AC 2012-3279: ASSESSING THE IMPACT OF FACULTY TEACHING, ADVISING, AND MENTORING IN AN ALTERNATIVE MULTI-YEAR, INTERDISCIPLINARY CAPSTONE DESIGN PROGRAM

Ms. Mary Raber, Michigan Technological University

Mary Raber currently serves as Associate Director for the Institute for Leadership and Innovation and Director of the Enterprise Program at Michigan Technological University. She has overseen the implementation and growth of the Enterprise Program at Michigan Tech since its inception in 2000, and is responsible for its overall coordination and development. Her responsibilities include corporate sponsorship development, interdisciplinary program evaluation and assessment, and workshop/course instruction in the areas of teaming and leadership. She is also actively involved in coordination, curriculum development, assessment, and instruction in the Pavlis Global Leadership program. She received her B.S. in mechanical engineering from the University of Michigan and an M.B.A. from Wayne State University and is currently working on her Ph.D. at Michigan Technological University. Before joining MTU, she held various engineering and management positions during a 15 year career in the automotive industry.

Dr. Susan L. Amato-Henderson, Michigan Technological University

Susan Amato-Henderson is an Associate Professor of psychology in the Department of Cognitive and Learning Sciences at Michigan Technological University, earning her Ph.D. in experimental psychology from the University of North Dakota. Her research focuses on assessment of educational outcomes in higher education as related to STEM learning, with a focus on the effects of various experiences on individuals' self-efficacy, entrepreneurial intentions, creativity, and other related constructs, as well as the effects of an individual's values and professional role orientation on STEM learning, retention, persistence, and ethics.

Assessing the Impact of Faculty Teaching, Advising and Mentoring in an Alternative Multi-Year, Interdisciplinary Capstone Design Program

Abstract

In 2000, Michigan Technological University introduced a new undergraduate engineering curriculum option intended to serve as an alternative to the traditional two-semester senior capstone design experience and one that would better meet the needs of both students and industry. Initially funded through an NSF Action Agenda grant, this program offers teams of students from varied disciplines the opportunity to work for several years in a business-like setting to solve real-world engineering problems supplied by industry. This alternative capstone program is now a self-sustaining program that attracts engineering and other STEM-discipline students to the university, retains them, and makes them more marketable to employers when they graduate. Each alternative capstone design team operates as much as possible like a real company in the private sector and is run by the students. Team sizes range from 10 to 70 or more members. All team members have prescribed responsibilities corresponding to their level of maturity, abilities, and technical education. Team members define problems, develop and design solutions, perform testing and analyses, make recommendations, manufacture parts, stay within budgets and schedules, and manage multiple projects. This alternative capstone design program has converted the traditional classroom into a multi-year, interdisciplinary, experiential learning environment and has transformed the role of instructor from one who imparts knowledge to that of advisor and mentor who guides students as they discover and apply knowledge.

Under NSF's IEECI program, we undertook a study to determine whether student participation in this multi-year, interdisciplinary design program and the roles of faculty mentors and advisors are positively correlated to successful student education outcomes. Although routine instructor evaluation takes place each semester for coursework associated with the program, no assessment project has attempted to measure the impact of faculty involvement on outcomes such as student retention and entrepreneurial intentions. The impacts of teaching, advising, and mentoring in team-based design programs are not typically susceptible to the kinds of metrics used to measure research accomplishments. Therefore, a model that can directly measure quality in hands-on, discovery-based learning environments and its impact on student outcomes would be potentially transformative. Evaluation results can help strengthen the business of engineering education by offering additional evidence of the impact of a curriculum such as that used in capstone programs, and the contribution of faculty who teach, advise, and mentor students. This is valuable information for recruiting engineering students, for designing programs that retain engineering and other STEM students, for improving engineering education, and for attracting industry support. Students from both the traditional senior capstone design program and from the alternative capstone design program participated in this survey so the possible impact of multi-year participation could be assessed.

In this paper, we share the evaluation methods used and results of our study. We suggest practical applications of the knowledge gained to the improvement of engineering education. We also include recommended methods and metrics for assessing the impact of teaching,

advising, and mentoring on student retention in engineering, graduation, career intentions, and other outcomes.

