AC 2012-4583: FOSTERING INDUSTRY ENGAGEMENT IN THE CO-CURRICULAR ASPECTS OF AN ENGINEERING LIVING-LEARNING PROGRAM

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Fostering Industry Engagement in the Co-Curricular Aspects of an Engineering Living-Learning Program

Introduction

The CoRe (Cornerstone Engineering / Residential Experience) living-learning program at Michigan State University (MSU) entails both a large scale, hands-on, team-based curricular component, and a residential-based, co-curricular component. The goal of this program is to graduate engineering students with knowledge, experiences and mindsets that prepare them to function in the rapidly changing global engineering world of the 2000s. The development and components of this program, other than the industry engagement described herein, have been previously reported[1,2]. A brief summary and update is included to provide context for the rest of this paper.

The engineering education literature has provided many summaries of living-learning programs in recent years [3-6]. Common features of these programs typically include scheduling certain classes in common, tutoring, peer mentoring, faculty seminars and other faculty interaction activities, field trips, etc. However, it appears that most of these have been supported on federal grant funds, institutional funds, or some combination. A unique aspect of the MSU program, and the focus of this paper, is the involvement of industry sponsors/partners in pursuing the goal described above.

The learning component includes two courses. The first, a team-based design course, is required of all incoming students, and serves 1100 students per year. The second, a computing-based problem solving course, is required for eight of ten engineering majors and serves 850 students per year.

The residential-based (living component) co-curricular program involves nearly 500 first-year students living in a residence hall near the main engineering building. In addition, the facilities for the lectures and labs of the courses mentioned above are co-located in that residence hall, along with first-year academic advising. Hence, the residence hall serves as a focal point for all first-year engineering students and their activities, whether or not the students reside there.

The overarching goal of the residential, co-curricular component, named Engineering Residential Experience (ERE), is to connect students to the challenges of the engineering profession in the 21st century in a broad-based set of engagement activities.

In addition to significant financial support, the corporate partners provide in-kind support related to a mutually agreed-upon theme, which in many cases is or will be aligned with the Grand Challenges of Engineering as identified by the National Academy of Engineering[7]. The partners provide our students both with interactions with their engineers and with educational content around the selected theme and their company's related efforts. The theme, in turn, is reflected in a physical presence in the form of a theme-lobby on a floor of the residence hall. Partners on board at the time of this writing include Consumers Energy, sponsor of the energy theme, and GE, sponsor of the transportation theme.

Conversations are ongoing with additional potential partners. In addition, the program has further engaged corporate entities in several lesser-commitment activities that 1) serve our students and the program goals in a more narrowly targeted sense, and 2) provide opportunities for additional potential sponsors to familiarize themselves with our programs and its goals, and hence begin to consider potential theme sponsorship.

The following sections of this paper will further describe the goals, planning, evolution and execution of the program with special emphasis on the sponsor partnerships. As the initial partnership is just now completing its first year, assessment is still evolving. But early anecdotal information is both indicating success and informing the future direction of the initiative. The value of connecting students to their future work, in settings beyond the classroom and the faculty, is becoming apparent to all stakeholders as essential to student success.

Goals of the Co-Curricular Program

The mid-2000s saw some paradoxes in the need for producing engineers and what should be included in engineering curricula and co-curricular career preparation. At the same time that national calls continued for producing more engineers, the manufacturing heavy states of the Midwest saw significant numbers of engineers being laid off or driven into early retirement, sometimes involuntarily, and the nation as a whole saw the loss of some engineering jobs due to outsourcing.

The NAE publication, *The Engineer of 2020*[8], considered this shifting landscape and made recommendations that included:

- (2) Transform engineering education …
- (3) Build a clear image of the new roles for engineers, including as broad-based technology leaders, in the mind of the public and *prospective students* who can replenish and improve the engineering workforce (*emphasis added*).
- (5) Find ways to focus the energies of the different disciplines of engineering toward common goals.

Further, the report notes and recommends

- (p. 23) "Providing a broad engineering education to students has become an enormous challenge…. Engineering education must avoid the cliché of teaching more and more about less and less…. "
- (p. 24) "Engineering schools are going to have to prepare engineers to do so by teaching them to learn how to learn…."
- (p. 51) "We should reconstitute engineering curricula and related educational programs to prepare today's engineers for the *careers* of the future, with due recognition of the rapid pace of change in the world and its intrinsic lack of predictability" (*emphasis added*).

