Assessment of the Enterprise Program at Michigan Tech

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Abstract *— In 1998 we r eceived funding from the National Science Foundation through the Action Agenda program to assist us in a major overhaul of our engineering curricula. One of the key features of our successful grant application was the implementation of a program we called the Enterprise. Students elect to join an Enterprise at the beginning of their sophomore year and continue to participate within the organization through graduation. As they work in the Enterprise, they take on increasing responsibility for its operation and management. It is our intent that by the time students are seniors, they will be the enterprise leaders --directing, managing, encouraging, and supervising the sophomores and juniors on the team. Students from outside of engineering, e.g., business, tec hnical communication, computer science, are also able to participate on an Enterprise. The Enterprise curriculum consists of several 1 -credit modules of instruction as well as credit for design project work. Students are able to take these modules to compl ete either a minor or a concenration in Enterprise and participation in the program does not extend their time to graduation. It is anticipated that students will work on several "real-life" design projects over the course of their three -year involvement i n an Enterprise. This paper describes the overall program and highlights some assessment data obtained over the first four years of operation .*

Index Terms *— Business, Entrepreneurship, Multi -disciplinary Design, Teamwork*

BACKGROUND

Entrepreneurial education is gaining increased attention within the engineering education community in recent years resulting in the development of several new programs or options within existing programs. In response to this new national focus on entrepreneurial education and 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:

- create an environment for students to facilitate the transition from undergraduate student to the professional work force.
- provide opportunities for students and faculty to develop leadership and entrepreneurial skills in a learning setting that closely resembles an industrial or professional environment.
- give the students ownership of a portion of their academic program that connects strongly to career goals.
- give the students a taste of the rewards and accountability associated with creating new products and working with paying clients, and
- 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

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 [1-4]. 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
- ability to lead and work effectively as a member of a team
- sound understanding of non-technical forces that affect engineering decisions
- awareness of global markets and competition
- demonstrated management skills and a strong business sense

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 and assessment results thus far, as we enter the fifth year of operation.

THE ENTERPRISE CURRICULAR STRUCTURE

Although the Enterprise Program by design is multidisciplinary in nature, the curricular structure was originally developed within the framework of the engineering degree programs. Consequently, participation by students in non-engineering programs has been less than optimal likely due to the fact that curricular requirements in the Enterprise Program had not been clearly articulated for majors outside engineering. To remedy this situation, a generic 'Minor' was established to build off the original Enterprise curricular framework. In addition to the minor, which is open to all Michigan Tech students, most departments also offer a 12-credit concentration within their discipline. In most cases, these twelve credits replace existing courses in the program and are not incremental to the degree requirements.

Students are recruited into an enterprise primarily through presentations given by the various enterprises in the spring semester of their first-year where faculty and staff associated with the Enterprise describe the program in general and provide information about the individual enterprises from which to choose. Students are free to join any Enterprise that is working on projects that are of interest to them. Most students who elect the Enterprise at the beginning of their sophomore year are committed to the program and participate until graduation. There are also options available for students to join an Enterprise at the beginning of their junior or even senior year.

The Enterprise Curriculum is a 20-credit, 3-year experience. The curriculum is two-pronged and consists of participation in the operation of a business (project work) and 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 Minor are:

- Minimum of 2 credits in teaming instruction and 2 credits in technical communications.
- Minimum of 6 and maximum of 7 credits in project work (i.e. operating the company). Sophomore and junior project-work courses are 1-credit each semester; senior project courses are 2-credits each.
- Minimum of 5 credits in business related courses. Topics for these courses include things like budgeting, engineering economics, entrepreneurship, and project management.
- Remaining credits from any of the previous lists as well as several technical electives.

Typically, students enroll in the Enterprise Program for 6 continuous semesters. 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 participates in a minimum of three different projects during their tenure in the enterprise. Their tasks and responsibilities on each of the projects are 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. Ideally, by the time students are seniors, they will be the enterprise leaders--directing, managing, encouraging, and supervising the sophomores and juniors on the team.