Introduction

Since the Enterprise Program was implemented in 2000, over 1000 students have graduated having completed the Enterprise curriculum. During that time, we have accumulated both quantitative data and myriad anecdotal data to document participation levels and skills development. One of the most surprising and significant outcomes of the program is the difference in six-year graduation rates between Enterprise and non-Enterprise students – our most recent numbers show 91% for Enterprise students and only 75.7% for non-Enterprise engineering students. We can probably ascribe this result to many features of the Enterprise program – its more interesting interdisciplinary nature; the fact that participation is a commitment that extends over several years of undergraduate study; its focus on real-world problem solving; the Enterprise team structure; and ***the impact of faculty teaching, advising, and mentoring on Enterprise student participants***. But we have never attempted to study why Enterprise works, therefore we don't understand if and why these factors have an impact, and what the relationship among these factors might be.

Many faculty are needed to teach Enterprise courses. Additionally, each Enterprise team must be advised and mentored by one or more faculty members. Faculty participation, which is voluntary, is critical to the success of each Enterprise team and to the program as a whole. Faculty who advise an Enterprise team are supposed to be given release from one course per year, though the consistency of this practice varies from one department to another. As recognized in the IEECI program announcement, and as confirmed by early feedback in the Enterprise program, faculty advisors do not feel that Enterprise advising and mentoring count for much in terms of promotion and tenure criteria. They are right; advising an Enterprise team is not included as an item for consideration on the promotion and tenure checklist at Michigan Tech. Yet, these faculty members are contributing to a program that, without question, has a tremendous and measurable impact on the business of 21st century engineering education at Michigan Tech, on regional economic development, and on the career success of Enterprise participants.

In this project, we have hypothesized that teaching, advising, and mentoring activities have meaningful and measurable impacts on the success of the Enterprise participants. As a first step, we attempted to measure and explain the impacts of faculty teaching, advising, and mentoring on student participants in the Enterprise program at Michigan Tech. P principal questions that we sought to answer in this "Insights into the Business of Engineering Education" project involved he relationship between the quality of Enterprise teaching/advising/mentoring and retention in engineering majors, graduation rates and other academic and eventual career success outcomes among Enterprise student participants?

The impacts of teaching, advising, and mentoring in programs such as Enterprise are not typically susceptible to the kinds of metrics used to measure research accomplishments. Therefore, a model that can directly measure quality in the classroom and its impact on student outcomes would be potentially transformative. Evaluation results can help strengthen the business of engineering education by offering additional evidence of the importance of teaching excellence, the impact of curriculum like Enterprise, and the contribution of faculty who teach, advise, and mentor students. This is valuable information for recruiting engineering students, for designing programs that retain engineering and other STEM students, for improving engineering education, and for attracting sustainable industry support for Enterprise.

Context

In the fall of 2000, Michigan Technological University introduced a new undergraduate engineering curriculum option intended to serve the needs of both students and industry. The Enterprise program, initially funded through an NSF Action Agenda grant (EEC-9872533), offered teams of students from varied disciplines the opportunity to work for several years in a business-like setting to solve real-world engineering problems supplied by industry. Enterprise has succeeded beyond any of our expectations and has proved to be a sound investment[4]. It is now a self-sustaining program that attracts engineering and other STEM-discipline students to Michigan Tech, retains them, and makes them more marketable to employers when they graduate.

Each Enterprise team operates like a real company in the private sector and is run by the students. A team includes anywhere from 10 to 70 or more members. All Enterprise team members have prescribed responsibilities corresponding to their level of maturity, abilities, and technical education. Within their projects, team members perform testing and analyses, make recommendations, manufacture parts, stay within budgets and schedules, and manage multiple projects. Faculty members and industry sponsors serve as advisors and mentors. Toward the end of spring semester each year, enterprise teams submit detailed written reports that include results of their projects. The teams also make oral presentations to Michigan Tech faculty and students, industry mentors, and the public.

All Enterprise participants complete an Enterprise curriculum which includes a minimum of 12 credits. Some of the courses are required and others are elective. Enterprise is an alternative to Senior Design, which is still offered at Michigan Tech. Enterprise students may also elect an Enterprise Minor or an Enterprise Concentration, requiring additional coursework. Outcomes for Enterprise participants include:

- Students gain hands-on experience solving real-world engineering problems by applying both technical and business skills
- Students confront the complications of a real engineering project
- Students learn how to apply critical thinking and problem solving skills
- Students practice managerial judgment and project management skills
- Students experience the importance of teamwork in engineering and the challenges associated with working on a diverse, cross-functional, multi-disciplinary team
- Students address multiple objectives, accomplish multiple goals, and communicate effectively with diverse constituents
- Students integrate concepts such as sustainability, ethics, safety, business processes, innovation, creativity, and communication regularly into their project work.

