Teaching Students Sustainability: An Interdisciplinary Design Project for Sophomore Engineering Students

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Abstract

Universities can be leaders not only in research advances in reducing greenhouse gas emissions, but also have the potential to be leaders in *practices* that reduce greenhouse gas emissions. All 56 colleges and universities in New Jersey recently joined together to endorse a Sustainability Greenhouse Gas Action Plan for New Jersey. In signing this "sustainability covenant," Rowan University has pledged to reduce its greenhouse gas emissions to 3.5% below 1990 levels by 2005. We have used this agreement as the basis for a novel collaboration between the New Jersey Higher Education Partnership for Sustainability (NJHEPS) and the College of Engineering at Rowan University.

We have developed a course project in which sophomore students from all engineering disciplines calculate CO_2 emissions for the university and propose methods for further reducing our greenhouse gas emissions. This project has been developed for Sophomore Clinic II, 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. Sophomore Clinic II emphasizes public speaking skills, design principles, and engineering economics.

Objectives for the course include the following:

1. Calculate greenhouse gas emissions for the university from 1990 to present according to the NJHEPS format.
2. Propose low-cost solutions to improve energy efficiency.
3. Propose alternative energy sources that can be incorporated into the future growth of the university.
4. 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.
5. Formulate a well-supported, articulate oral argument for using alternative energy sources at Rowan University.

Introduction

In 1992, the local industrialist Henry M. Rowan made a generous donation to Glassboro State College in order to establish a high-quality engineering school in southern New Jersey. As a result of this generous donation, the College of Engineering was created and the university underwent a name change to Rowan University. The College of Engineering is composed of four departments: Chemical Engineering; Civil and Environmental Engineering; Electrical and Computer Engineering; and Mechanical Engineering. The class sizes are limited to 20 to 25 students in each discipline to guarantee quality education. 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. The students develop their technical knowledge, communication skills, awareness of social implications, life long learning ability and ethical judgment. Graduates who will become effective leaders in areas such as infrastructure enhancement, and environmental preservation need this breadth of skills. To best meet these needs, the engineering curriculum at Rowan University emphasizes: (i) "hands-on" and team oriented education; (ii) inter and multi-disciplinary education; (iii) use and incorporation of state-of-the-art technologies; and (iv) improving technical communication skills. To achieve these objectives, the four engineering programs of Civil, Chemical, Mechanical and Chemical Engineering include a common engineering clinic throughout their eight semesters of study.

In the Engineering Clinic, students and faculty from all four engineering departments work side-by-side on laboratory experiments, design projects, and research. The solution of these real-world problems require not only a 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. 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 discussion in this paper will focus on the Sophomore Engineering Clinic conducted in Spring 2002.

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

Year	*Engineering Clinic Theme (Fall)*	*Engineering Clinic Theme (Spring)*
Freshman	Engineering Measurements	Competitive Assessment Laboratory
Sophomore	16-Week Multidisciplinary Design Project/Composition & Rhetoric	16-Week Multidisciplinary Design Project/Public Speaking
Junior	Product Development	Process Development
Senior	Multidisciplinary Capstone Design/Research Project	

The Sophomore Engineering Clinic has laboratory and design components in at least two of the major engineering disciplines. In addition, the students are expected to improve their technical presentation skills. The semester-long sophomore clinic course taught in

Spring 2002 focuses on calculation of greenhouse gas emissions on the Rowan University campus. In addition, the students will also look at alternate energy resources that could be economically used to reduce greenhouse gas emissions.

Course overview

Sophomore Clinic II is a 4 credit course; 3 of these credits are taught by public speaking faculty in Rowan's College of Communications. The remaining credit hour is devoted to engineering practice and design. The engineering design project for Spring 2002 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 CO_2 load on the environment. Student teams will accomplish the following activities during the spring 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 include an in-depth economic analysis of a team-selected method of reducing greenhouse gas emissions.

Calculation of greenhouse emissions

CO_2 emissions are calculated according to the procedure established by the NJHEPS. A worksheet at http://orion.ramapo.edu/~jquigley/NJHEPS/success/protocol.html provides detailed instructions and conversion factors for energy costs. This activity not only accomplishes the first step in reducing emissions, it also introduces students to the idea of establishing a reference point for future calculations and correcting for changes in campus size.

Introduction to economic principles

While many institutions would like to implement energy-saving measures, there is a perception that saving energy is inversely proportional to saving money. Putting energy

efficient systems into practice may cost more initially, but can save money in the long run. Engineering economics often gets short shrift in many curricula, and is often not introduced until the senior year. Introducing simple economic principles at the sophomore level and requiring the application in an engineering design project gives students exposure to an important aspect of engineering practice.

Researching low-cost solutions

Student teams will select a building on campus to study in terms of energy consumption. Power consumption of various types of equipment in the building (lights, computers, copiers, printers, etc.) will be measured and catalogued. Based on these measurements and consultations with NJHEPS, students will propose some energy-saving solutions and implementation plan backed by an economic analysis.

Investigating alternative energy sources

Students will also be required to evaluate the installation of alternative energy sources such as fuel cells, geothermal energy systems, and photovoltaics. Student teams will identify future construction projects on campus that are likely candidates for support from these types of energy systems, and perform a simple economic feasibility report.

Student and Course Assessment

Students are assessed through a combination of written assignments and oral presentations. The final course deliverables include a written proposal with an economic analysis for implementing the energy-saving measures or installing an alternative energy source. A presentation of each team's report will occur on the last laboratory session of the course. Administrators, campus facilities engineers, and interested faculty and students are invited to attend and ask questions of the students. These participants will be asked for informal feedback, and serve as an objective third party in assessing the quality of the students' work.

Course assessments will occur at midterm and in the final week of the course. A standard assessment tool used by the College of Engineering at Rowan University will be used. In addition, the outside participants mentioned above will be consulted for feedback on the merits of the course. These results will be presented at the annual conference in Montreal.

Conclusions

This project is designed to expose sophomore engineering students to sustainable energy practices, introduce engineering economics as a valuable tool, and give student teams the authentic experience of completing an engineering design project for a real client, their own university. Although we have dedicated a specialized course to this project, aspects of it can easily be adapted to core courses in the engineering curriculum.

Biographical Information

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