In the follow-on report, *Educating the Engineer of 2020*[9], it is noted that "the disconnect between the system of engineering education and the practice of engineering appears to be accelerating" (p. 13), and it is recommended that "The desired outcomes should include an enhanced educational experience for engineering students (and) opportunities to pursue engineering as a liberal education…"

Responding to these concerns, our goal was to graduate engineering students with knowledge, experiences and mindsets that would prepare them to function in the rapidly changing global engineering world of the 2000s. In doing so, the administration of the MSU College of Engineering recognized that:

- Curricular change alone (i.e., courses) may not fully address such broad-based goals for engineers, nor may change come quickly enough;
- Co-curricular programming could add a valuable, flexible and "nimble" means to engage engineering students outside the classroom, and earlier than most of their classes; and finally,
- Partnering closely with industry sponsors would provide credible, up-to-date "real-life" perspectives and reality checks to our students in addition to furnishing needed external financial support.

Accordingly, the ERE was created to address these concerns and also address the following student-centered objectives:

- To enhance the classroom experience by implementing experiential opportunities related to the profession of, and challenges of, engineering.
- To introduce students to resources on campus and in the college.
- To create peer mentoring relationships between upper class students and students new to the College of Engineering.
- To build a lasting connection between students and faculty.
- To introduce students to engineering majors early in their academic careers.
- To create an environment where students are free to express themselves and learn from one another.

To foster this type of environment, the program's co-curricular director and a group of engineering student peer leaders have worked with faculty and the corporate partners to create speaker series, student success seminars, free tutoring services, peer mentoring, community service opportunities and site visits to engineering companies, all further discussed later in the paper.

Goals of Industry Engagement

The primary goal of industry engagement is to provide our early engineering students with information and context for the engineering challenges of this new century from the sources most engaged with those challenges, and the sources where most students will find their careers—corporations.

Many jobs that were done by senior engineers at the time they were entry-level engineers are today the work that is outsourced overseas: "routine" design, adaptive design from one version of a product to the next, etc. The jobs for which our students will most likely find work lie in two areas where the US remains a leader, innovation and integration (outsourced design must eventually be reviewed, evaluated, and its many components integrated to a final design).

As the former entry-level jobs are increasingly globalized, it is now critical for our students to be thinking about, and planning for, pre-professional employment from the first day in an engineering college. At the same time, moving from a high school job to a pre-professional job is a clear source of student anxiety, even among the most talented of students. Students need to see industry as approachable, and they need to understand the breadth of industry (from government to non-profit) opportunities, including those industries and jobs that are less familiar to them.

Hence, industry partners in an early engineering living-learning program serve a number of important roles:

- Through exhibits, lectures, fireside chats, tours, etc., they can assist with our students understanding the technical challenges facing the world today.
- They can provide pre-professional co-ops and internships
- Through their visibility and personal engagement with early engineering students, they can provide a smoother transition for students to pursuing employment opportunities in general.
- Finally, but of significant importance, they can bring financial resources to expand the opportunities of the program (tutors, peer leaders, facilities) beyond what can be provided by the institution alone.

Planning and Evolving the Industry Connections

The Dean of the MSU College of Engineering frequently speaks with industry leaders, many of whom are alumni or continuing employers of our graduates, on a frequent basis. Once the key elements of the ERE program[1] were in place, the Dean used every opportunity to discuss his unique vision for corporate engagement with students, outside the classroom. Commonly heard comments from industry about "what we seek in your graduates and what they should be able to do" can be, have been, and continue to be redirected to "how industry partners can help us achieve that goal."

While the program has a faculty director and two academic specialists as co-directors (one each on the academic and co-curricular sides) and the college has a development (fund-raising) staff, conversations have been most fruitful when they start at the Dean-to-engineer/executive level, regarding the broad qualities needed in today's and tomorrow's engineering graduates and the need for early connections. Following initial discussion, potential corporate partners have been invited to tour facilities, accompanied by the Dean, a development officer and program faculty and staff. This is followed by sending a formal funding proposal to the potential sponsor.