One of our major efforts with the Enterprise program has been to promote a learning atmosphere where faculty serve as mentors and advisors to Enterprise team members; that is, they move from the role of imparting knowledge to helping students discover and apply knowledge. We envision a relationship that parallels the one between faculty members and student researchers wherein inquiry and innovation are the norms, learning and application go hand-in-hand, and students and faculty advisors work in a team environment to solve problems of significance to industry.

Enterprise has a twelve-year track record that includes several quantitative and qualitative evaluative results that document the successful outcomes of the Enterprise program[1,2,3,4]. Some of the quantitative outcomes achieved by Michigan Tech's Enterprise include: (1) Three year retention rates based on fall first-year engineering and technology students indicate a range of 93-100% for Enterprise students versus a range of 65-85% for non-Enterprise students. (2) Graduation rates for the fall 2000 incoming cohort of Enterprise students were 83.6% and 77.2% for non-Enterprise students; for the fall 2001 incoming cohort, the graduation rate was 91% for Enterprise students and only 75.7% for non-Enterprise students. (3) Enterprise students make up 11% of the undergraduate student body, but they account for over 30% of undergraduate patent disclosures. (4) Enterprise annual participation has grown from 230 students to over 800 students from at least 19 different disciplines. (5) The number of Enterprise teams has increased from 11 to 28. (6) Each year, more than $750,000 in industry funding sustains and grows the Enterprise program.

Methods

One of the significant challenges of this research project was to identify an assessment tool that can measure the impact of teaching, advising, and mentoring either separately from or in relation to other variables that may also impact the outcomes of programs like Enterprise.

Initially, our efforts focused on review of existing instruments in order to determine whether any might prove useful to our own evaluation needs, or to inform development of new instruments as needed. Several potentially useful instruments were identified, including:

- The Search Institute's Developmental Assets Profile (2006, Minneapolis, MN)
- AWE's Undergraduate Engineering Mentor Pre/Post-Participation Survey (2006)
- AWE's Students Persisting in Engineering Survey (2007)
- KSU's Academic Advising Inventory (2009)
- CAEE's Academic Pathways of People Learning Engineering Survey (Apples)

A review of the above, as well as of several internal (MTU) assessment tools, were helpful, but did not encompass all aspects of the teaching, advising and mentoring role we were hoping to measure, nor did they provide a method of differentiating the impacts of teacher, advisor, and mentor. It was therefore decided that development of a new assessment tool was in order.

In order to identify key relational factors to be included in this assessment tool, a logic model was developed to capture key inputs, outputs and outcomes of the program that we intended to measure and that would appear to have some relational aspect to the role of the faculty mentor. The expected outcomes from Enterprise program participation as generated by the logic model process are shown in Figure 1. From there, a set of assessment statements were developed, intending to measure the outcomes. Specifically, we sought to measure students' perceptions of the value or impact of various aspects of the program (instructors, coursework, team, program mentors, etc.) toward the outcomes as identified in the logic model. A modified Likert scale was utilized allowing students to rate their level of agreement from Strongly Disagree (-3) to Strongly Agree (+3). No option was provided for students to provide a neutral response in an effort to force a rating toward the "disagree" or "agree" end of the scale. In summary, this new rating scale was designed to identify and measure the influence of several different people and experiences on students' educational and career intentions, as hypothesized to exist by our logical model.

Figure 1.
EXPECTED OUTCOMES FROM ENTERPRISE PROGRAM PARTICIPATION

Knowledge	***Actions***	***Conditions***
Technical skills	Project work	Integration into "engineering" work environment
Business skills	Project management	Invested in outcomes
Critical thinking	Diverse teamwork	Commitment to team and project
Problem-solving	Communicate to diverse constituents	Increased marketability of student skills (job placement)
Time-management skills	Integration of concepts (ethics, sustainability, …)	Increased retention rates
Knowledge of career	Patent disclosures	Increased graduation rates
	Presentations	Increase students attracted to MTU, STEM
		Enhanced intentions to pursue STEM career
		Increased entrepreneurial intentions
		Academic success
		Career success
		Impact on regional economy