EXPERIENCE IN THE FIRST FOUR YEARS OF OPERATION

Student and industrial participation in the program during the initial years of operation has been extremely enthusiastic. The upcoming 2004-05 academic year marks the fifth year of operation of the Enterprise Program, and the third year of the Enterprise Minor offering. As of the fall of 2004 there will be 22 Enterprises on campus, involving over 500 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 with sponsorship in the form of

mentorship, financial support and relevant projects coming from numerous corporations and government agencies such as Ford Motor Company, GM, DaimlerChrysler, Kimberly-Clark, Environmental Protection Agency, TACOM and many others. Feedback received from industry sponsors is particularly telling as to the positive merits of the program as can be seen in the following excerpts from letters of support recently provided by two of our industry sponsors:

- "It was truly amazing to us to see how the students responded to the challenges presented to them via the Enterprise Program. Shy, returning students with no concept of leadership were forced to accept responsibility, and because of this, they developed the concurrent leadership skills. Their communication skills also grew at an exponential rate. It was rather intimidating to the undergraduates to have to present an oral report on their team's progress to a group of successful contractors and engineers, knowing that we were going to critique them, and, at the same time were looking at them as potential summer and permanent employees." – Richard Anderson, President-elect of ABET and Principal Engineer of SOMAT, Inc.
- "I believe that the Michigan Tech Enterprise is a leading program in preparing engineering students with leadership skills, attitudes, and valuable insights to enable rapid personal and professional excellence. I also believe that this program supports a critical U.S. Engineering educational need to prepare students to thrive in the fast paced, rapidly changing environment that is facing all U.S. industry. This environment involves collaborative global partnerships to develop and advance technology and manufacture products which will require not only technical skills but also strong communications, multi-disciplinary, and business knowledge and leadership skills of the engineering employees of U.S. based firms." – Randy Hill, Vice President of Product and Technology Development, Kimberly-Clark Corporation.

Student enthusiasm for the program can be seen in the steadily growing enrollment. Table 1 includes enrollment statistics for Enterprise Program since its inception in 2000.

	2000-01	2001-02	2002-03	2003-04	2004-05
Sophomores	85	140	120	166	183
Juniors	60	85	122	139	185
Seniors	85	86	140	161	144
Total Students	230	311	382	466	512
# of Enterprises	11	15	17	18	22

TABLE 1
ENTERPRISE ENROLLMENT STATISTICS

The technical emphases of the 18 enterprises in operation range from natural resource utilization to information technology and everything in between. Table 2 provides a list of the enterprises with a brief description of the business emphasis for each. The enterprise program is truly interdisciplinary—the majors of the students involved in the program are biomedical, civil, chemical, environmental, geological, mechanical, electrical, computer and materials science and engineering, mechanical and electrical engineering technology, computer science, business, biology, and physics. In addition, we are adding new enterprises in noise & vibration, entrepreneurship, nanotechnology, and international business in the fall of 2004.

Enterprise	**Business Focus**
AquaTerra Tech	Ground water evaluation for the Keweenaw Bay Indian Community
PrISM	Program in Integrated Sustainable Manufacturing
Wireless Communication	Test bed for wireless communication, hardware, and software development
IT Oxygen	Information Technology Consultants
Consumer Products Mfg	Development & manufacturing of disposable consumer paper products
Pavement Design/Constrctn	Consultants for construction aspects of the road pavement industry
Integrated Microsystems	Design and development of wireless integrated microsystem technologies
Automotive Systems	Engineering consulting for the automotive industry
Robotic Systems	Design and development of robotic manufacturing solutions
Planning & Development	Consulting engineering firm focused on the improvement of campus and community
Aerospace	Design and development of aeronautical/space craft
Alternative Fuels	Development of alternative fuel technologies
Future Truck	Hybrid Electric Sports Utility Vehicle for national design competition

Formula Car SAE	Indy-style race car for national design competition
Mini-Baja SAE	Mini-baja car national design competition
Clean Snowmobile	Noise and emission reduction national design competition
Innovative Castings	Research and engineering in Die Casting, Investment Casting, and Continuous Casting
Blue Marble Security	Development of security solutions for home, community, and industry markets
Nanotechnology	Research, development and manufacturing of nano-scale materials
Entrepreneurial Ventures	Research, development and commercialization of promising technologies/applications
Interntl Business Ventures	Collaboration across national boundaries in the area of product realization
Noise and Vibration	Development and testing in the area of noise/vibration, particularly of engine systems

