A GENDER LENS ON ROWAN UNIVERSITY'S COLLEGE OF ENGINEERING

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EXECUTIVE SUMMARY

BACKGROUND TO THE STUDY

This study was designed to put a "gender lens" on Rowan University's engineering program. Its main purpose was to assess whether the institutional environment of Rowan University's Engineering College is favorable to women's retention, self-confidence, satisfaction and commitment to engineering. The focus on this particular college stemmed from the nature of its program: it was set up as "best practices" in undergraduate engineering education, one of the first in the country which initial set-up followed the guidelines solidified in EC2000, rather than as a "women in engineering" program. Yet many features of the engineering program have the characteristics of being "female-friendly": the interdisciplinary teamwork, the continuous hands-on experience every semester, the integration of communication skills into the required coursework, the entrepreneurial opportunities, the partnership with industry for Clinic projects and internships, the nurturing rather than competitive climate, the personal faculty-student relationships fostered by small class size and faculty mentoring, and the relatively high proportion of female role models (in the faculty and Dean). Because these features of the engineering program overlapped with curricular and climate reform advocated by those trying to help more women succeed in engineering, they were expected to help women (and all other students) feel that they belong and can develop as engineers, and to encourage their persistence in the program to its end.

RESEARCH QUESTIONS

The main research questions of the study were:

Do females enter the Rowan program with any disadvantage in terms of their input into the system (their family background, their math or science background, or the support of significant others for their pursuit of engineering)? Does Rowan help to mitigate any disadvantage women might bring with them?

Do the female students participate in the extra-curricular engineering activities at Rowan as much as the male students do? What is the impact of participation in the local chapter of the Society for Women Engineers on women's integration into the engineering culture of Rowan? How does it impact their self-confidence to be engineers?

Does the Rowan program strengthen women's self-confidence in their pursuit of engineering? Are there certain stages in their undergraduate studies at Rowan that are particularly empowering or problematic for women?

Are the female engineering students at Rowan as satisfied with the engineering program as males are? Is the Rowan engineering program as male-friendly as it is female-friendly? What aspects of the Rowan program are particularly satisfying or problematic for female students as compared to male students? Are males and females satisfied with the same aspects of the program? In particular, how do male and female students react to those aspects of the program that are expected to be "female-friendly", such as

the emphasis on teamwork, the personal faculty-student relations, the extensive lab work, the real-world context of projects?

Do the students perceive special problems for women who pursue engineering? How does their undergraduate experience at Rowan affect this perception?

How does the input students bring with them into Rowan impact their academic performance? Does academic achievement differ for male and female students?

Is the retention of female students as high as that of male students? How is retention impacted by students' initial input into the system? By satisfaction with the program? By academic achievement?

POPULATION AND METHODS

The population of the study was all undergraduate female engineering students. Male students were studied as a comparison group against which to evaluate the responses of the female students. This facilitated conclusions about gender-specific reactions to the programs. Students were surveyed during required courses, which ensured a high response rate, less biased toward those particularly committed to engineering than other methods of data collection might be.

Students were surveyed twice during the academic year 2000-1, once at the beginning of the Fall semester, and once at the end of the Spring semester. This allowed the tracking of changes that occurred over the course of the academic year. Official transcripts provided records of academic achievement. Focus group interviews were held with three groups of female students over the course of the year. Interviews were

conducted with all department chairs (and acting chairs), the founding Dean of Engineering, the current Dean and Associate Dean of Engineering, faculty members who helped found the program and had seen it evolve from its inception, and all female faculty. These interviews provided more in depth understanding of the program and its impact.

MAIN RESULTS

Understanding Undergraduate Student Progress toward Becoming an Engineer

A model was developed to understand the progress of undergraduate students toward becoming an engineer. The process by which students become engineers is seen as beginning with characteristics that they bring with them into the university setting. Students come in with varying family and demographic background, high school math and science background, and initial levels of engineering self-confidence. While gender differences in terms of family and high school background are minimal, female students enter with lower engineering self-confidence than males and their engineering self-confidence is more closely tied to their family and high school background than is males'.

Once in the program, students' progress is indicated by their academic performance in class and their participation in a variety of extracurricular enrichment and help activities each year. As a result of the interaction of their input characteristics and experience over the course of the academic year, their engineering self-confidence may increase or decrease (or remain stable), they reach varying levels of satisfaction with the various aspects of the program and interpersonal climate, and decide whether to continue in the program for another year. At the end of the program, they have either graduated or

dropped out earlier. As graduates, they may continue on to graduate school in engineering, get a job as an engineer, or change fields.

