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Integrating Sustainable Product Development into the Engineering Curriculum

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Abstract

Criterion 3c for the Accreditation Board for Engineering and Technology specifies that "Engineering programs must demonstrate that their students attain … an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability." In partial fulfillment of this objective, the Kate Gleason College of Engineering at the Rochester Institute of Technology has introduced an interdisciplinary minor program of study that is available to all engineering undergraduates and to other technically oriented students. This paper describes the general configuration of programmatic minors at RIT and the specific structure of the new interdisciplinary minor in Sustainable Product Development.

1. Background

Efforts to reform engineering education over the past two decades have met with limited success. Although some engineering programs have effectively addressed a new vision for engineering pedagogy, the National Academy of Sciences [1997] and the National Research Council [2003, 1999] have identified several problematic attributes in engineering education. In particular, engineering programs have been criticized for their inability to effectively integrate multiple engineering and non-engineering disciplines in solving today's complex science and technology problems.

Nowhere is the appreciation of the technical and non-technical aspects of the engineering field more appropriate than in problem domains related to "sustainability". Interest in sustainability and related issues continues to grow nationally as well as internationally. A sustainable economy is one that can meet the needs of the present without compromising the ability of future generations to meet their own needs [UNWCED, 1987]. Moving an economy toward the goal of sustainability presents myriad challenges for all professions, especially business and engineering. As we move forward in the 21st century, the problems associated with delivering society's goods and services using traditional, non-sustainable practices will become more apparent, and the value of more environmentally and socially responsible approaches to meeting society's needs will become increasingly evident. Engineers and managers must be equipped to become environmental leaders and decision makers.

Toward this end, undergraduate college curricula that address product and process development will need to change in order to equip engineers and business leaders with the tools they will need to meet the challenge of delivering goods and services through sustainable means. This notion is reinforced by the inclusion of knowledge about sustainability as one of the core criteria that engineering programs must demonstrate their students attain in order to earn accreditation by the Accreditation Board for Engineering and Technology.

> Engineering programs must demonstrate that their students attain… an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability [ABET, 2006]

2. Sustainable Product Development

To partially fulfill the sustainability requirement described above, the Kate Gleason College of Engineering undertook the design of a programmatic minor in "Sustainable Product Development" (SPD). The development of a program in SPD was chosen because of RIT's collective expertise in this field and our belief that issues linked to sustainability represent critical concerns facing civilization in the 21st century.

Sustainable product development refers to the integration of social, environmental, and economic considerations into the product development and delivery process. Most engineering curricula fail to adequately address the social and environmental issues that arise from the production/consumption cycle, and economic models often fail to account for increasingly important environmental and social externalities. Sustainable product development requires the consideration of the complete product life-cycle during the product development effort. The intent is to minimize the environmental impacts across the entire product lifecycle while simultaneously maximizing the benefits to social and economic stakeholders. The potential tradeoffs between environmental, social, and economic objectives are examined and addressed in the design and development stage with the goal of maximizing system performance across the complete (cradle to grave to cradle) product lifecycle.

3. Developing the Minor

Development of the minor in Sustainable Product Development (SPD) was led by faculty from the Departments of Industrial and Systems Engineering and Mechanical Engineering. These two departments were in a uniquely advantageous position to develop and deliver this minor. Currently, all academic programs at RIT are in the process of curricular revision with the objectives being to increase the flexibility of current program curricula, expand opportunities for program minors, and enhance opportunities for cooperation across disciplines.

This interdisciplinary minor was developed and will be delivered in cooperation with other academic departments on campus. Programs participating in the development and delivery of the minor represent the College of Engineering, the College of Applied Science and Technology, the College of Liberal Arts, and the College of Science.

To develop the minor, a planning team led by a core group of faculty members from the participating academic departments was assembled. The team collected information and conducted surveys, using industry leaders and employers for important guidance. The team sought to develop a truly multidisciplinary minor program that would best fit the educational needs of the students and the requirements of U.S. employers in the emerging field of sustainable product development.

At RIT, program minors consist of a series of at least 5 four credit hour courses (20 credit hours). The minor in SPD was initially developed relying on courses that were already being taught at RIT. The development of new courses specifically for the minor program was not anticipated, though as academic departments continue to revise offerings to meet their own needs, new courses that fit the theme of the minor may become available. The planning team will continue to meet periodically to review the inclusion of these new courses in the minor program of study.

The program that emerged from this process specifies 3 "core" courses and two electives. Electives are selected from two groups of courses: "technical electives" and "social context" electives. Students are required to take at least one social context elective. Course titles for the core courses and the electives are shown below.

