials Science and Engineering at the University of Utah in 1979. He returned to the Department of Metallurgical and Materials Engineering at MTU in 1984. He was the recipient of the 1990 State of Michigan Teaching Excellence Award and the MTU Distinguished Teaching Award, also in 1990. Dr. Plichta was appointed as Associate Dean for Academic Programs in the College of Engineering in 1997. His research interests include the study of microstructural development and stability in metals and ceramics as well as engineering education.

## MARY RABER

Mary Raber is the Industrial Projects Coordinator in the College of Engineering at MTU. She received her BS in Mechanical Engineering from the University of Michigan and an MBA from Wayne State University. Before joining MTU she held various engineering and management positions at Chrysler Corporation and TRW. In addition to coordinating university and industrial interaction for student projects, Mary is involved in delivering some of the instructional modules within the Enterprise Program, including the Teaming module.