Our focus was on the experience of the Rowan students in the Rowan program, as it interacted with the characteristics they input into the program. We followed them for one year in the program, from Fall to Spring.

Input Characteristics Students Bring with them into the Program

Female students at Rowan exhibited few of the disadvantages in pre-college background that the literature had led us to expect. They did not enter Rowan at a disadvantage in terms of having role models in terms of mothers or fathers or siblings in science, engineering or math. In terms of educational role models (having significant others in college), there was no gender difference in terms of fathers, but females had stronger educational role models in their mothers than did males, and males had stronger educational role models in their siblings than did females. Nor did they differ much from males in terms of the support for their pursuit of engineering that they received from significant others.

In terms of pre-college math and science background, the main disadvantage the female students had was fewer computer science courses before college than their male counterparts; on the other hand, they had several advantages over the males students in terms of participation in extra curricular math- or science-related activities, participation in honors math and science classes, and higher grades in high school science classes.

Overall, the gender differences in background characteristics and pre-college preparation seem to be fairly balanced, without one gender having much advantage or disadvantage when compared with the other.

However, females do enter Rowan with less self-confidence that they belong in engineering and with less self-confidence in their engineering abilities. This is not a generalized lack of self-confidence: the female students do not have less confidence in their overall academic abilities or communication skills.

The engineering self-confidence of women is more sensitive to their background influences than that of males, especially among the students with weaker backgrounds. The impact of such background influences is greater in the first year, when students first enter Rowan, and then again in the senior year, when they face the prospects of leaving the university environment.

Engineering Self-Confidence

After being in the Rowan program even for one year, the traditional gender gap in self-confidence, with which students enter Rowan, is reduced. Participation in extra-curricular activities makes a particularly important contribution to the engineering self-confidence of females in the Rowan program, as compared to males. That Rowan strengthens female's engineering self-confidence is reinforced when we compare the self-confidence of Rowan engineering students to engineering students in other colleges and universities: Rowan females have higher engineering self-confidence than female engineering students in other programs, and the gender gap in self-confidence at Rowan is smaller.

However, the empowering effect of the Rowan program on its female students does not appear to persist to the end of the program. As Rowan students get ready to graduate (in their senior year), the gender gap in engineering self-confidence is greater than ever. Perhaps it is the anticipation of the labor market, or a greater awareness of the minority

status in the profession, that mitigates the Rowan effect on female students' engineering self-confidence in the senior year. Because of the relationship between engineering self-confidence and commitment to persist in the field, this is a topic of concern we believe merits important consideration.

Performance and Activities in Engineering at Rowan

Family and high school background have relatively weak impacts on how involved students get in engineering activities, even in their first year. Female engineering students participate as much or more than do the male students in the various kinds of enrichment and support activities available at Rowan. Female students are significantly more involved in academic enrichment activities, such as work with faculty, hearing guest speakers, going on field trips. They were at least as likely as men to have had summer or year-round internships in engineering. They are more likely to participate in study activities, such as study groups and tutoring, and as likely as males to participate in counseling activities, such as meeting with academic advisors or getting career counseling. While most of the engineering students participate in one of the five student chapters of professional engineering societies on campus, female students are more likely than the male students to participate in and be officers of these organizations.

Over a third of the women are members of SWE, and over half of the women attend SWE meetings at least occasionally. Participation in SWE adds to the effect of the discipline-specific organizations as a help network (SWE participants are more likely to be involved in "help" activities – and not because they are disproportionately "needy" as measured by high school background and achievement, or fall semester GPA), by

enhancing a sense of efficacy in their engineering abilities, by increasing participants' satisfaction with the course load.

Involvement in engineering activities at Rowan enhances engineering self-confidence, and is more strongly related to the engineering self-confidence of female than male students.

Involvement in engineering-related activities also enhances satisfaction with the program for both males and females. Student involvement in academic enrichment and faculty contact, mentoring and counseling activities, and professional organizations are all related to greater satisfaction with various aspects of the program. SWE involvement enhances women's satisfaction with programmatic elements like coursework demands, acting apparently as an additional help network for the women participating in it.

