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A Synergistic Interaction between Industry, Academia, and Government with a Focus on Green Engineering Undergraduate Education

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Abstract: - This paper presents two case studies which examine successful synergistic interaction between industry, academia through the Rowan Engineering Clinic Program, and a government agency through the US Environmental Protection Agency. The challenges and obstacles that have been encountered are also described.

Key-Words: - *Industry-Academia interaction, project-based learning undergraduate research*

1 Introduction

Rowan University is a public institution with a primary focus in undergraduate education. The College of Engineering has been in operation since 1996 and has four ABET-accredited engineering specialties. Rowan Engineering has created an exceptional program that fosters synergistic interaction between industry and academia. Through this program, engineering students of all four disciplines have the unique opportunity to participate in industrially sponsored research or design projects.[1] The work is done in multidisciplinary teams that may include students from any of the four engineering disciplines offered at Rowan, and it may also involve students from Chemistry and Biological Sciences. The student-team works on semester-long or year-long projects that are supported by external sponsors. The clinic program starts in the junior year and runs for four consecutive semesters. All engineering majors enroll in their junior or senior clinic, which are approved 2-credit core courses. In addition to providing a mechanism to introduce emerging technologies relevant to regional industries, the clinics provide the students with exposure to industrial projects with real deadlines and deliverables, and an opportunity to develop their project management, teamwork, and oral and written communication skills. This program also provides the students with a most realistic approach to a working environment where industrial products and processes are designed as the result of an interdisciplinary effort and not by the major specific compartmentalization. The clinic program offers the industrial sponsor a cost-effective approach to problem solving with potential for a high return on investment, through technical assistance from advanced undergraduate engineering students supervised by faculty. These projects also help the program address many of the "softer" skills required by ABET. [2] Students function in multidisciplinary teams, design and conduct experiments, learn about safety and environmental issues, analyze and interpret data, communicate through oral and written reports, and use modern engineering tools.

2 Clinic Projects

The typical engineering clinic project could be initiated by a grant that a group of faculty has written or by the initial contact between a professor and a scientist or engineer from a regional company. The industrial contacts are often the results of a connection made through a professional society meeting, student internship, or newspaper article about the university or company

This paper describes a unique situation in which the university received funding from the US EPA Region 2 for two pollution prevention initiatives, one in pharmaceutical and the other one in petroleum refining. Both federal grants required industry ties and a clear definition of a pollution prevention strategy for the pertinent industrial field. Rowan Chemical Engineering partnered with Bristol-Myers Squibb (New Brunswick, NJ), for the pharmaceutical area; and with Valero Energy Corporation (Paulsboro, NJ) for the petroleum refining area.

2.1 Case Studies

Bristol-Myers Squibb (New Brunswick, NJ)

This project advances the concept of green engineering in the pharmaceutical industry by a partnership with Bristol-Myers Squibb (New Brunswick, NJ). Through this project we gain an understanding of the critical issues effecting the development and manufacture of a particular drug and explore ways to apply green engineering principles to solvent use and reduction strategies to reduce pollution in this important industrial sector.

A engineering-clinic team of chemical engineering faculty and students has interacted with a drug development group at Bristol-Myers Squibb Pharmaceutical Research Institute (Process Research and Development). The basic environmental issues and challenges in the pharmaceutical industry were examined. The Rowan clinic team chose to examine the development of an Active Pharmaceutical Ingredient (API) made by an organic synthesis route which is the predominate production method for the pharmaceutical sector. The pharmaceutical industry utilizes complex and often mass and energy intensive manufacturing techniques to produce a single batch of a desired drug. Large amounts of solvents and raw materials are needed to produce a relatively small amount of product. The project was started through a series of presentations and discussions with R&D and manufacturing personnel to find the best venue to proceed with a collaborative effort. Through a non-disclosure agreement with Bristol-Myers Squibb we have been allowed to examine the actual process synthesis and related documentation and pilot plant facilities for a particular drug under development. Initial meetings between the Rowan clinic team and Bristol-Myers Squibb group were a learning opportunity for both parties as we gained a valuable insight into the drivers for the pharmaceutical industry and how our group could contribute to both the specific pollution prevention improvements to the process and impact the industry in general. The Rowan team spent time with the Bristol-Myers Squibb scientists examining past process development practices and tracking improvements made to the drug development from laboratory scale through pilot plant scale. The groups engaged in brainstorming sessions where active participation enabled several alternate process routes to reduce chemical use, waste generated, water or solvent use, were proposed. Through this exchange the Rowan team observed what would be the likely candidates for P2 improvements to be successfully implemented for this drug and therefore, what the pharmaceutical industry would adopt as P2 practices. Upon close examination of the pharmaceutical process, Rowan was able to suggest potential ways to improve the process through solvent, water, and product recovery and recycling.