On the newly created *Educational and Career Impacts Survey*, students were asked to rate their level of agreement to each of 34 core statements in terms of the contributions of a variety of people and experiences as follows: Enterprise Advisor (often referred to as *mentors*), Academic Advisor, Enterprise courses, Enterprise teammates, and overall involvement with the Enterprise Program (see Figure 2 for how these people/groups were defined for students). Specifically, students were instructed to rate their level of agreement with the core item with respect to each of the 5 individuals or groups. For example, the core statement *"My ________ increased my awareness of career opportunities and career alternatives within engineering fields"* resulted in 5 student ratings of agreement - one for each of the 5 people/experiences above. A similar survey was created for students who chose to complete their capstone requirement through Senior Design (a standard two semester, 6-credit team based project with 3-4 teammates from a single discipline). The only difference in the Senior Design student surveys was the replacement of the word “Enterprise” with “Senior Design” (i.e., students rated the impact of their Senior Design instructor, mentor, coursework, and project involvement). The Senior Design group was used as our control.

Figure 2. Differentiating the Roles of Advisors for Survey Participants

Your Enterprise Advisor:	This is the faculty member(s) who advises and mentors your Enterprise team, provides project/team guidance, and evaluates your work and assigns a grade for your participation in the Enterprise project courses.
Your Academic Advisor:	This is the person who provides academic advice for your department/major and who guides you in the fulfillment of requirements of your major. This person helps you to interpret the University's requirements, select appropriate courses, and develop a suitable educational plan to help you meet your career goals.
Your Enterprise Course Module(s):	These are the professional skills development course modules taken to supplement your enterprise project course experience and to fulfill enterprise concentration or minor requirements. Example course modules include Teaming, Leadership, Marketing, Design for Manufacturing and Industrial Health & Safety.
Your Enterprise Teammates:	These are the student team members with whom you interact on your Enterprise project.
Your Overall Involvement with the Enterprise Program:	This refers to your overall experience as a member of your Enterprise team.

In addition to the newly developed assessment tool, it was decided to include much of the APPLES survey instrument. We felt this was an opportunity to also gather useful information for our Michigan Tech students (both Enterprise and non-Enterprise) that could then be compared to persistence in engineering data available through the national APPLES database.

Methods

With over 800 students participating in Enterprise each year, and a similar amount participating in Senior Design, we attempted to collect data from as large a set as possible for each group. It was decided to wait until February (spring semester) to administer the surveys in order to give all students ample time to gain team experience, and therefore better evaluate their team-based experience. Most students – Enterprise and Senior Design control group - would have by then been working in their teams for at least 4-5 months.

The survey was first administered to a pilot group of 10-12 students to ensure clarity of questions and to determine the average time required to complete the survey. The pilot group provided useful feedback to improve the questions, which was fed back into the final version of survey. The average time to complete the survey was 20 minutes.

After much deliberation, it was decided to administer the surveys in hard-copy form during one of their Enterprise (or Senior Design) team meetings in order to secure the largest possible sample size. Enterprise students were offered a pizza dinner for teams that had a 100% completion rate of the surveys. In this way, over 320 completed surveys were returned (and 12 teams earned a pizza dinner for their Enterprise). Senior Design students were offered a coupon to the Campus Union cafeteria. Over 120 Senior Design surveys were completed. Sample sizes for some of the findings presented below are slightly smaller in analyses that were done on multi-question constructs, as students that had missing data points were not included in those analyses.

Results

Using Exploratory Factor Analysis (Principal Components Analysis) for data reduction, we sought to identify constructs underlying Enterprise students' perceptions of the impact of their involvement in the Enterprise Program on their career and educational intentions. We intended to identify constructs, or groupings of items, associated with the outcomes generated in our logic model (i.e., knowledge, actions, or conditions associated with program outcomes as hypothesized in our logical model, see Figure 1) as verification of the logic model outcome expectations. For this analysis, we utilized only data generated by Enterprise program participants, and only the agreement ratings in response to the contributions of the program (not the mentor, instructors, courses, etc). The scree plot suggested the presence of four factors accounting for over 63% of the variability within the data. The first factor represented those items inquiring about a variety of the knowledge and skills we expected students would gain from participation in Enterprise (skills useful for career, better understanding of what practicing engineers do, ability to work within teams, ability to work with cross-disciplinary team members, leadership skills, etc.). This factor, accounting for 25.77% of the variance, will be referred to as the Career Skills Factor in later analyses. The mean rating of the seven items with high loadings on this factor (and low loading on the other factors) were calculated for each student for use in other analyses. The second factor, accounting for 13.44% of the variance, represented three items inquiring about the development of entrepreneurial skills, interest, and intentions. This factor, represented by the mean ratings on those three items, is referred to as the Entrepreneurial Factor in later analyses. Factor three, titled Time Management Factor and accounting for 13% of the variance, was comprised of 3 items related to prioritization of tasks and time management skills. The fourth factor (Communication Skills Factor), comprised of 3 items related to improvement in communication skills (oral, written, and presentation communication skills), accounted for 11.49% of the variance.

