

IMPACT OF RESEARCH EXPERIENCES ON FEMALE ENGINEERING STUDENTS

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Abstract - The College of Engineering at Rowan University has a novel curriculum in which students enroll in 'engineering clinic' classes every semester. These classes are designed to stimulate students' interests in multidisciplinary open-ended challenging engineering projects, which are mainly research oriented or industry sponsored. Key program features include an emphasis on inter- and multi-disciplinary education created through collaborative laboratory and coursework. Teamwork is stressed as the necessary framework for solving complex problems. Research experiences expose undergraduate students to the creativity of the research process and enable them to apply their acquired knowledge from formal coursework. Active research experience is considered one of the most effective ways to attract talented undergraduates to and retain them in careers in science and engineering, including careers in teaching. Involving undergraduates in research also encourages them to pursue graduate education. This paper focuses on the innovative engineering curriculum developed at Rowan University and its impact on female engineering students.

INTRODUCTION

The Rowan University College of Engineering has a brand new engineering building, including state-of-the-art equipment and computer resources, and a dedicated and extremely competent faculty. Facilities such as seminar and lecture rooms, laboratories, computer rooms, audiovisual equipment and study hall space are located in Rowan University's state-of the art \$28M Henry M. Rowan Hall. This newly constructed home of the college of engineering has a 92,500 sq. ft. space with multifunctional state-of-the-art teaching and research laboratories. Founded in 1923 as Glassboro State Teachers College, Rowan University has evolved into a comprehensive regional state university with six colleges. The College of Engineering was initiated as a result of a major donation in 1992 from the Rowan Foundation [1]. The engineering faculty use innovative methods of teaching and learning to better prepare students for entry into a rapidly changing and highly competitive marketplace. Key program features include: (a) creating inter- and multi-disciplinary experiences through collaborative laboratories and coursework; (b) stressing total quality management (TQM) as the necessary framework for solving complex problems; (c) incorporating state-of-the-art

technologies throughout the curricula; (d) and creating continuous opportunities for technical writing and communication [2-5]. The College has four engineering programs of Chemical, Civil and Environmental, Electrical and Computer and Mechanical Engineering.

This generous gift has enabled the university to establish perhaps the most innovative and forward-thinking engineering program in the country. While most traditional engineering schools provide students a taste of independent research well into their senior year in some form of capstone design, the Rowan engineering program experience allows students to be exposed to the intricacies of realistic open-ended engineering research and design as early as their freshman years.

ENGINEERING CLINICS

All engineering students at the College of Engineering at Rowan University are required to take a course called "engineering clinic" every semester. This 4year, 20-credit Engineering Clinic sequence offers students at Rowan University the opportunity to incrementally learn the science and art of design and research by continuously applying the technical skills they have obtained in traditional coursework. The clinics allow faculty to infuse design into all levels of the curriculum. In the Engineering Clinics, students learn the art and science of design in a multidisciplinary team environment. The Engineering Clinic allows students to practice communications and teamwork skills in a multidisciplinary environment while honing their design skills throughout their four-year career.

In the first semester of the freshman year, students learn basic engineering skills (problem solving, teamwork fundamentals, engineering measurements) and are introduced to the variety of activities in each of the four disciplines at Rowan (Chemical, Civil and Environmental, Electrical and Computer, and Mechanical Engineering) [5]. This is followed in the second semester by intense study of engineering design through reverse engineering ("dissection") and competitive assessment (instrumentation, testing and side-by-side comparison of technical performance) of a consumer product [6]-[7]. In this manner, students are introduced to design by studying the designs (good or otherwise) of practicing engineering designers. Past products examined include hair dryers, water filters,

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electric toothbrushes, beer brewing processes and remote-control cars, to name a few. Other topics included in this semester are engineering ethics and intellectual property, both of which complement well the course themes of reverse engineering/competitive assessment. To support the Freshman Clinic, we have received funding from the National Science Foundation in 1998 to build five “competitive assessment stations”—customized workstations with a PC, data acquisition, temperature, pressure and flow transducers, function generators, and oscilloscope. The sophomore clinic focuses on design taught from the viewpoint of the four disciplines: chemical, civil, electrical & computer, and mechanical [8]-[9]. In the sophomore year, the Clinic’s emphases shift to technical communications skills and the application of design. The students are organized into “corporations” that design and build products using advanced engineering tools while developing their speaking and writing skills through the embedded assignments [10]-[11]. The junior and senior clinics emphasize multidisciplinary design on projects of progressive complexity. The majority of these projects are funded by local industry, faculty research grants or departmental budget. Clearly, projects such as these are central to developing the design, problem solving and project management skills that are lacking in the traditional engineering coursework. Students work on projects suggested by industry, government, non-profit, and community groups, and entrepreneur/faculty interests. By the junior/senior years, students are well equipped to embark on completely original, entrepreneurial enterprises or design of experiments or products as relevant to their specific interests.

