An Innovative Environmental Design Module

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Abstract

A major objective of the Junior Engineering Clinic at Rowan University is to introduce students to open-ended design projects. All engineering students from the four engineering disciplines namely Civil, Chemical, Electrical and Mechanical share a common engineering *clinic* class. This class is a major hallmark of the Rowan engineering program for all engineering students throughout their eight semesters of study. The purpose of the clinic classes is to provide engineering students with a hands-on, multidisciplinary experience throughout their college education. The junior and senior clinics emphasize multidisciplinary design on projects of progressive complexity. This paper focuses on three environmental engineering design projects that were sponsored by local wastewater treatment plants and the National Science Foundation. Multidisciplinary student teams conducted a thorough literature search, developed models or design experiments related to their projects. This type of innovative approach for allowing students to become involved in realistic open-ended design problems is beneficial for enhancing their problem solving skills and encourages them to pursue graduate studies.

Introduction

The College of Engineering at Rowan University was created through a $100 million gift from Henry and Betty Rowan in 1992. The College of Engineering's key features include collaborative teamwork in inter- and multi- disciplinary laboratory and coursework and the incorporation of state of the art technologies and innovative teaching methodologies. Activities of the freshman and sophomore engineering clinic classes at Rowan have already received national recognition (1-8). The freshman clinic focuses on primary principles, measurements, and competitive assessment. The sophomore clinic focuses on formalized engineering design techniques. The junior and senior clinics emphasize multidisciplinary design on projects of progressive complexity. Faculty lead a team of 3-4 students on open-ended design or research projects.

Multidisciplinary student teams engage in semester or multi-semester projects. Funding for the majority of these projects are mainly sought from industry and faculty research projects. The rationale for this approach is to build a strong partnership with local industry, enhance critical thinking skills and to expose students to the engineering profession. Clearly, projects such as these are central to developing design, problem solving and project management skills that are often lacking in traditional engineering coursework. A total of 26 projects were led in the fall (1998) and spring (1999) semesters.

At the conclusion of four semesters of Junior and Senior clinic activities, students are expected to:

- Demonstrate expanded knowledge of the general practices and the profession of engineering through immersion in engineering project environments of moderate complexity.
- Demonstrate an ability to work effectively in a multidisciplinary team.
- Demonstrate acquisition of new technology skills through use or development of appropriate computer hardware, software, and/or instrumentation.
- Demonstrate understanding of business and entrepreneurial skills by developing a business plan, market plan, venture plan, or other approved instrument.
- Demonstrate effective use of project and personnel management techniques.
- Be better able to meet customer needs.
- Integrate engineering professionalism and ethics in their work and as it relates to the context of engineering in society.
- Demonstrate improved communication skills including written, oral, and multimedia.
- Utilize information obtained from sources that cross geopolitical and language barriers

Junior Clinic Projects

During the Fall of 1998 and Spring 1999, three challenging environmental engineering design projects were conducted through the Junior Clinic Class. All three projects had external sponsors and were composed of multidisciplinary student teams. All projects had a chemical engineering student as the out of discipline student. The details of these projects are elaborated below.

Effect of Surfactants on Foaming Problems in Wastewater Treatment Plants

This study focused on foaming problems experienced by a wastewater treatment plant (Rahway Valley Sewerage Authority-RVSA, Rahway New Jersey) due to the presence of surfactants. RVSA operates a 40 MGD secondary wastewater treatment facility and serves 300,000 residents and 3,500 industrial and commercial customers in 12 communities. Two industries involved in the manufacture of shampoos discharge their wastewater to the RVSA. The objectives of this study were to:

- *Identify* the presence and *measure* the concentration of nonionic surfactants in the industrial wastewaters and the RVSA plant, and
- To *identify* monitoring parameters for RVSA to determine the impact of surfactants.

A monitoring plan for the RVSA plant was prepared by the research team to identify the impact of surfactants on foaming at RVSA. Key parameters that were identified included temperature,

surface tension, oxygen transfer efficiency and *Nocardia* cells. Surfactants have the ability to lower surface tension and thereby stabilize the liquid film between air bubbles. Therefore their presence can also alter oxygen transfer efficiency. Biodegradation of APEs is temperature sensitive. Literature also indicates that surfactants can stabilize and promote Nocardia foaming in WWTPs. The plant was also instructed to monitor for the occurrence of diffuse sludge blankets in the secondary clarifiers (sludge judge measurements) and in the settling tanks.