A similar factor analysis procedure conducted with only Senior Design students resulted in the same factor components and structure; therefore, mean factors scores were also calculated for Senior Design students on each of the 4 factors. Because Senior Design students were all 4^{th} or 5^{th} year students (while Enterprise participants included freshman through seniors), differences in factor scores between Senior Design and Enterprise students (seniors only) were examined with ANOVA. Table 1 provides the mean factor scores for senior-standing Enterprise and Senior Design students across the four factors (6 point scale, ranging from -3 to +3, with negative numbers reflecting disagreement that program involvement contributed to the abilities/intentions and positive numbers reflecting agreement that program involvement contributed to the abilities/intentions)

Table 1: Mean Agreement Ratings of Enterprise and Senior Design students with Senior Academic Standing on Educational and Career Impacts Survey Factors

		N	Mean	Std. Deviation
Career Skills Factor	Enterprise	172	1.6767	1.03556
	Senior Design	76	.9549	1.26902
	Total	248	1.4555	1.15870
Entrepreneurial Factor	Enterprise	172	.8391	1.50782
	Senior Design	75	-.3711	1.63909
	Total	247	.4717	1.64302
Time Management Factor	Enterprise	173	1.6387	1.13268
	Senior Design	76	.4342	1.65016
	Total	249	1.2711	1.42204
Communication Skills Factor	Enterprise	173	1.7033	1.24940
	Senior Design	76	.9605	1.47770
	Total	249	1.4766	1.36398

Note that mean ratings on the 6 point scale, which ranged from -3 to +3 (no zero value), with negative numbers reflecting disagreement that program involvement contributed to one's abilities/intentions and positive numbers reflecting agreement that program involvement contributed to one's abilities/intentions.

ANOVA revealed significant differences between senior-standing Enterprise students and Senior Design students on all four factors. Enterprise students more strongly agreed that their involvement in the program contributed to the development of career skills [F (1, 246) = 22.213, P < .000]. Enterprise students agreed that their involvement in the program enhanced their interest in and intentions of pursuing entrepreneurial activities, whereas Senior Design participants disagreed with items contributing to this factor [F (1, 1, 245) = 31.897,p < .000]. Enterprise students more strongly agreed that their program involvement led to increase time management skills [F (1, 247) = 44.535, p < .000], and improved their ability to communicate [F (1, 247) = 16.645, p < .000].

In recognition that using Senior Design students as the control group for comparison with Enterprise students presents potential biases related to self-selection into groups, all students responded to items designed to measure characteristics such as creativity, leadership ability, problem solving, math aptitude, etc. These items were also agreement-ratings, but were not tied to specific people or experiences. Rather, they sought a student's general agreement with statements such as "Creative thinking is one of my strengths". No differences existed between Enterprise student responses and Senior Design student responses on these items, supporting the use of the Senior Design students as the control group.

To assess the relative contributions of program (i.e., Enterprise vs. Senior Design) mentors and academic advisors, factor scores were also calculated from students' agreement ratings with the statements in terms of the contributions of these people to their career and educational goals. Factor scores were the mean ratings across all items contributing to each factor, as described above, when rating the contributions of program mentors and academic advisors. Mean ratings of agreement are shown in Table 2. Enterprise and Senior Design groups rated significantly higher levels of agreement to all factors, suggesting larger contributions of Program Mentors as compared to Academic Advisors on the factors. Furthermore, Enterprise students rated the contributions of their Enterprise program mentors significantly higher than Senior Design students rated the contributions of their Senior Design project mentors on all factors.