The overall objectives of the engineering clinics are:

- *Generating* excitement among the undergraduate students by providing them with the opportunity to work on engineering issues of national and international significance,
- *Providing* undergraduate students with the opportunity to work on fundamental research projects that have significant impact on human health and the environment,
- *Mentoring* undergraduate students by providing leadership roles by faculty and students,
- *Exposing* a broad and interdisciplinary group of undergraduate students to the scientific method used in creation, investigation, and documentation of a research project,
- *Encouraging* undergraduates to pursue advanced degrees.
- *Sharing* research with communities outside the university (e.g., industry, pre-college groups which include minorities) through presentations during recruiting efforts and engineering open houses, and

- *Serving* as a model for other undergraduate institutions in integrating research and quality education.

The engineering clinics have been highly successful in integrating design and research experiences for the Rowan Engineering students. Impact of the clinics are assessed in the following ways:

- clinic Course and peer evaluations
- internships
- student awards in research and academic excellence
- exit interviews
- feedback from industry, alumni, employers
- graduate school

This paper specifically focuses on the impact of the Rowan engineering curriculum on female students.

WOMEN IN ENGINEERING AT ROWAN UNIVERSITY

The College of Engineering currently has 7 female faculty out of a total of 30 faculty. The distribution of women in the four engineering disciplines is presented below in Figure 1:

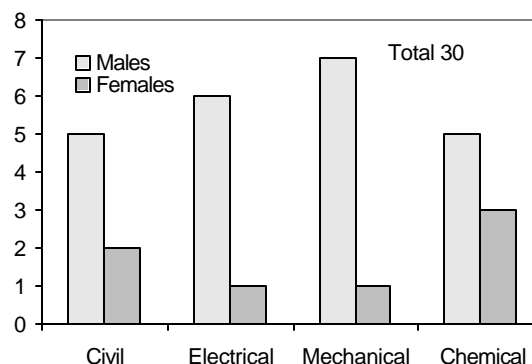


Fig. 1: Female Faculty Distribution

The College of Engineering also has a female dean. There are currently 14 female deans in the USA in ABET accredited programs.

The College of Engineering has graduated two classes so far in 2000 and 2001. The number of women entering the program is similar to the national average of 15-20%. The numbers of women and men enrolled during their four years of study for the class of 2000 is presented in Figure 2. The

College lost 3 women to other colleges at the university. The retention rates of men and women for this class are similar.

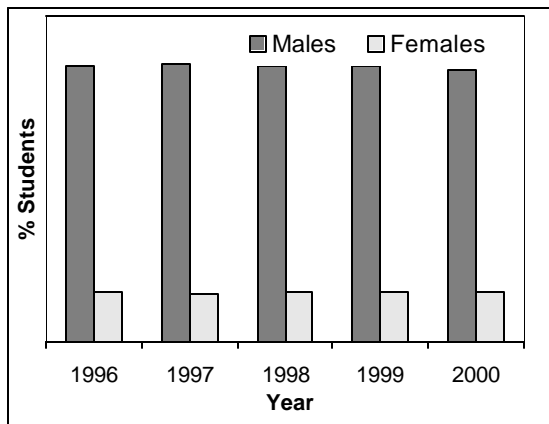


Figure 2: Distribution for the Class of 2000

Current data on the female students of the class of 2000 indicate that all students are employed in major engineering companies such as Lockheed Martin, Tetrattech, Campbell Soup Co., US Navy, Sargent and Lundy, Dupont, FAA Tech Center, Tams EarthTech, US Filter etc.

The number of women pursuing graduate school from the class of 2000 is 6 out of 12, an impressive 50%.

Figure 3 indicates the number of students entering the College of Engineering since it opened in 1996. The percentage of female students entering the College is not significantly different from the national average.