Core Courses
Engineering Economy/Engineering Economics
Fundamentals of Sustainable Product Design
Introduction to Life Cycle Assessment and Costing

Social Context Electives
Science, Technology, and Values
Intro. to Environmental Studies
Science and Technology Policy
Face of the Land
Social Consequences of Technology
Environment and Society
Great Lakes I/II
Energy and the Environment
Environmental Values
Environmental Policy
Biodiversity and Society
Tech Innovation and Public Policy
Energy Policy

Technical Electives
Design for the Environment
Contemporary Issues in Energy and the Environment
Fuel Cell Technology
Product Stewardship
Environment, Health, and Safety for Eng. Tech.
Survey of Solid and Hazardous Waste Mgmt.
Survey of Industrial Wastewater Mgmt.
Survey of Air Emissions Mgmt.

The minor is available to technically oriented students interested in the relationship between engineering, technology, and the emerging area of sustainability. We expect that the majority of the students interested in the new minor will come from the fields of Industrial and Systems Engineering, Mechanical Engineering, Industrial Design, Mechanical and Manufacturing Engineering Technology, Environmental Science, Biotechnology, Public Policy, and Civil Engineering Technology, Environmental Management, and Safety. Combined, these programs graduate over 250 students each year. If just 10% of the available student population took part in the new minor, over 25 students would receive in depth exposure to these very important issues each academic year. Further, as students engaged in the minor participate in projects with classmates from their programs who are not enrolled in the minor, lessons and learnings from the minor program will be transmitted to students and faculty not directly involved in it. In addition, we are currently seeking funding to support a seminar series linked to the SPD minor. If funded, the seminar series will be open to all members of the institute community. We believe that numerous faculty, staff, institute administrators, and individuals from outside the RIT community not directly involved with the program would attend the seminar sessions and take away at least an appreciation of the topics discussed.

The availability of this minor is being advertised to students using a number of approaches. The availability of the minor has been posted on RIT's Academic Minors website (http://www.rit.edu/programs-minors.php3). Posters describing the minor program are being developed. They will be displayed prominently in the academic departments that are most likely to house students interested in and qualified for the minor. A web site will also be developed to further disseminate the activities associated with the new program; the site will be accessible to individuals across the university and around the world. Further, the RIT student chapter of the professional society, Engineers for a Sustainable World, will host a series of mini expos and a lecture series in which the availability of the minor in Sustainable Product Design and Development will be featured.

4. Evaluation of the Minor

The programmatic minor in Sustainable Product Development was approved by RIT's curricular review process in May, 2006. The minor was officially listed as available on the Institute's website in September, 2006. Since the program is so new, it is too soon to gauge its reach or its impact. However, we anticipate evaluation of the program to be an ongoing process. More specifically, there are plans in place to have at least three dimensions of the program evaluated by various audiences. These dimensions are: (a) the structure and overall content of the minor, (b) the content and delivery of individual courses, and (c) student retention of program knowledge. Evaluation methods will incorporate both qualitative and quantitative approaches. A description of the procedures used to evaluate the SPD minor follows.

a) Structure and overall content: The SPD planning team consists of interested faculty from departments that will be involved with the delivery of the minor as well as 4 to 6 participants from local industry. The planning team was responsible for developing the structure of the minor, determining the courses that will be included in the minor, and overseeing the delivery of the program. The entire team will meet annually to examine progress toward programmatic goals and to suggest changes in the program if needed.

b) Content and delivery of courses: Student surveys will be used to capture open feedback from the entire student population (not just a sample of the students) enrolled in each of the program's courses. Surveys will be administered during the last week of each course to obtain both qualitative and quantitative information on several aspects of the course experience. The students will be asked to rank various aspects of the experience, express their perceptions about the impact of such approaches upon learning, critical thinking skills, and their degree of satisfaction with the approach. The surveys will also include free response questions that encourage open ended feedback. Results of the course evaluations will be available to the course instructors, the program administration, and the SPD planning team.

c) Student retention of program knowledge: Exit questionnaires will be used to capture quantitative data on knowledge retention over time. The instrument will be administered when a student completes the minor and the emphasis will be on the academic content of the courses he/she completed in order to fulfill the minor. A baseline will be developed with a control group of students that did not participate in the minor. Significant differences will be revealed with the appropriate statistical tests and analysis.

5. Summary

The Kate Gleason College of Engineering at the Rochester Institute of Technology has introduced an interdisciplinary minor program of study in Sustainable Product Development that is available to all engineering undergraduates and to other technically oriented students. The program combines a required core of engineering courses with social context and technical electives. Evaluation of the program's effectiveness is ongoing.

6. Bibliographic Information

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7. Biographical Information

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