Valero Energy Corporation (Paulsboro, NJ)

This project provides Valero Energy Corporation, the expertise for optimizing its water network in order to minimize the freshwater consumption and reducing effluent treatment.

The Rowan team first studied the state of the petrochemical industry in the region. The petroleum refineries in New Jersey are one of the largest industries in size, quantities of material processed, and emission issues. Since no new refineries have been built in the United States in the last 25 years, these petrochemical plants have to be upgraded and optimized in order to meet environmental regulations and profitability. Moreover, the lack of infrastructure and natural resources has caused a strain on the industry in meeting the increasing demand; thereby requiring the United States to import more petroleum to meets its needs.

Valero Refining Company – New Jersey (Paulsboro Refinery) is located in Greenwich Township on approximately 950 acres of land adjacent to the Delaware River in Gloucester County, New Jersey. The facility has been operating since 1917 producing hydrocarbon products that include gasoline, distillate fuels, lubricating oil base stock, asphalt and liquid propane gas. It was previously owned by Mobil Oil Corporation and was purchased by Valero in 1998. The refinery water influent averages around 7.5 million gallon per day from the Delaware River, wells and storm water ponds. The plant operates a 15.84 million gallon per day wastewater treatment plant on site.

Through our review, it was found that one of the most important natural resources used in petroleum refineries is water. It is used in several processes, i.e. sweetening, desalting, steam generation, etc. The predicted scarcities of industrial process water for the coming decades and the increasing stringent environmental regulations for wastewater disposal are significant drivers to consider optimization of water usage as a P2 initiative in refining facilities. It was also determined that there are similarities between refinery operations at different facilities, so that any improvements made on this project would have transferability to other refineries in Region 2 as well as across the country.

We chose to divide the analysis of the refinery project into three areas in order to study in detail the pollution prevention opportunities. These three

subdivisions are Refinery Processes, Cooling Towers & Utilities, and Water Quality & Wastewater Treatment plant. Typically, freshwater has been used for process use, and the generated wastewater treated in a central common facility in order to remove contaminants to meet regulatory specifications for its disposal. In contrast, reusing and/or recycling the water streams in an integrated water network helps in decreasing the freshwater consumption and minimizes the wastewater that has to be treated. As a result, a significant freshwater flow rate reduction can be accomplished (P2 water savings) and the cost of freshwater as well as the effluent treatment (cost and flow) is brought down.
Freshwater minimization, as mentioned before, is a challenging opportunity for pollution prevention.

3 Conclusion
Rowan University has developed a program that fosters synergistic interaction between industry and academia which provides a mechanism for performing industrially sponsored research or design projects in an academic environment. In addition to providing a mechanism to introduce emerging technologies relevant to regional industries, the clinics provide the students with exposure to industrial projects with real deadlines and deliverables, and an opportunity to develop their project management, teamwork and oral and written communication skills.
This program offers the industrial sponsor a cost-effective approach to problem solving with potential for a high return on investment, through technical assistance from advanced undergraduate engineering students supervised by faculty. Successful projects have led to the implementation of several new process modifications and process units that have resulted in increased capacity, higher product purity, decreased labor cost, and less process down time. In addition, the company has the opportunity to watch for potential interns and employees for future hire.
Students have learned new technology through industrial projects, have gained exposure to industrial culture, gain experience with deadlines, progress meetings, presentations and written deliverables, and in many cases have secured summer or full-time employment with the sponsoring company. Students have won external awards for their work and have presented their work at national conferences. Faculty members have developed valuable relationships with industrial partners, secured funding for research projects, learned about new technologies, and occasionally have published results externally.

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5 References
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