2006-1575: CREATING A MULTI-DISCIPLINARY COURSE WITH INDUSTRIAL INPUT

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Creating A Multi-Disciplinary Course With Industrial Input

Abstract

A diverse group of faculty has begun working on a multi-pronged project that aims to raise awareness among faculty and students about the environmental impact of decisions in manufacturing and product design. The project incorporates a multi-disciplinary approach at several levels including cooperation among diverse faculty, input from industrial partners, and direct collaboration between students, faculty, and administrators.

Initially, the group will develop an engineering elective course employing proven, innovative pedagogical methods and tools that enable students to incorporate environmental as well as economic concerns into technical design. The course will be offered for both undergraduates and graduate students. In an attempt to reach as many students as possible, the course is being offered with minimal prerequisites. It will be team-taught by faculty in Industrial & Manufacturing Engineering, Business, and Liberal Studies. Significant input into the modules will be sought from Mechanical Engineering and Chemistry faculty.

The multi-disciplinary nature of the course allows the topic to be presented in a comprehensive and unique fashion. The course modules begin with a module exploring historical and ethical perspectives on the environmental impact of industrial processes. Technical content and engineering tools comprise the middle weeks of the course, as life cycle concepts and material choices are introduced. The course concludes with a module presenting business and management perspectives, and will include multiple case studies that illustrate how environmental considerations can be incorporated in the design process.

In addition to the multi-disciplinary faculty component, an industrial advisory board made up of local industry professionals and university professors has been created to oversee the project. The advisory board meets annually to review technical progress by the group and also to provide guest speaker and plant trip opportunities. Ford Partnership for Advanced Studies has offered a set of modules for use in adaptation and implementation of the course.

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Introduction

The goal of creating a multi-disciplinary course with industrial input arose out of the words cited in *The Engineer of 2020* as written by the National Academy of Engineering (NAE). The NAE states that "Engineering practices must incorporate attention to sustainable technology, and engineers need to be educated to consider issues of sustainability in all aspects of design and manufacturing.[1]" The NAE further states that "engineers have been aware that solutions to many societal problems lie at the interstices

of subdisciplines" and that "there is a growing need to pursue collaborations with multidisciplinary teams of experts across multiple fields." Thus, the idea of a multi-disciplinary course in designing products for the environment should prove to have national merit in the field of engineering.

The uniqueness of the course lies in the proactive product and process design focus, the multi-disciplinary faculty involved in module development and teaching, significant industrial input into the course. In addition to course development, this project attempts to engage the larger university through student groups and guest speakers. Dissemination and outreach efforts attempt to engage others outside of the university.

A web search of existing environmental programs and courses via university websites was undertaken by the Kettering faculty team. Programs and courses with similar concepts were examined and university partners were invited to participate on the KIET advisory board. Similar discussions and web searches were utilized to identify local industrial partners for the purpose of insuring relevancy in the applications of the classroom concepts presented.

The National Science Foundation DUE-CCLI- Adaptation and Implementation Grant (DUE#0511322) required that the researchers adapt and implement an existing concept in a new and meaningful way. Thus, the new course will adapt material from the Ford Partnership for Advanced Studies (Ford PAS) curriculum. One specific Ford PAS module titled "Closing the Environmental Loop" employs case studies and engaging examples to instruct students about the environmental issues surrounding product design. This module will serve as the framework for the undergraduate-level modules currently being developed.

The Ford PAS is a combination of innovative curriculum for high school students; partnerships between high schools, higher education, and business; and technical support from the Ford PAS program itself. The Ford PAS provides high school students with high-quality interdisciplinary learning experiences that challenge them academically and develop their problem-solving, critical thinking, and communication skills. By building strong local partnerships with business and higher education, Ford PAS encourages and prepares students for success in college and professional careers in fields such as business, engineering, and technology.

Several institutions of higher education have become actively involved in the Ford PAS program. Ford PAS has partnered with Kettering University for the purpose of advancing the topic of environmentally responsible engineering. The modules used in Ford PAS provide a framework upon which the Kettering University undergraduate course IME540 *Environmentally Conscious Design and Manufacturing* is modeled. In addition, Ford serves on the industrial advisory board for the Kettering Industrial Ecology Team and as an example of a company that puts environmental issues at the fore-front of the design process. They have provided guest speakers and plant trip opportunities to Kettering students and continue to support the early education of engineers.

