

A Sustained Effort for Educating Students about Sustainable Development

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Abstract

Rowan University has been developing a series of courses that address the importance of sustainable development and practices in the 21st century. This paper details a series of courses taught in the freshman, sophomore, junior and senior year, which emphasizes this practice. The first course in the series is titled "Issues in sustainable development" and is offered to freshmen students as a First Year Experience course and is funded through the Bildner Family Foundation and coordinated by the Association of American Colleges and Universities. The course provides an opportunity for Rowan University students, in their earliest tenure, to experience the complexity surrounding issues about democracy, diversity and sustainable development. The course is team taught by faculty in Civil Engineering and the School of Business. The key objectives for this course are to (i) increase awareness about sustainability challenges and issues; (ii) explore appropriate frameworks for thinking about the institutional foundations of sustainability; (iii) understand the roles of different types of institutional actors involved in processes of development; and (iv) understand the environmental impacts of development and explore the role of appropriate technologies in developing sustainable strategies.

The second in the series is an engineering course called Sophomore Clinic II, which is taken by all engineering students at Rowan University. Sophomore Clinic II is the 4th course in an innovative eight semester multidisciplinary engineering design and practice, project-oriented course sequence that is a hallmark of the Rowan Engineering program. The students in this course work on projects related to reducing greenhouse gas emissions. As part of the course, students participate in a semester-long project in which sophomore students from all engineering disciplines calculate CO₂ emissions for the university and propose methods for further reducing greenhouse gas emissions. In addition, they enhance their knowledge by going on field trips to a green building in the area, which is constructed with various recycled materials and employs some of the latest technology to reduce greenhouse gas emissions and conserve resources. They also examine the sustainability debate in the engineering industry by visiting Dupont's facilities and having a guest speaker. Sophomore Clinic II also emphasizes public speaking skills, design principles, and engineering economics.

We also continue this education on sustainable development for engineering students into the junior and senior year by incorporating Engineers Without Borders (EWB) projects into the Junior and Senior clinic. In junior and senior clinics, students from all disciplines are formed into multidisciplinary teams of 3-8 students that work closely with a faculty project manager. In these last four semesters of study, the Clinics focus on teamwork, communications, business and entrepreneurial skills, and synthesis and application of technical knowledge to solving open-ended design problems. Most EWB projects deal with water resource management, power conversion, generation and storage, and civil infrastructure development. The students, through the Junior and Senior clinics will develop a sustainable design solution for an Engineers Without Borders project in a developing country.

Introduction

The goal of sustainability education is to ensure that present and future generations ^[1]:

- attain a high degree of economic security and social equity
- create and ensure democratic participation in their communities and globally
- maintain the health of the ecological systems upon which all life and all production depend.

Rowan University has decided that sustainability education and practice is extremely important to the students and has made an effort to integrate it from the freshmen to the senior year. This paper describes three courses that have been developed and are “Issues in sustainable development” for the freshmen year, sophomore engineering clinic, and junior and senior clinic where the students get to address issues of sustainability in a design forum. The structure of the engineering clinic will be described in more detail here to give the reader a better understanding of the sustainability projects that are conducted under the purview of the clinics.

Background on Engineering Clinics at Rowan University

Rowan University is developing an innovative engineering curriculum that will produce engineers that are suited to meet the needs of a challenging workplace in the 21st century. One of the hallmarks of the program is the truly multidisciplinary curriculum in which laboratory/design courses are offered simultaneously to engineering students in all four disciplines. Indeed, the hallmark of the engineering program at Rowan University is the multidisciplinary, project-oriented, Engineering Clinic sequence. Every engineering student at Rowan University takes the Engineering Clinics each semester. In the Engineering Clinic, which is based on the medical school model, students and faculty from all four engineering departments work side-by-side on laboratory experiments, real world design projects and research. The solutions of these problems require not only proficiency in the technical principles, but, as importantly, require a mastery of written and oral communication skills and the ability to work as part of a multidisciplinary team ^{[2][3]}.

Table 1. Overview of course content in the 8-semester Engineering Clinic sequence

<i>Year</i>	<i>Engineering Clinic Theme (Fall)</i>	<i>Engineering Clinic Theme (Spring)</i>
Freshman	Engineering Measurements	Competitive Assessment Laboratory
Sophomore	Multidisciplinary Design Modules	16-Week Multidisciplinary Design Project
Junior	Product Development	Process Development
Senior	Multidisciplinary Capstone Design/Research Project	

Table 1 contains an overview of course content in the 8-semester engineering clinic sequence. As shown in the table, each clinic course has a specific theme although the underlying concept of engineering design pervades throughout. The solutions of these problems require not only proficiency in the technical principles, but, as importantly, require a mastery of written and oral communication skills and the ability to work as part of a multidisciplinary team. In the first semester of the freshmen year, students learn basic engineering skills such as problem solving and teamwork fundamentals through the centralized theme of engineering measurements. This is followed in the second semester by intense study of engineering design through reverse engineering (or “dissection”) and competitive assessment of consumer products. “Soft” topics included in this semester are engineering ethics and intellectual property, both of which complement the course themes.