Execution: Partnership with University Housing and Residential Life

It is worth noting that the MSU College of Engineering does not "own" the residence hall facilities. Rather, they are owned and managed by the university housing office, and student support programming is managed by the department of residence life. Hence, the initiative to have sponsored theme floors with significant renovations and corporate displays in the floor lobbies was potentially an intrusion, and was certainly a "never done before" proposition.

Fortunately, the proposition was warmly received, with several notable factors related to this success, (1) a significant time period of the Dean promoting the program at the level of the University Provost and President, (2) the arrival of a new vice-president for residential and hospitality services, who is a change agent, and (3) the university housing operation being among the largest in the country, but aging, and needing to develop better means of attracting returning students.

Execution: The Energy Partner, Theme Floor and Student Engagement

One floor of the ERE program residence facility, Wilson Hall, is designated the Energy Theme Floor, sponsored by Consumers Energy, a large, Michigan-based utility. While any students in the ERE program may participate in the energy-related activities, the lobby of the Energy Theme Floor serves as a physical anchor and display area to highlight the sponsor's activities. To the extent practical, new students are polled when reserving housing as to what focus areas they are interested in, and those designating energy or transportation are placed on that corresponding floor (however, it is well known that student interests are varied and subject to change).

The previously empty and drab lobby was renovated with murals, video displays, a display case and student-friendly furniture for gathering or studying. Murals and one video screen portray the sponsor's energy facilities--coal, wind, gas and power distribution, etc., as well as some of the college faculty's own related research. Next to the mural photos are QR codes that can be scanned by student smartphones, which will take them to sponsor sites with additional information about the facility or initiative. A second video monitor provides vignettes of the college alumni who are employees of the sponsor as well as recent student interns and their work. The latter brings home the recognition that students a year or two ahead of the program participants, who are people they may see in the engineering building, are already in pre-professional work experiences with the sponsor. Finally, a display case in the theme floor lobby is used to exhibit industry related items, ranging from industry related artifacts of the past to the most recent technology. For fall 2011, these were related to the electricity side of the company, and in spring 2012, they were replaced with displays from the gas distribution side. In all cases, the intent of the theme floor displays is first to attract students' attention to problems, challenges and opportunities in the theme area, with the corporate identification kept more subtle and secondary, similar to PBS's approach of "made possible by a grant from…." A picture from the September 22, 2011, Consumers Energy theme floor dedication is shown in Figure 1.

Beyond the theme floor physical presence, we have had two evening presentations by the CEO of the corporate partner to our student body, one to mark the sponsor coming on board, and one at the time of the completion of the theme floor. Both of these were held in the large auditorium located in Wilson Hall. While open to the entire college and campus community, these were particularly focused on first-year students in the residential program. Each presentation focused on current challenges of the industry, with a significant portion of each presentation devoted to questions from students and two-way conversations between the students and CEO. In addition, Consumers Energy engineers provided a more informal "fireside chat" on SmartGrid technology.

Figure 1: Dedication of the Consumers Energy Theme Floor

Execution: The Transportation Partner and Theme Floor

The second corporate partner, the transportation division of GE, producers of both jet engines and diesel locomotives, came on board early in 2011 and the related theme floor lobby was dedicated in fall 2011.

Similar to that previously described, the renovated theme lobby includes murals and video screens to describe the sponsor's transportation-related activities, and scannable QR codes to take the student to web sites for further information. It also includes casual furniture to encourage student gathering. Nevertheless, the "look" of the lobby is very different from the first one and avoids "carbon copying." As of this writing, planning is underway for additional sponsor/partner involvement in co-curricular programming. Dedication of the GE transportation theme floor on November 1, 2011, is shown in Figure 2.

Figure 2: Dedication of the GE Transportation Theme Floor

Execution: Industry Engagement in the Curricular Component

As detailed in earlier publications [1,2], the academic portion of this integrated program, Cornerstone Engineering, consists of two introductory courses. The first, EGR 100, Introduction to Engineering Design, provides a set of broad, team-based, hands-on design experiences and an introduction to topics common across all engineering disciplines. This course is required of all incoming engineering majors and is the greater beneficiary of involvement by our industry sponsors. The second course, EGR 102, Introduction to Engineering Modeling, introduces problem solving and mathematical modeling of engineering problems and systems. It is required of all majors except computer science and computer engineering.