Satisfaction with the Rowan Engineering Program

Satisfaction with the engineering program takes on many aspects. Students distinguish between satisfaction with the programmatic elements of the program (opportunities available, and coursework), how the programmed is actually applied (teamwork, the Engineering clinic, and Labwork), and the interpersonal climate (faculty-student relations, and peer relations).

According to our results, the program, its delivery and the interpersonal climate are indeed female friendly: female students are as satisfied or more satisfied than the male students with the programmatic elements of choice and opportunity, classwork load, with the delivery of lab work, teamwork, and the Engineering Clinic, and with peer and student-faculty relationships. Once high school background has been controlled, most of

the gender differences lose their statistical significance, which means that the satisfaction of the female students is not at the expense of the satisfaction of male students.

Involvement in extra-curricular enrichment and counseling activities is related to satisfaction with many of the aspects of the program. The importance of integration into all facets of the program, not just class work, is underscored by this finding: enrichment activities and "help" activities are related to students' greater satisfaction with the program.

Students with stronger engineering self-confidence are more satisfied with the programmatic elements of program opportunities and classwork, and with peer relationships. The relationship between engineering self-confidence and satisfaction with peer relationships is particularly important for female students and reinforces findings in other research about the importance of community and networking for keeping women in engineering. Satisfaction with the way the program is delivered in labs and in teamwork is related to the engineering self-confidence of males. In turn, males who are less successful academically are less likely to stay in engineering.

Perception of Problems for Women in Science, Engineering and Math

Students were asked about their perception of problems for women pursuing careers in science, engineering or math (SEM). Their responses resulted in three factors of perceived problems: societal attitudes toward women in SEM, the conflict between feminine qualities and careers in SEM, and the conflict between family and career for women in SEM. The majority of students do not perceive special problems for women pursuing careers in science, engineering or mathematics with regard to societal attitudes

toward women in SEM or the conflict of feminine qualities and careers in SEM, but they do perceive as somewhat problematic possible conflicts between career and family responsibilities. There were few gender differences in the perception of problems for women; however, the female students were more concerned than the male students about discriminatory attitudes toward women in SEM and the conflict between family and career in these fields.

Exposure to female role models in science, engineering or math sensitized both male and female students to possible problems women encounter in those fields. Women were especially more aware of potential problems when they had sisters in SEM, or had more female instructors for their engineering courses. Members of SWE were also more sensitized than were female students who were not SWE members to the potentially negative societal stereotypes about women in SEM and conflicts between these fields and femininity; however, they were less likely to perceive conflicts between career and family as problematic, presumably because they were exposed to ways of resolving these conflicts.

Exposure to real-world experiences also reduced the female students' perception of problems for women in SEM: having job or internship experience in engineering reduced the perception of problematic issues for women in science, engineering or math. This is another reason to support the exposure of female students to positive real-world experiences in these fields, so that their fears may be alleviated.

The perception of problems for women in SEM was related negatively to women's engineering self-confidence, their satisfaction with the engineering program, their expectations from a degree in engineering, and their intentions to persist in the

major and the career. Addressing the issues women find problematic, and showing how problems can be resolved, would appear to have a major impact on how comfortable women feel in engineering and whether they intend to stay in the field.

Gender Differences in Engineering Outcomes: Academic Achievement and Retention

The female engineering students have as strong an academic record and rate of retention as the male engineering students at Rowan. As in any program, of course, a certain number of students switch out of the major each year. By analyzing the differences between those who took the survey and stayed in the program, and those who took the survey and left the program, we could answer some of the important questions of the research.

Because of the unusual nature of the Rowan program it was important to determine whether leavers were dissatisfied with the clinic set-up or the emphasis on teamwork throughout the curriculum. However, this was not the case for males or females. Leavers (male or female) were even more satisfied with both the clinic and teamwork than stayers. This apparently was not the reason they left the program.

Previous research has suggested that women in particular leave engineering because they find the coursework too demanding – again, not in the case of Rowan. Other research suggests that interpersonal climate as a factor in students' leaving engineering, especially women. Again, this is apparently not the case for Rowan. Both leavers and stayers are satisfied with faculty-student relationships and peer relationships.

The main difference between stayers and leavers appears to be their grades (for males) and dissatisfaction with the opportunities offered in the program (for males and

females). Also, leavers have stronger verbal SAT scores than stayers, which suggests that they may have strengths rewarded better in other majors and careers.

The most important conclusion is that the special "female-friendly" nature of the program does not push men away nor are females pushed away because of dissatisfaction with the interpersonal climate, difficulty of the coursework, or the nature of labwork.