Table 2: Perceived Contributions of Program Mentors and Academic Advisors: Mean Agreement Ratings on Educational and Career Impacts Survey Factors

		Group	N	Mean	Std. Deviation
Career Skills	Program Mentor Contributions	Enterprise	335	1.3132	1.19875
		Sr Design	78	.3342	1.61334
	Academic Advisor Contributions	Enterprise	335	.1873	1.63024
		Sr Design	78	-.4647	1.57674
Entrepreneurial Intentions	Program Mentor Contributions	Enterprise	333	.6326	1.46541
		Sr Design	77	-.9091	1.60990
	Academic Advisor Contributions	Enterprise	333	-.3243	1.62506
		Sr Design	77	-1.2619	1.38429
Time Management	Program Mentor Contributions	Enterprise	337	1.0851	1.31108
		Sr Design	78	-.0684	1.73693
	Academic Advisor Contributions	Enterprise	334	.1936	1.64250
		Sr Design	78	-.8034	1.66228
Communication Ability	Program Mentor Contributions	Enterprise	334	.9646	1.40171
		Sr Design	77	.1948	1.71368
	Academic Advisor Contributions	Enterprise	334	-.2600	1.66207
		Sr Design	77	-.6515	1.60459

Further Work

While existing quantitative and qualitative data suggests that the extensive hands-on discovery-based learning environment that Enterprise provides has a significant and measurable impact on the success of students while at MTU, little has been done to study the impact Enterprise has had on their career success post-graduation. We believe that the Enterprise experience provides an effective environment in which students can develop the professional competencies identified as critical to engineering career success[5]. Building upon the work done here, we plan to further investigate the following questions, both within the program, and post-graduation:

1. What specific factors contribute to the higher perceived impact of the Enterprise Program advisors (for instance, increased opportunity for relationship building)
2. What impact, if any, has participation in the Enterprise curriculum had on addressing the identified competency gaps and the ability of its graduates to successfully acclimate to the work place?
3. Are graduates of the Enterprise Program more (or less) likely to start their own businesses?
4. Are graduates of the Enterprise Program achieving greater and/or more rapid career success than their peers?

In addition, we hope to strengthen the research methods presented here through triangulation. In particular, we note that the survey method used represents only an indirect measure of the skills and impact of the advisor role. Further study will be focused on the collection of direct measures to test the findings presented here, providing both direct and indirect measures and qualitative as well as quantitative data. Our goal will also be to try to articulate those particular aspects of Enterprise team advising that positively impact the four educational and career factors identified in this study with the intention that these are skills and attributes that can be adapted to other contexts beyond the structure of the Enterprise model. Finally, further analysis must be done to evaluate and compare the APPLES portion of the data collected to identify/explain any differences in persistence in the engineering discipline as compared to national data.

Conclusions

The preliminary results of this quasi-experimental survey research indicate that there are significant differences between senior-standing Enterprise students and Senior Design students on all four factors (career skills, entrepreneurial intentions, time management, and communication ability) and that these differences are attributable to the Enterprise program in general and to the project advising that Enterprise students receive from faculty team advisors or mentors. Results indicate that Enterprise students perceive that their faculty team mentors have made significant contributions to their skills, entrepreneurial intentions and career intentions, perhaps due to the length of time that students participate in Enterprise with a longer and perhaps stronger relationship with the Enterprise mentor. On a broader educational perspective, these results may have important implications for the value of long-term, regular, and more focused faculty advising/mentoring, especially in project-based learning, but with potential applicability for all students. It is an area that warrants expanded study.

References

1. Lehman, J.B. & Raber, M. (2005, June). *Tech PrEP: seeding technology careers via Michigan Tech University's enterprise program.* Proceedings of the American Society for Engineering Education Annual conference, Portland, Oregon.

2. Raber, M. & Moore, M. (2005, June). *The enterprise program at Michigan Technological University: a professional development curriculum in action.* Proceedings of the American Society for Engineering Education Annual Conference, Portland, Oregon.
3. Sorby, S. & Raber, M. (2005, September). *Learning across boundaries through Michigan Tech University's enterprise program.* 4th Global Colloquium on Engineering Education, Sydney, Australia.
4. Stone, D., Raber, M., Sorby, S., & Plichta, M. (2005). The enterprise program at Michigan Technological University. *International Journal of Engineering Education*, Volume 21, No. 2.
5. Society for Manufacturing Education. Manufacturing Education Plan: Phase I Report, Industry Identifies Competency Gaps Among Newly Hired Engineering Graduates. 1997.
6. Walvoord, Barbara E. (2004). Assessment Clear and Simple. San Francisco: Jossey-Bass.