EGR 100 is a two-credit course taught in a lecture and laboratory format. Lectures are held once each week for 50 minutes throughout a 15 week semester. The laboratory sessions meet once per week for 110 minutes each. Lectures are held in a traditional auditorium; whereas the laboratory sessions are held in a computer facility populated with Windows®-based PCs. Lectures primarily deal with the various aspects of design, communication and the engineering profession while introducing students to the NAE Grand Challenges[7]. Laboratory sessions concentrate on applications of the lecture topics through individual and team-based assignments and small projects as related to two team-based major design projects.

The major design projects consist of a five-week, team-building project and an eight-week open-ended design project. Students are assigned to teams based on their individual interests, backgrounds and talents so as to create parity across all teams. Although students are given the opportunity to change teams between projects, nearly all teams remain the same throughout the course. Both of the projects involve the construction of functioning prototypes.

Development of the two team-based major projects had several objectives. First, we sought to have non-discipline-specific projects that could be worked on by any team of students regardless of proposed individual engineering major or background. Secondly, we wanted to incorporate some of the NAE Grand Challenges so as to enable the collection of many teams (nearly 150 in a single semester) to create unique solutions.

Our corporate sponsors have had an opportunity to participate with the EGR 100 design projects in two manners. The first is purely by their financial support of materials and other needs in our labs. To date, this has been the primary method of support. We have also been working with our sponsors to develop student projects that may be particular to their individual companies that also fit within the scope of the Grand Challenges. Thus, we have an energy-themed project corresponding to our energy partner. The current course projects are detailed below.

Our first major project has teams of students design, built, program, test and evaluate an autonomous robot built from a Lego® NXT Mindstorms kit. All student teams are assigned this project so as to develop their teaming skills as well as engineering and design skills. The project culminates with a performance evaluation in the form of a timed competition to determine the team's robot that completes the task in the shortest time.

The second major project has the student teams select from a suite of three possible design tasks. The first is a more extensive robot challenge in the form of a competitive game. The second is concentrated on an energy theme. And, the third involves a service-learning component.

The second robotics project has student teams compete with one another in an arena arrangement similar to the Robot Wars games of the past. In our situation, the robots are to collect balls of various colors and point values and deposit them into a goal within a set time limit. Most of the balls have positive point values while others have negative values and may be deposited into an opponent's goal.

The energy project has been expanded to two different projects that are offered during alternate semesters. The first has teams develop a solar water heater that draws a specified volume of water from a reservoir, holds it in a device for a limited time while it is being heated, and then dispenses the heated water. The team prototypes are to fit within a test fixture with high intensity heat lamps. The team designs are evaluated on performance, economics, and quality of written and oral presentations.

The alternate semester energy project has student teams develop working prototypes that fit within the test fixtures previously described that insulate a volume of water from increasing in temperature. The teams are given a 25 ml volumetric flask with a thermocouple that is to fit within an insulating device to minimize the water temperature increase during a specified time.

Teams are evaluated on their design's ability to insulate the flask and water from increasing in temperature while minimizing material weight, volume and cost.

Beginning spring semester 2011, a small number of student design teams (10) were given the opportunity to work on service-learning projects for clients of the MSU Resource Center for Persons with Disabilities (RCPD). These projects were then expanded to 20 teams for the fall semester 2011. Selection of the teams was done via written proposal. The spring semester teams developed working prototypes of devices to be used in daily life by RCPD clients including: a wheel chair charger docking station, an iPad® driven home environmental control system, a wheel chair mounted standing device, a utensil holder for a cooking-application robotic arm, and a wheel chair accessible computer desk. The fall projects included teams developing working prototypes of anatomy teaching models for blind students at a resource school in India, an award ribbon cutting machine to be operated by a physically disabled adult working at a local workshop, and an iPod® Shuffle device and integrated work table for a blind four-year-old afflicted with cerebral palsy.

We have had discussions with current and pending program sponsors to further develop our project offerings. As new partners are enrolled and are identified with the 14 Grand Challenges, we plan to work with those organizations to develop new and additional projects to fit within the scope of the course that may match their particular business. Our goal is to educate our sponsors on the mission of our course and capabilities of our students to develop challenging projects that correspond to their needs.