TABLE 2
CURRENT ENTERPRISE TEAMS AND MAJORS

PROGRAM ASSESSMENT

One of the challenges associated with assessing outcomes for Enterprise is that there is a great deal of individuality among enterprises. Some enterprises focus on designing solutions for problems supplied by industry or governmental sponsors; some focus on the design of vehicles for student competitions; still others work on potential patentable ideas of their own choice. Departments within the College of Engineering have typically established a set of rules and procedures for their senior design projects, however, since Enterprises operate much like virtual companies, the students in them have much more flexibility in defining the direction that their organization will take. As a result, each Enterprise has developed its own set of procedures and focus, and there is limited uniformity across the program. Since the program is supposed to be a model of the "real world," it is appropriate that there be flexibility in enterprise operation, however, this does not lend itself to a "one size fits all" assessment plan. Based on difficulties identified in conducting the 2002-03 assessment, the program assessment plan was modified for the 2003-04 academic year and further modifications are likely for 2004-05.

Our intent is to demonstrate through assessment that our students are achieving the stated ABET outcomes and goals for engineering design. In general, we need to demonstrate (both anecdotally and from hard assessment data/statistics) that "students are being prepared for engineering practice through the curriculum, culminating in a major design experience based on the knowledge and skills acquired in course work and incorporating engineering standards and realistic constraints that include most of the following considerations: economic, environmental, sustainability, manufacturability, ethical, health and safety, social and political." [5] Examining the specific ABET assessment criteria, the Enterprise Program has decided to focus on a relevant subset of desired outcomes, i.e. outcomes (c), (d), (e), and (g):

(c) An ability to design a system, component, or process to meet desired needs.
(d) An ability to function on multi-disciplinary teams
(e) An ability to identify, formulate and solve engineering problems
(g) An ability to communicate effectively

In addition, we have evaluated ABET Criterion 4 which addresses how effectively students take into consideration realistic design constraints such as ethics, environment, politics, and health and safety. Assessment methods and results for each outcome are outlined in the following sections.

Assessment of Communication Skills

To assess communication skills (outcome g), several methods were employed with the results as described below:

- All students are required to take ENG2962-Communication Contexts. In this class, students are given individual writing assignments. A random sample of the assignments are then graded by a panel convened to assess writing skills. In this course students were also required to give an oral report that was judged by external reviewers.
- Oral communication skills were assessed at the Undergraduate Expo through external judges who view team presentations.
- A focus group was facilitated by one of our enterprise faculty to discuss their experiences communicating within their respective enterprises.

Faculty from Scientific and Technical Communication, the University Writing Center, Geological/Mining Engineering and Sciences, and Electrical and Computer Engineering participated in the holistic scoring of 39 randomly selected memos. For each rubric item, memos were evaluated on a scale from 0-3. The results from this scoring are presented in Table 3.

Rubric Item	0	1	2	3	Avg.
Discusses the question "to what extent were you able to solve any of your internal or external communication challenges through the planning, design, and distribution of your Enterprise Communication Style Guide?"		29	91	75	2.24
Tone and Diction: the information is presented in a professional tone appropriate for the occasion, and the writer uses a language at the appropriate level of difficulty.	4	27	96	68	2.17
Grammar and Mechanics: Memo is free of grammatical and mechanical errors	7	20	103	65	2.16
Format: three identifiable sections on the memo	10	18	90	78	2.20

TABLE 3
WRITTEN MEMO ASSESSMENT RESULTS

In general, performance on memo-writing improved compared to the previous year's memos. It could be from improvements made in the Communication Contexts course module or from providing students with a better writing prompt for the memo used in the assessment. Based on the results from this assessment future offerings of the course will include a stronger focus on grammar and mechanics.

A random sample of team oral presentations were also evaluated by a panel of external reviewers from Scientific and Technical Communication, the University Writing Center, Geological/Mining Engineering and Sciences, and Electrical and Computer Engineering. Each student from the teams participated in the presentations, so virtually every student was observed through this assessment. Again, rubric items were evaluated on a 0-3 score with results presented in Table 4.