In an effort to reach a larger audience, the Kettering IME540 course will be open to engineering, science and management undergraduate and graduate students with the only prerequisite being senior standing. Course examples will focus on the environmental aspects of the goods and services produced by Kettering University's industrial co-operative education partners. In addition, guest speakers will be brought to campus every term to educate the larger university on the needs of the environment. The researchers will also be developing educational materials to be distributed freely via an internet website to anyone interested outside of Kettering University.

Problem Statement & Assumptions

How does a faculty team bring environmental consciousness to a small private engineering school campus within an already full curriculum?

Kettering University is uniquely positioned in Flint, Michigan as a premier engineering school with a bright student population. All students must be employed by one of over 700 co-op employers for the duration of their undergraduate experience. Thus, students are keenly aware of the needs of industry and often bring such needs into the classroom. The typical Kettering student carries a full load of classes consisting of approximately 20 credit hours over the course of 11 weeks. As with many engineering schools, the desire to facilitate graduation in four years results in a packed curriculum with few electives. One major obstacle for this project was to convince the university curriculum committee that this new course was important enough to add to the catalog. This course becomes one more competing course trying to fill the schedule for those few elective courses.

Assumption #1: Industry needs engineering graduates who have a concern for the environment as well as a skill set to address product design decisions necessary to meet those environmental concerns.

Assumption #2: Students are interested in the needs of the environment and will take an elective course related to this topic if it is well-developed.

Assumption #3: A good course related to environmental concerns will spawn outreach opportunities for recruiting females and minorities to pursue engineering.

Information Gathering

The first key component was a committed team of faculty with input from key industry personnel. Two faculty members from the Industrial & Manufacturing Engineering (IME) Department led the effort and, as such, the course was approved within the IME Department as IME540. Other faculty members from Liberal Studies, Management, Chemistry and Mechanical Engineering became involved in the early stages representing all departments that exist at Kettering. The specific faculty members were carefully chosen as excellent teachers well-respected across the university. In addition, a well-rounded advisory board, well-attended campus guest speakers and insightful course module development discussions resulted from the multi-disciplined team.

The second key component was a review of existing university programs to ascertain what was currently being taught throughout the world related to environmental concerns. In general, there are many courses and curricula related to air and water quality as well as energy usage. There are limited courses related to the initial design of products and processes with the needs of the environment as part of the design process. Several of these design oriented university programs were invited to join the KIET advisory board. A listing of these programs is given in Table 1.

Table 1 Selected Universities with Similar Programs, Invited to Join the Kettering Industrial Ecology Team (KIET) Advisory Board

Program	Contact	Course Website
Clarkston University	Susan Powers	http://www.clarkson.edu/evmm/edu_prog.php
Michigan Tech University	Mary Durfee	http://www.cee.mtu.edu/envindustrialecology.html
Carnegie Mellon University	Scott Matthews	http://www.ce.cmu.edu/GreenDesign/
Virginia Tech University	Steven Kampe	http://www.mse.vt.edu/academics/green.html
University of Washington	Joyce Cooper	http://faculty.washington.edu/cooperjs/index.htm

A third key component was real-world application of the course concepts. Initial visits to prospective companies allowed the researchers to gather ideas and gauge interest in the topic. Michigan companies were chosen for the initial advisory board to show a local impact and for ease in travel. All Kettering students must have a co-op employer and a majority of the students are employed by Michigan-based companies.

Table 2 Industrial Advisory Board Members – Participating Companies

Delphi
Ford Motor Company
General Motors
DTE Energy Technologies
Steelcase
Herman Miller
Global Engine Manufacturing Alliance (GEMA) Div. of Daimler Chrysler

The fourth key component was students. In an attempt to gauge student interest, a speaker series was planned to bring in an environmental speaker every term. Each speaker came to campus twice to repeat their presentation to both A and B sections of Kettering students. Surveys were distributed with questions relating to student and employer interest in the topic and the need for a course of this nature. Survey response was overwhelmingly positive illustrating the importance of creating an elective course for all students. Attendance ranged between 85 and 120 students out of a student population of approximately 1100 across the university. All speakers spoke to a standing-room-only

crowd and with a classroom so packed that students had to be turned away. Female attendance exceeded 35% out of a current female enrollment of less than 18%.