In the sophomore year, the attempt is made to integrate design and communication (written and oral) by serving the dual purpose of introducing students to formalized engineering design techniques and providing them with the necessary foundation for their careers as technical communicators. The course is team-taught by faculty from the College of Communication and the College of Engineering. In the fall semester, the thrust is on integrating discipline specific design modules with communication ^[4] by applying the principles of Total Quality Management (TQM) ^{[5][6]}. One of the projects described in this paper is spring semester Sophomore Engineering Clinic II (the fourth of the 8-semester clinic sequence) where communication is integrated with a semester long multidisciplinary design project. Students pick one of two design projects. The first is to design and build a guitar effects pedal. The second involves an economic and engineering analysis of the energy use on the Rowan University campus and calculation of the greenhouse gas emission. This necessitates an excellent design and communication with both technical and non-technical people.

By their junior year of study, Rowan engineering students are prepared to tackle very substantial technical problems. Junior and senior students from all disciplines are formed into multidisciplinary teams of 3-8 students that work closely with a faculty project manager. In these last four semesters of study, the Clinics focus on teamwork, communications, business and entrepreneurial skills, and synthesis and application of technical knowledge to solving open-ended design problems. Since the Clinics’ inception, we have successfully completed a wide range of projects focusing on a problem, product, or process, most of which are generated and sponsored by local industries. Working cooperatively with local industry has also enabled us to obtain valuable experience in supporting small- and medium-size businesses.

First Year Experience Course

In the freshmen year, a course in “Issues of sustainable development” will be introduced as a First Year Experience class, which is open to all disciplines. This course is a series of courses that have been funded by the Bildner family foundation and coordinated by the Association of American Colleges and Universities to prepare students for a diverse democracy. Through participation in the Bildner New Jersey Diversity Initiative, Rowan University is developing challenging interdisciplinary team-taught courses for entering students, which provide an opportunity for Rowan University students, in their earliest tenure, to experience the complexity surrounding issues about democracy and diversity. The freshman experience sponsored by the Bildner grant will promote intercultural dialogue and understanding as a means to reduce prejudice and bigotry.

The course on sustainability will be team taught by a faculty in engineering and one in business and is open to students from all disciplines. Key objectives for this course are:

- Increase awareness about sustainability challenges and issues;
- Explore appropriate frameworks for thinking about the institutional foundations of sustainability;
- Understand the roles of different types of institutional actors involved in processes of development; and
- Understand the environmental impacts of development and explore the role of appropriate technologies in developing sustainable strategies

The first part of the course describes the global sustainability challenges and considers a number of frameworks for thinking about institutions and organizations, focusing in particular on the very fervent debates around the concept of social capital. These debates can be helpful in deciding how we think about notions of political economy, human agency, and civil society. The interaction among market driven entities, public policy, and community groups will be explored using appropriate cases. The cases considered will start with local issues that the students can relate to and include issues about over-development, water consumption, energy use and contamination as it relates to the campus, county and state and then will be extrapolated to the global issues that are facing the world.

With this discussion in mind, we go on to consider more specific ways of thinking about the development roles of the state, business, international and national NGOs, social movements, and role of global institutions like the World Bank. In all of these instances, some of the cases we will discuss will refer to the environmental dimensions of development, while others will refer more to questions of poverty, quality of life, and empowerment. With reference to the environmental dimensions of development, there will be a discussion of energy consumption, and the technological imperative for efficient systems and alternate energy sources. In addition, there will also be a discussion of sustainable engineering design.

The primary pedagogical approaches are:

- Enhance critical thinking and reflection through writing in the form of critiques and position papers.
- Refine oral communication skills through debates and presentations.
- Stimulate collaborative learning and synthesis through team projects that explore multiple perspectives.

Sophomore Clinic II

Sophomore Clinic II is a 4-credit course; public speaking faculty in Rowan's College of Communications teaches 3 of these credits. The remaining credit hour is devoted to engineering practice and design. The engineering design project for Spring 2002 and 2003 was developed to assist the University in fulfilling its commitment to reduce greenhouse gas emissions by 3.5% below 1990 levels by 2005. Engineering sophomore teams will work closely with engineering faculty, university facilities engineers, and representatives from NJHEPS to devise an action plan for reducing the university's CO₂ load on the environment. Student teams accomplish the following activities during the semester:

- Calculate greenhouse gas emissions for the university from 1990 to present according to the NJHEPS format.
- Investigate low-cost solutions to improve energy efficiency.
- Investigate alternative energy sources such as fuel cells, solar panels, and geothermal units that can be incorporated into the future growth of the university.
- Perform an economic analysis and report any short-term and long-term costs or savings associated with implementing low-cost solutions and/or alternative energy sources.
- Formulate a well-supported, articulate oral argument for using alternative energy sources at Rowan University.