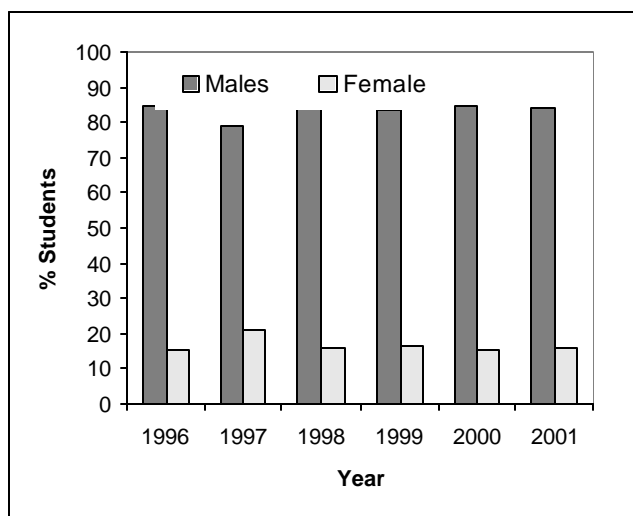


Figure 3: Incoming Students by Year

The retention rates for male and female students for the class of 2000 through 2002 is presented in Figure 4.

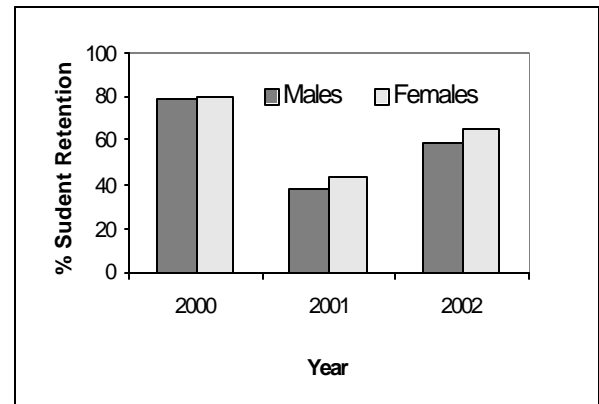


Figure 4: Student Retention

It is interesting to note that the retention rates for the two classes of 2000 and 2001 are significantly different. The primary reason that was identified for the drop in retention was the lack of an attractive scholarship package to attract quality students for the class of 2001. It is important to note that the class of 2000 had received attractive scholarships for their four years of study at Rowan. The retention rates have increased for the class of 2002 as better scholarship packages attracted better quality students.

Alumni surveys for the class of 2001 female students indicate that all students are employed in major engineering firms/industries such as the US Navy, Remington and Vernick, Andersons, Coastal Engineering, Lennox China etc. The number of women pursuing graduate school from the class of 2001 is 2 (full time) and 1 part time, an impressive 42.8%.

Surveys from the current graduating class of 2002 indicate that 5 out of 11 female students are pursuing graduate studies. The national % for women pursuing graduate school for an M.S. in the 1990s has been reported at 17% [12].

Rowan University has also allowed a faculty from Sociology to conduct gender related research for the students at the College of Engineering. Hartman's [13] study focused on gender differences at the College of Engineering. The study gathers baseline survey data on all undergraduate engineering students during the first semester and compares these to end of the year attitudes, satisfaction, performance and commitment to the engineering program and to engineering as a career. Hartman reported that the female students recruited to Rowan's engineering program differ very little from the male students, and in some ways have an even stronger academic preparation for engineering. However a higher proportion of women expressed weaker self-confidence in their engineering skills and ability, less satisfaction with and less commitment to the engineering major and career. Focus group interviews are

in progress to obtain more insight into explanations for this finding.

This paper has focused on the impact of the engineering curriculum on female students at the College of Engineering. While the data reported is for only three years it is important to note that the research and mentoring via the engineering clinics seem to have a major impact on female student retention, job placement and their pursuit of graduate studies. This is indicated during the exit interviews. The college will have to implement attractive programs to increase the number of incoming female freshman. A workshop for middle school girls titled "AWE: Attracting Women into Engineering" is offered every summer to mentor and expose girls to engineering careers at an early age [14]. Similar workshops for high school girls are being planned. The College has also formed partnerships with local high schools to establish Engineering Academies. These partnerships have been formed to prepare students for engineering careers during their high school years.

CONCLUSIONS

The Rowan Engineering curriculum is innovative and effective in providing students meaningful design and research experiences as early as their freshmen years. The Engineering Clinics have proven to be a critical component in our ability to accomplish multidisciplinary design and implement meaningful research experiences. Similarly, the use of project-based instruction has led to the development of a cadre of students who are design ready.

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