Rubric Item	0	1	2	3	Avg.
Presenters focus on specific examples and discuss specific problem-solving outcomes		1	43	30	2.39
Visual Aids: Presenters employ thoughtfully designed, memorable, and integrated use of visual aids.	8	11	27	28	2.01
Professional Commitment to Materials: Presenters demonstrate professional interest or enthusiasm for the materials.	1	5	26	42	2.47
Organization and structure: Presenters make explicit and obvious the structure and organization of the presentation.		4	35	34	2.41
Audience Awareness: Presentation is appropriate for the audience; tone vocabulary, level of detail		4	16	54	2.68
Interactivity: Presenters invite comments, questions, or feedback, and handle interactions well.	2	3	36	33	2.35

TABLE 4
ORAL PRESENTATION ASSESSMENT RESULTS

It is apparent that the oral communication skills of the Enterprise students are adequate, however, there is room for improvement. In the future, the Communication Context instructor will incorporate more instruction on the effective use of Visual Aids in the module.

In the spring of each year, the College of Engineering hosts the annual Undergraduate Exposition where student researchers, senior design teams, and enterprise teams present the results of work performed during the academic year. Each Enterprise team is required to give an oral presentation which is evaluated by engineering professionals from industry and by MTU faculty. During the Spring 2004 Expo, student representatives from each enterprise team gave a 15 minute presentation highlighting their business's activities during the academic year. Each presentation was evaluated by three judges on the basis of content, delivery, and the ability to respond effectively to audience questions. Average evaluation scores for each category were determined for each of presentations using a 5-point scale, the results of which were as follows:

- Content – 4.01 (3.76 in 2003)
- Delivery – 4.21 (3.69 in 2003)
- Questions –4.33 (4.00 in 2003)

Specific comments made by Expo judges included:

- Good presentation skills. A little light on practical, industrial applications of technology.
- Well balanced effort. Appears to be highly labor intensive - i.e. product will "be made in China".
- Excellent presentation. Good focus on data and improvement over past years work. Very professional. Good team organization.
- Too many words in slides. No time for questions. Should explain business structure of enterprise and how it will sustain. What was the purpose of the small engine study other than a material substitution exercise?
- Good presentation. Would have liked to see more technical details in terms of technology implementation.
- Well presented. Well answered questions. Enthusiastic. Obviously automotive interested.
- Suggest more specific details regarding the competition objectives and specifically how they were attacked. Good job!
- A little lacking on substance and professionalism. Good job, definitely room for improvement. Stick to your mission statement.
- Great presentation. How large was the team? Picture of your snowmobile would be neat.
- Good prompt answers to questions. Professional presentation. Good breakdown of delegation. Nice job.
- All points were covered. Excellent presentation!!!

Finally, one of our enterprise faculty convened three focus groups of students from across all Enterprise teams to discuss experiences in communication. Topics included: 1) positive experiences in working with students of other disciplines, 2) practicing editing and revising strategies, and 3) the importance of making distinctions between internal and external audiences. Most comments given by students during the meetings indicated that the communication module is meeting the needs of the students with regards to skill development. Some of the issues raised by students during these Focus Group meetings pertinent to communication skills that we plan to address in future offerings of the modules were the need to make the written memo assignments more relevant and less repetitive and to improve the consistency between instructors for the various modules.

Assessment of Teaming Skills

To assess teaming skills (outcome d), the Associate Dean of Engineering reviewed a random sample of videos made during team sessions for students enrolled in the required teaming module (ENG2961). Tapes were divided into two categories--those made at the beginning of the semester (pre-tapes) and those made at the end of the semester (post-tapes). To assess the effectiveness of the Enterprise Program in preparing students to problem-solve effectively in team-based environments, we developed a rubric to evaluate enterprise teams as they worked together to solve "real-world" engineering problems. Several videotapes were reviewed and team performance was assessed on each rubric item shown in the following table using a four-point scale, with 1=Low and 4=High. Results (average scores) are shown in Table 5.