Deliverables for the course include a report detailing Rowan's estimated greenhouse gas emissions for 1990 and present, a midterm presentation that discusses low-cost energy saving solutions, progress reports (both oral and written), and a final presentation and report that includes an in-depth economic analysis of the various energy savings solutions.

Engineers without Borders Project

Through the vehicle of the Engineering Clinic, we conduct projects that are presented by Engineers Without Borders (EWB). Projects selected by EWB-USA present an ideal framework for incorporating social, cultural, and environmental considerations into the design process in a meaningful way. Since projects come from developing countries that may have poor infrastructure, few resources, and little access to western technology, students will be required to be creative in use of resources and developing design solutions. Additionally, students will have the opportunity to work closely with end-users who may not have formal training in science and may view technology from a different cultural perspective.

Engineers Without Borders™-USA (EWB-USA), the US affiliate of EWB, is a nonprofit 501(c)(3) tax exempt corporation founded in Fall 2000. Its mission “is to help disadvantaged communities improve their quality of life through implementation of environmentally and economically sustainable engineering projects, while developing internationally responsible engineering students ^[2].” The challenge of EWB-USA is “the education of engineers: (i) who have the skills and tools appropriate to address the issues that our planet is facing today and is likely to face within the next 20 years; (ii) who are aware of the needs of the developing world; and (iii) who can contribute to the relief of the endemic problems of poverty afflicting developing communities worldwide.

Starting in the Freshman Clinic, selected case studies are integrated into the fall semester that incorporate the Engineer’s Code of Ethics, environmental concerns, and community concerns in the Rowan Seminar developed through the Bildner grant and Freshmen clinic. These case studies will eventually be linked to EWB projects as juniors and seniors report their experiences. The Sophomore Clinic I will be used as a preliminary design and planning phase for an EWB-type project. Students will identify and consult with stakeholders, as well as research materials and resources needed to accomplish the project. Additionally, students will be required to conduct a societal and environmental impact study as part of their design process. In Sophomore Clinic II, students will be able to continue working on this project, developing more complete designs that include technical specifications and an economic analysis. Deliverables for this design project will include participation in a town hall setting in which student teams must defend designs to a variety of audiences, including non-technical majors.

A final design for the project will be selected from those proposed in Sophomore Clinic, and a student team will begin work on implementing the project the summer between sophomore and junior year. The student team may travel to the host community to obtain details and conduct a preliminary investigation. The same team will continue this process through the Junior-Senior Clinic in the following year, with the goal being final design and implementation by the following summer. In the senior year, students on this project will conduct a sustainability study and assess the impact of the project on the community and make recommendations for further improvements. Student teams will also be responsible for converting their experience into a case study for freshman and sophomore engineering students, as well as liberal arts or business majors.

The EWB program fosters active participation as a citizen of a diverse democracy, discernment of the ethical consequences of decisions and actions and deep understanding of one’s self and respect for complex identities of others, their histories and their cultures. This provides opportunities for students to be an empowered, informed and an intellectual learner. A student who can effectively communicate, understand and work within complex systems and with diverse groups, understand the interrelations within and among global and cross-cultural communities and finally a student that has a sense of social responsibility and ethical judgment.

In many curricula, case studies are presented in specialized courses, or as segments of a design course, but identification of end-users needs and views are not effectively included in the design

process itself; hence, societal or environmental effects are *reported* at the end of the project rather than *integrated* as part of design considerations. As educators, our goal is to not only train competent and creative engineers, but to prepare citizens (both those with technical and non-technical training) who can systematically assess the impacts of technology on local and global populations and environments, and implement engineering solutions that minimize negative effects. Through a “hands-on, minds-on” approach to integrating engineer-without-borders service project from the freshman to the senior year, a model will be established for other programs. This program encourages student to interpret knowledge from different disciplines and requires interaction with the world in a different cultural perspective. This project will initially be implemented in the Engineering Clinic sequence in the College of Engineering at Rowan, and then disseminated in various forms to other disciplines.

Conclusions

At Rowan University, the importance of sustainable design practices and design is understood to be critical in the education of engineers. To achieve this objective, several courses have been developed that integrate sustainable design practices into the engineering curriculum. The students will obtain a better understanding of sustainable engineering practices by being exposed to it from the freshmen through the senior years. The freshmen course addresses issues of sustainable design, the sophomore course deals more with addressing local issues of sustainability through the framework of the sophomore clinic and the junior/senior courses involve design for a global problem using principles of sustainable design.

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