Table 3 List of Past and Scheduled Guest Speakers

Name Term - section	Company	Topic
Claudia Duranceau Sp04 – A, Su05 -B	Ford Motor Company	"Environmental Considerations in the Design of an Automobile"
Bruce Coventry and Jalonne Newsome-White Fa05 - A, Wi06 - B	GEMA Div. of Daimler Chrysler	"Clean, Lean and Green"
John Bradburn Sp06 – A, Su06 – B	General Motors	TBD
Gabe Wing Fa06 – A, Wi07 –B	Herman Miller	TBD
Dave Rinard Sp07 – A, Su07 - B	Steelcase	TBD

Draw Conclusions

Feedback from the advisory board clearly suggests that assumption #1 is accurate. "Industry needs engineering graduates who have a concern for the environment as well as a skill set to address product design decisions necessary to meet those environmental concerns." Through discussion at the advisory board meetings, industrial representatives stated that students needed not only to understand the technical aspects of environmental concerns, but also the economic impact that those decisions would have on the bottom line for the company.

Survey data collected from the multiple guest speakers on campus suggest that assumption #2 is accurate. "Students are interested in the needs of the environment and will take an elective course related to this topic if it is well-developed." A student representative currently attends weekly Kettering Industrial Ecology Team (KIET) meetings for the purpose of including a student voice in all decisions. The student representative has initiated the process of forming a student organization with a common interest in environmental concerns. Participation in this student organization will be one gauge of student interest in the topic. Learning effectiveness within the course will be gauged by an assessment plan developed by an external evaluator and applied in every term offering of the course. The importance of the topic convinced the Kettering University curriculum committee that this elective course would have sufficient enrollment to make it sustainable. The first course offering will be in late 2006 or early 2007.

The third assumption "A good course related to environmental concerns will spawn outreach opportunities for recruiting females and minorities to pursue engineering" is yet to be determined. Efforts are currently underway for the course module development and

dissemination of the results. Additionally, one interested student's fifth-year thesis project is titled "Development and Implementation of a Process to Optimize Corporate, University and College Prep Partnership" and is intended to determine the needs and resources available to develop environmental outreach efforts in the local community.

The Course – IME540 Environmentally Conscious Design and Manufacturing

Course material is currently being developed and it is anticipated that the course will be offered for the first time in the Fall of 2006. Six modules will comprise the course. Each module has a primary author, but one or more faculty from a different discipline will be working with the primary author. This will allow the module to address a wide range of perspectives.

Each module will be scheduled for three, two-hour blocks. A brief summary of the modules is as follows:

Technology, the environment and industrial ecology - In this module students will be introduced to the broader implications of the environmental impact of industrial activity. This will include a discussion of the historical, social and ethical motivations for a sustainable society. This will be followed by a discussion of the notion of industrial ecology and sustainable business practices. Finally, students will be introduced to basic environmental science and specific environmental performance metrics.

Life-cycle concepts and assessment - This module presents students with the notion that environmental impact extends beyond production to material extraction, product use and end-of-use strategies. Such a perspective is often novel to engineering students who have spent much of their time in college focusing on product development and production. Students will discuss life cycle stages for a variety of example products. Strategies for assessing the impact of each life cycle stage will be presented and the students will explore the advantages and challenges associated with each. This discussion will include discussions of the role of suppliers in minimizing the impact of the life cycle of a product.

Material selection strategies and requirements - A frequent challenge faced by corporations is eliminating or minimizing the use of environmentally hazardous materials or materials that require large amounts of energy to produce or manufacture. In this module students will be introduced to environmental impact measures, industrial standards and guidelines, and decision-making strategies that can be used for material selection.

Process design and improvement - Another common challenge faced in industry is to reduce the environmental impact of an existing manufacturing process. Students will be introduced to methods of identifying the most damaging part of the process flow through material and energy balances. Common practices for reducing energy consumption and waste will be discussed. In addition, strategies for product packaging and delivery will be presented.

End-of-use strategies - This module addresses strategies and challenges associated with reducing the environmental impact of a product after it has been used by a consumer or business. Discussion will address re-use, remanufacturing, recycling, and disposal options. Design for recycling tools will be demonstrated and practiced on real products. In addition, the current economic and legislative realities of end-of-use strategies will be presented.

Environmentally responsible management - Industry also faces the challenge of communicating the technical and financial advantages of environmentally conscious design and manufacturing within their corporations both to engineers and managers. This module will present current best practices in promoting design for the environment within the corporation. In addition, the module will introduce students to current trends in environmental management systems, green supply chains, lean manufacturing and total cost accounting.

Results of the course introduction, learning assessment, and technical course module content will be further disseminated through various divisions within ASEE. The authors would like to acknowledge and thank the National Science Foundation for financially supporting the project with a three-year CCLI grant DUE #0511322.

Bibliography

[1]NAE 2004. *The Engineer of 2020: Visions of Engineering in the New Century*. National Academy of Engineering, The National Academies Press, Washington, D.C. 2004.