Also, as we offer project choices to our student teams from semester to semester, we will continue to modify and improve their specifications and goals such that each new group of teams is afforded the opportunity to develop a set of unique solutions to the presented problems. We also monitor the designs developed by the student teams for the various project types so as to ensure parity in the level of effort required and opportunity for successful solutions between the individual project offerings for a particular semester.

Execution: Industry and Faculty Involvement Beyond the Theme Floor Communities

Industry and faculty have engaged with students in the living-learning program in a number of ways beyond the theme floors. Speaker series in smaller, classroom and dining room-size settings have provided an opportunity for faculty and other engineering professionals to lead formal and informal discussions with students that centered on their professional research, their profession, admissions requirements, and how to be successful in higher education. These types of programs provide an opportunity for students with various comfort levels to interact with faculty members, engineering professionals, upper level students and staff members in a way that is often less intimidating than a formal classroom or office setting.

In 2009, NASA presented a program to students on how to use their engineering educational experience to secure an internship or professional position in the area of space research or travel. Students were also provided with an opportunity to spend time with the chief engineer on the Hubble Space Telescope project and to ask questions regarding the presentation and the role of NASA in future space travel.

Students have also visited engineering faculty members research labs, toured engineering corporations, and networked with the top administrative staff from Fortune 500 companies, private business sectors, government agencies, and engineering alumni. A retired chief of powertrain research from a major auto company has recently taken an MSU engineering faculty position and holds office hours in the residence hall in an effort to inspire students to persist to graduate as an engineer.

An additional benefit of industry participation is the financial support making possible resources such as providing peer leaders and peer tutors. Structured peer mentoring as noted by Durkin and Main[10] is known to improve students' self confidence in their belief they can be successful. Integrating peer mentoring into the structure of the ERE program is seen as an important contributing factor to student and program success. Our mentors, titled *peer leaders*, are engineering students beyond the first year, who serve as role models for those in the living-learning program. They assist first-year engineering students with time management skills, study skills, social issues, family and friend problems or tensions, and other difficulties typically facing students new to the college academic and social environments. A peer leader can also simply be someone for a student to hang out with or from whom a student can learn more about engineering majors, the curriculum, college research, engineering career fairs, engineering student organizations, college faculty and staff. Peer leaders do not serve in any disciplinary role, so the relationships established are mutual. Peer leaders also assist the co-curricular director to create an environment that is designed to engage living and learning participants in their academic and social environment.

Peer leaders work to include students in the development of all aspects of the living and learning environment. Each semester, the peer leaders and the co-curricular director recruit students to participate in a residential focus group and as community program assistants. The main goal of the focus group and the role of the community program assistants is to create programs that directly relate to the needs of the residential students. The focus group is considered the voice of the students and provides the staff with a direct link to understanding the needs of the program participants.

Free peer tutoring in math and science is provided in the student living environment five nights per week on a walk in basis. Tutors are hired from students who have successfully mastered the needed academic skills and are further trained to assure they can ride the fine line between "showing them how" and "helping them learn and understand."

Beyond industry, our faculty provide evening "fireside chats" on their research and its relation to today's engineering challenges. Examples have included:

- A biomedical materials faculty partnered with an orthopedic supplier, regarding the design of a special face mask for a basketball player.
- A computer science faculty presenting on biometric data bases (facial recognition, fingerprints, tattoos, etc.) and their use in security applications.
- A biosystems faculty presenting on food safety, and the role of heat, mass and microbial transport.

- An environmental faculty presenting on chemical contaminants in systems of environmental interest.

We have also had our academic departments host dinners where panels of alumni from a particular discipline present and answer career-related questions.

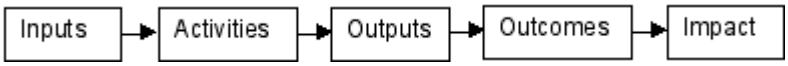
More recently this spring, , we had an evening co-curricular presentations by an alumnus who sold his software company to a major global IT company, speaking on "What I Wished I Had Known Then," and additional presentations from NASA, our sponsors and others.

As the program grows, we expect to add additional partners and themes, and additional activities such as field trips and professionals in residence who can spend extended times with students in the living-learning community.