CONCLUSIONS AND RECOMMENDATIONS

The most important findings from this research are the extent to which the program does work for the female students. Traditionally, females leave the engineering program at higher rates than male students and complain of marginalization, alienation, discomfort, and loss of interest. In contrast, in comparison to the male students the female students in this program:

- Are as *active* or more in academic enrichment activities, counseling and mentoring activities, study group activities, and student chapters of professional organizations
- Are as *satisfied* or more with the program's opportunities and offerings, the course workload, the laboratory work, the clinic program, the teamwork emphasis, the faculty-student relationships, and the peer relationships
- Have as high or higher *academic achievement* both overall and in engineering specifically
- Have as high or higher *retention* throughout the program (first-year to second year, second-year to third-year, third-year to fourth-year, fourth-year to graduation)

Women's involvement in academic enrichment and counseling activities is related to greater engineering self-confidence and satisfaction with many aspects of the program. In turn, their satisfaction with the program is related to greater engineering self-confidence, including their confidence that they will stay in the major and the career.

Importantly, males were not less satisfied with the program than females. In particular, there was no gender difference in satisfaction among the most-qualified males and females. Among weaker students, females were more satisfied than males, and indeed male students who did not do well in their courses were more likely to drop out of the program. Female attrition from the program was much less linked to their grades than was males'.

Students who dropped out of the program did not do so because they were dissatisfied with the innovative aspects of the program: satisfaction with clinic, with teamwork, with lab work, with faculty-student relations or peer relations. Nor do they drop because of greater dissatisfaction with the workload.

At the same time, the study has found that female students had less self-confidence in engineering and were less satisfied that engineering was the right major for them, much like findings in other national studies, and that they were somewhat more likely to perceive problems for women in science, math and engineering than were males.

Because of the successful research design of the study, changes could be traced over the course of the academic year at each level of the program. We could thus locate the impact of experience in the program for both males and females. With regard to self-confidence in engineering, for females it was strengthened during the course of each academic year except the senior year, while male self-confidence was undermined during

the course of each academic year except the senior year, when it was strengthened. As a result, the gender gap in self-confidence narrows during the course of the first years of the program, a significant finding in contrast to other studies, which have shown deterioration in female self-confidence after the first year. It seems that while women enter the program with less engineering self-confidence than men, apparently the first years of the Rowan program reinforce female self-confidence to reduce the gender gap in self-confidence -- but the gap grows again in the senior year, This pattern needs to be given more attention. It suggests that as nurturing as a program is, unless it empowers women to deal with their transition to the wider engineering world, its impact may be limited.

RECOMMENDATIONS

These results confirm that engineering programs set up according to the guidelines of EC 2000 and on the cutting edge of undergraduate engineering education can indeed be female-friendly, and that special programs targeted at women are not necessary to reduce the gender gaps that more traditional engineering has demonstrated. Further, the results demonstrate that an innovative, female-friendly, program is still male-friendly; that is, it does not cut into the satisfaction of the male students.

These are important findings for any program interested in restructuring along the Rowan model. Here are key features that seem to work:

- Extensive, interdisciplinary team work every semester in engineering clinic
- Nurturing approach rather than weed-out
- Hands-on laboratory experience every semester

- Small faculty-to-student ratio and personal accessibility and attention
- Extra-curricular engineering activities in discipline-specific professional organizations
- Extensive internship opportunities
- Real-world context of projects
- Entrepreneurial and communication skills built into clinic projects

FUTURE RESEARCH

Tracking the changes over the course of the academic year gave us much insight into the impact of the engineering program on the students. To better understand the impact of specific parts of this program, it is important to add to this research design:

- longitudinal study to track students as they progress from their beginning in the program to their graduation.
- comparison of the Rowan experience to other programs which also have been set up in accordance with EC2000 and incorporate the principles of teamwork, personal attention, real-world context, communication skills and entrepreneurial experience, which seem to be fundamental to the Rowan program and to cutting edge engineering programs.

If we have mastered a model that reduces the gender gap in persisting through the undergraduate years, we can concentrate our efforts on:

- implementing this type of program in other settings
- recruiting more women so that they will have the opportunity to participate in a female-friendly training ground for engineering,

- empowering women as they turn to leave the nurturing undergraduate environment, so that they can with confidence address and resolve workplace and career issues which serve as obstacles to long-term careers in engineering.