Experiments were also identified for laboratory studies. These included the following tests:

- Foam height test with nonionic surfactants
- Foam height with activated sludge from RVSA
- Biodegradability of nonionic surfactants
- Toxicity test of wastewater from RVSA using respirometry techniques
- HPLC characterization of nonionics

Stress Testing Plan for the Gloucester County Utilities Authority (GCUA) Wastewater Treatment

The Gloucester County Utilities Authority is a 24.1 MGD regional wastewater facility that currently utilizes fluidized bed incinerators for disposal of biosolids. The facility accepts household septage, commercial wastewater, preapproved industrial wastewater (including landfill leachate) and municipal wastewater. There are approximately 40 metering stations throughout the GCUA service area with nine pump stations conveying 17 MGD of sewage to the facility. The facility has an NJPDES-DSW permit for discharging treated wastewater into the Delaware River.

This project focused on evaluating the performance of the GCUA wastewater treatment plant under critical loading conditions. Each unit operation of the plant is checked independently by analyzing current design specifications and applying critical stress loading conditions. The project involved trips to the GCUA plant located in the West Deptford area and gathering design specifications and monitoring data. Students also prepared a virtual tour of the plant for the GCUA web page. The virtual tour aided students in learning about the wastewater treatment plant, its design and optimization of treatment processes.

Novel Membrane Applications in Water and Wastewater Treatment

This project focuses on developing some novel membrane applications to water and wastewater treatment. In conventional aeration systems it is difficult to attain high concentrations of gases into water without avoiding problems of wastage, supersaturation and bubble formation. A novel sealed end hollow fiber membrane gas transfer device (9) allows gases to be dissolved without bubble formation, thereby allowing very efficient gas transfer. A multidisciplinary student team fabricated a bubbleless gas transfer device to conduct studies on aeration of various industrial wastewaters. Celgard X 20 microporous polypropylene membranes from Hoechst Celanese, Charlotte NC, were selected for this study. These membranes are hollow fibers with a wall thickness of about 25 □m and pore diameters of 0.02-0.05 □m. Sealed-end fiber modules were constructed and evaluated for the oxygenation of water. Pure oxygen was maintained inside a bundle of sealed-end membranes at a pressure below the bubble point. The water to be

aerated was pumped over the outside of the membranes. This process provides 100% oxygen transfer efficiency at reasonable power input. This experimental project allows students to evaluate the feasibility of membrane aerators in comparison to conventional ones. The students were also involved in predicting mass transfer performance of the membrane system.

Discussion

The Junior Engineering Clinic Class provides a great environment for teaching students about *real open-ended design* problems in environmental engineering. It helps foster critical thinking skills and a direct application of coursework material. The course also sets the groundwork for graduate research if a student should pursue a graduate career. Students also enhance their project management skills by working with time constraints and a large range of activities. Student activities for the above-mentioned projects ranged from a wide variety of tasks. Starting from an extensive literature review of their project topic, students have to design experiments, order materials and supplies, become familiar with measurement and analytical techniques. Students also are exposed to mathematical modeling of their experimental data using Excel, POLYMATH or MATLAB. A major emphasis is placed on technical writing and communication skills. Students have to prepare technical reports with proper data analyses and data representation. Formal presentations to the sponsor organizations either in verbal or poster format is required and is part of their grade. The students are further challenged by participation at local professional conferences such as the New Jersey American Water Works Association and the New Jersey Water Environment Association's annual conferences by participating in poster competitions. Students are also encouraged to write technical papers for conferences and competitions sponsored by professional organizations. Students also designed web pages for their projects to disseminate information.

The "open-ended" nature of the projects sometimes poses some constraints in time management. Every project has it's own unique equipment, supplies and materials needs and sometimes this can delay the project progress considerably. Projects involving biodegradation are labor intensive and time consuming. They also require more hours from the students apart from the weekly 5.5 contact hours. Sometimes this can also limit the scope of the project.

The involvement of a chemical engineering student in the projects was very beneficial. They added strength to their teams and projects in various ways. The students had exposure to POLYMATH and HYSYS, which were useful modeling aids to the environmental engineering students. They also had considerable knowledge on mass transfer phenomena and chemical reaction engineering. The integration of the 'out-of-discipline" student, a hallmark of the Rowan Engineering Clinic, was well suited for the overall success of these projects. The project coordinator does have the added responsibility to assure that these students are being exposed to experiences valuable in their own engineering discipline.

Conclusions

The Junior Engineering Clinic class at Rowan University provides engineering students with a

number of positive experiences, including working in teams; participation in multidisciplinary problem solving; and the solution of open-ended problems. Most of the objectives outlined at the beginning of this paper are met especially the "hands-on" laboratory skills. Although some of the students are initially overwhelmed by the nature of the "open-ended" problems, they do rise to the challenge with success.

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