Rubric Item	Pre-Assessment				Post-Assessment				
	1	2	3	4	1	2	3	4	5
The team had a clear task/purpose.	2	2	3	3	3	2	2	3	3
Meetings were well organized, efficient, and effective.	2	2	2	2	3	1	2	3	3
Communication was specific, descriptive, and problem oriented.	3	2	3	1	4	2	3	3	4
Team members listened to each other.	4	3	3	2	3	2	4	3	4
All team members actively participated.	2	2	1	1	2	1	2	1	3
Team members worked interdependently.	2	3	1	2	2	3	3	3	4
Team members challenged each other, respectfully.	3	2	1	2	3	2	3	2	3
Both task and relationship roles were evident, no blocking roles.	2	2	2	2	3	3	3	2	3
Conflict was appropriately managed using collaboration and compromise rather than avoidance and/or dominance.	2	2	2	3	3	2	3	3	3
Members appeared to trust each other and enjoy working as a team.	3	3	1	3	4	3	3	3	4
Average	2.5	2.3	1.9	2.1	3.0	2.1	2.8	2.6	3.4

TABLE 5
TEAMING ASSESSMENT RESULTS

As can be seen from the data presented in the table, the post-assessment scores were generally higher than the pre-assessment scores with respect to teaming activities. The primary problem noted in the pre-assessment videos was the lack of engagement among all team members. In the pre-assessment videos team meetings were dominated by 1-2 individuals with others passively looking on. These behaviors were largely absent in the post-assessment videos.

Assessment of Design and Problem-Solving Skills

To assess ABET outcomes c and e, we employed several methods including:

- External sponsors of Enterprise projects were asked to use a rubric we provided that evaluated these outcomes.
- Each advisor, in consultation with student leaders, rated the contribution each student made towards the enterprise design. Students were rated on a 0, 1, 2 scale and records kept into the future. The goal here is to ensure that each student has at least one or two semesters of "2" design experience throughout their tenure in the Enterprise program.
- Each enterprise team was required to complete a rubric regarding consideration of design constraints for the professional component.

For outcomes regarding design and problem-solving ability, external review of Enterprise projects was sought. External evaluators were also asked to comment on the extent to which ABET Criterion 4 was met through the project as well as on the teaming and communications outcomes. Each aspect was assessed with choices of Needs Improvement (NI), Satisfactory (S), Outstanding (O), or Not Observed (NA). The results from this assessment are summarized in Table 6.

Team	Design				Problem Solving			
	NI	S	O	NA	NI	S	O	NA
PrISM		5	2			2	1	1
WCE-Guidant		4	3				4	
WCE-Rockwell			5	2			1	3
WCE-EAS		7				4		
Future Truck			7				4	
Consumer Product Mfg.		5	2		1	2	1	
Robotic Systems		5	2			2	2	
Planning and Development		7				2		2
Integrated Microsystems		5	2			1	3	
Alternative Fuels		4	3			1	3	

TABLE 6
EXTERNAL EVALUATOR ASSESSMENT – DESIGN AND PROBLEM SOLVING

The data presented in this table indicates that the Enterprise students are meeting or exceeding expectations with regards to design and problem-solving, as assessed by external evaluators, most of whom are currently working in industry. One of the questions specifically asked of external reviewers was whether or not the "team chose the optimal solution based on technical and economic criteria" and also whether the "team took into consideration most of these other factors (as appropriate) when choosing an optimal solution- ethical, environmental, sustainability, political, manufacturability, health & safety, and social." Table 7 summarizes the results obtained from the ten external reviewers to date regarding consideration of the realistic design constraints.

	NI	S	O	NA
Team chose the optimal solution based on technical and economic criteria		6	4	
Team took into consideration most of these other factors (as appropriate) when choosing an optimal solution-ethical, environmental, sustainability, political, manufacturability, health & safety, and social.		7	2	1

TABLE 7
EXTERNAL EVALUATOR ASSESSMENT - PROFESSIONAL COMPONENT

As observed from the data presented in this table, it seems that the external reviewers believe that the Enterprise design teams are meeting the professional component criterion. Also included on the rubric completed by external reviewers were questions regarding teaming and communication skills. The results from this are presented in Table 8.