Assessment Plans and Lessons Learned

As much effort as has been directed to date to obtaining sponsors/partners on board, formal assessment of their constituencies and their effect on campus constituencies (students, faculty, peer leaders) is in a late planning stage. Continuation and expansion of existing assessment will have occurred by the time of publication of this paper, and early results will be available at that time.

The proposed extended assessment plan will generally follow the logic model as reported by McCawley[11]. A simplified form of the sequence of elements to be considered is shown below:



The logic model has been used to guide consideration of assessment of fairly complex processes. At this point, the assessment team has identified the following elements for the living-learning community and its interaction with industrial partners (recalling the overarching goal to graduate students with experiences, knowledge, and mindsets that prepare them to function in the rapidly changing global engineering world):

- Inputs: the partners, students, faculty, time and money
- Activities: those surrounding the theme-based floors; faculty and industry presentations
- Outputs: students, industry partner participants, faculty and peer leaders
- Outcomes: Short-term: change in knowledge, skills, attitudes, motivation, and awareness of engineering
- Outcomes: Medium-term: persistence and retention from the first year through the second year of engineering
- Impact (or long-term outcomes): this will be demonstrated by the alumni of the living-learning program; the program will have its first graduates in May, 2013.

Phase I of the broader assessment will focus on students, program administrators and industrial participants. Assessments of satisfaction, attitudes and plus-delta evaluation will be conducted

largely by focus groups. Surveys will be used to address a broader perspective on changes in student knowledge, skills, attitudes, and awareness of engineering. Existing validated surveys[12,13] will be modified to address the specific effects of student interactions with industrial partners and their presence in the living-learning community (theme floors). Clusters will be used to determine differences among outcomes in students who live on theme floors versus those who do not. Students in their junior year (rising seniors) will also be queried in focus group formats to determine the influence of the living-learning communities on their educational experience at MSU. When the program has graduates, alumni will be surveyed to assess the effects of the industrial interactions in the living-learning community on their early professional progress. Industrial partners will be interviewed to determine the level of satisfaction with their involvement, their perceptions of student engagement, and for suggestions on how to improve the university/industry collaboration.

Assessment results to date are encouraging for expectations for the long run. Presently, each time students participate in any of the co-curricular programming, they are asked to complete a survey that will allow the college to better serve their needs. As a result of the student surveys, we were able to assess the effectiveness of engineering support services, co-curricular programming and peer support offered through the living and learning program. To date, we have learned that:

- Students feel that the environment is very inclusive of all students;
- Students are positively influenced by their peer leaders to participate in co-curricular programming;
- The speaker series and the tutoring services have had positive impacts on student success. Students have reported a strong desire to continue at the university as a result of their participation in this program;
- Students to develop a strong sense of community, especially within their major and through their late-night project work in the engineering computer labs located in the residential setting.

Results of the data collected from the program evaluation in the fall of 2011 yielded some intriguing results regarding the co-curricular programming. Data showed that students wanted more co-curricular programming that provided hands on experiences; they also wanted more informal presentations with personal interactions with the presenter(s), and more programs that involved recent engineering alumni. They wanted presenters who could relate to them given their limited exposure to the field of engineering and their lack of professional experience. By incorporating the feedback from our students, we are able to provide more consistent informal interactions with students. We do this in the form of recent alumni programs, town hall meetings, more frequent academic advising, and more meaningful personal engagement opportunities with students. This allows our program to provide services that are more responsive to student needs in a more real-time mode allowing us to incorporate their feedback into the daily operation of the program.

Conversations with industry partners have demonstrated that they have much interest in the hands-on components of the design course, with students getting their "hands dirty" as well as writing reports and making presentations in their first year. Following from the co-curricular

program, the industry partners see much greater engagement and reduced anxiety on the part of first-year students with whom they talk at career-related venues.

Our experiences have shown that industry engagement with early engineering students can have significant effects and benefits to the students, to the employers, and to the goals of making an engineering education more attractive and more relevant to students early in their educational pursuit.

Acknowledgments

We wish to particularly recognize the contributions and commitments of our first industry sponsor/partners, Consumers Energy and GE and the MSU Office of Housing and Residence Life for all of their efforts in bringing this initiative from idea to reality.

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