Team	Teaming				Communication Skills			
	NI	S	O	NA	NI	S	O	NA
PrISM		2	1	1		1	3	
WCE-Guidant			2	2			3	1
WCE-Rockwell			1	3			2	2
WCE-EAS		4				3		1
Future Truck			4				4	
Consumer Product Mfg.	1	2	1		1	2	1	
Robotic Systems		2	2		2	1	1	
Planning and Development		2		2	2	2		
Integrated Microsystems		1	2	1	3	1		
Alternative Fuels			2	2		1	2	1

TABLE 8
EXTERNAL EVALUATOR ASSESSMENT – TEAMING

The data presented in this table indicates that the Enterprise students have met expectations with regards to teaming, but there is some indication that their communication skills may be weak. In reading through the comments regarding communication included by external reviewers on the rubrics, it seems that most concerns in this area stemmed from a *lack of* communication rather than *poor* communication, i.e., external sponsors were expecting more interim progress reports or communication of this nature. Advisors will be made aware of this concern during an early Fall 2004 meeting so that they can coach their student Enterprise teams more effectively in the future.

Information regarding student participation in design activities has been gathered for the Fall 2003 and Spring 2004 semesters and will continue to be tracked each semester. Design contributions will be monitored throughout a student's enterprise experience. At the beginning of the 2004-05 academic year, advisors will be asked to review the past design experience for each student in their enterprise and assign individual design tasks as appropriate for the coming year to ensure that all students have at least two semesters of significant design experience before graduation.

Enterprise teams were asked to complete a rubric regarding their consideration of each of the realistic design constraints listed in Criterion 4 of the ABET criteria. Of the 69 completed rubrics, 5 were eliminated from consideration, because they were apparently teams that were not involved in the design-related activities of the Enterprise (e.g., Leadership, recruiting, communications, and lab development). For each constraint identified on the rubric, teams were asked to rate it on the following scale: 0=Not considered at all, 1= Factor considered somewhat, 2=Factor extensively considered, and N/A=Factor not applicable to the project being evaluated. Results from this assessment are included in Table 9.

	Number of Teams
Total Number (total minus non-design teams)	64
Considered 4 or more factors	52
Considered 5 or more factors	36
Considered **most** (i.e., more than half) of the "applicable" factors	59

TABLE 9
STUDENT ASSESSMENT – PROFESSIONAL COMPONENT

As can be seen from the data gathered through this assessment, most of our teams are meeting the ABET requirement for consideration of realistic design constraints. In the future we will work with Enterprise advisors to increase the number of design teams that consider most of the eight factors identified by ABET and will improve our data gathering through better prompts and guidelines for advisors/student teams.

CONCLUSIONS

Analysis of Assessment Results and Changes Based on Findings

It appears that students who participate in the Enterprise program are achieving the four outcomes identified for assessment. Their oral and written communication skills are generally adequate and their ability to work on teams is very good. Most student teams have demonstrated their ability to solve problems and to design solutions. Some problem areas have been found and corrective actions taken. Most problems identified in the previous year of program assessment were related more to the data gathering. Measures taken to change our data gathering procedures for the 2003- 04 academic year seem to have improved this situation, however, further areas for improvement have been identified. Based on our experiences in the 2003-04 evaluation cycle, the following changes will be made to the program and to our assessment plan:

- Improvements in course content for the two required modules (Teaming and Communication Contexts) will be made to address identified weaknesses: 1) more emphasis on mechanics and grammar, 2) increased use of engineering examples in the teaming modules, and 3) improved instruction on organizing an oral presentation.
- Students across the program will be surveyed with respect to their like/dislike of the 1-credit module courses. Based on the results from this feedback, we will explore the possibility of combining one or more modules into more "traditional" 3-credit courses.
- A faculty retreat for Enterprise advisors is currently being planned for August '04. One of the main topics for discussion will be assessment practices so that advisors are fully aware of expectations and requirements. Other topics will include a session on "best practices" and a review of data regarding student contributions to design.
- We will develop and implement a plan to compare outcomes obtained through Enterprise with those obtained through the traditional senior design approach.

In summary, the Enterprise Program, entering its fifth year of operation, has become a signature program for Michigan Tech's College of Engineering. By working together in a business-like setting, teams of students from every part of campus 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, including the social, environmental, and economical concerns. Working in this environment, they see the value of communication skills, teamwork, and life-long learning. With this program Michigan Tech is truly following its guiding principle that the success of our students is the measure of *our* success. In addition, true to our university mission we really are "preparing students to create the future".

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