A GENDER LENS ON ROWAN UNIVERSITY'S COLLEGE OF ENGINEERING

Harriet Hartman[1]

Abstract---*Rowan University's College of Engineering is a new program (less than 5 years old), incorporating in its design many features which previous research suggests are conducive to the retention and satisfaction of female engineering students. This paper presents the rationale and design of a recently funded NSF study focusing on gender differences in the College. 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. This design enables the pinpointing of primary "leaks" in the undergraduate education "pipeline" to engineering. Preliminary data from the first-semester survey will be presented, including gender differences in family background, pre-college preparation both formal and extra-curricular, self-assessments of strengths and weaknesses, attitudes toward engineering as a field of study and as a career, perceptions of difficulties for women in engineering, and future plans.*

Index Terms---gender, research, undergraduate engineering education, undergraduate students.

INTRODUCTION

A major "leak" in the "pipeline" of women to engineering has been traced to the undergraduate years. Girls who are recruited to an undergraduate major in math, science or engineering are often confronted with a pedagogy and "old boy network" which discourage further pursuit of the field. The tendency to a highly competitive academic climate, emphasis on hierarchy, greater opportunities for male bonding in the fields, impersonality, and a lack of concern for social concerns whether personal or societal, are all seen as obstacles to female comfort in the sciences, particularly where women are such a small minority as in engineering (see, for example, [1], [3], [6], [8], [19], [21], [25]). Interaction both within and outside the classroom, and among students as well as with faculty, may also contribute to a "chilly climate" for female students (see also [11]; [25]). The paucity of female role models and female mentors, particularly in the engineering field, is seen as a further deterrent to women's success in and persistent commitment to the field [1], [3], [5], [10], [19], [20], [25]. Many of these factors characterizing schools of engineering are embedded in long-standing traditions which are difficult to dismantle.

The new College of Engineering at Rowan University, only five years old, has made many efforts to establish an infrastructure more comfortable and nurturing to all students, female as well as male. Not encumbered by long-standing tradition to the contrary, it requires from the outset interdisciplinary team-work in which cooperation plays a central role. Direct hands-on laboratory work is provided from the first semester, to get all students on a level playing field. The engineering program prides itself on a low student-faculty ratio and a nurturing relationship between faculty and students. The curriculum integrates, early on, an emphasis on communication skills. Nearly a third of the faculty are female, many are young, and all have been recruited expressly to further the pedagogic ideals of the new College. All of these characteristics suggest an ideal environment for the development of female engineers.

This paper presents preliminary results from a recently funded NSF study focusing on gender differences among students in the Engineering College. The study is designed to gather baseline survey data on all undergraduate engineering students (approximately 340, of whom about 20% are female), to determine gender differences in family background and support, pre-college preparation both formal and extra-curricular, self-assessments of strengths and weaknesses, and learning style preferences. The study also surveys attitudes toward engineering as a field of study and as a career, self-confidence in engineering-related skills and abilities, perceptions of difficulties for women in engineering, and future plans and commitment to engineering. Two surveys are planned: the first survey took place toward the beginning of the academic year; the second, which will repeat many of the questions and assess reactions to the academic year which is ending, will be administered toward the end of the academic year. This research design enables the pinpointing of the primary "drips" or weak points within the undergraduate career. For instance, we will be able to identify when the greatest number of drop-outs occur from the program, or whether there is a drop in self-confidence at certain junctures. Such weak points can then be related to the effect of the background variables as well as experiences during the academic year. Focus group interviews with the female engineering students flesh out the gender differences in the educational experience.

The study has the advantage of including all engineering students, both female and male, so that findings characterizing Rowan students as a whole rather than

[1] Harriet Hartman, Department of Sociology, Rowan University, 201 Mullica Hill Rd., Glassboro, NJ 08028 (hartman@rowan.edu). The support of NSF-Power Grant No. 0074857 for this study is gratefully acknowledged.

women only can be identified. The larger sample also allows more in-depth analysis of differences across majors and years of study. Since survey questionnaires were administered in required major courses, a very high percentage of participation by the students was ensured. This reduced the self-selection inherent in voluntary participation in web-based surveys, for instance, or mail surveys for which the response rate is much lower. The findings represent a good cross-section of the engineering students, not just the most committed or interested in engineering, nor only the ones with major complaints to voice.

The present paper presents preliminary data from the first-semester survey, including gender differences in family background, pre-college preparation both formal and extra-curricular, self-assessments of strengths and weaknesses, perceptions of problematic areas for women in engineering, and commitment and satisfaction with engineering as a major and as a potential career.

GENDER DIFFERENCES IN BACKGROUND

The lower enrollment rate of women in engineering and their lower retention rate have been linked to various factors differentiating girls' from boys' socialization, including: girls' lesser support from significant others (including family, friends, teachers, and school counselors) for science, engineering, and math pursuits; fewer female role models in such pursuits; fewer opportunities for developing math and science interests both in quantity and quality -- on the average, girls have taken fewer math and science courses before college, engage in fewer extra-curricular science and math activities before college, and are less likely to have been exposed to a hands-on lab component which gives a more experiential basis for developing an interest and self-confidence in abilities ([1], [4], [9], [13], [15]-[18], [26]; but see also [14]).

Based on the literature, differences were hypothesized in terms of family support, academic preparation and extra-curricular participation, and same-sex role models among parents and siblings. However, our preliminary results suggest that the female students who are recruited to Rowan's Engineering College differ very little from the male students, and in some ways have an even stronger academic preparation for engineering than do the males.

Females had somewhat more honors math and science classes in high school than did the male students and were more likely to receive mostly A's in their high school science classes. There are no significant differences in verbal or math SAT scores; or in grades in high school science classes. On the average, the female students had participated in more extra-curricular science activities during high school than did male students. In fact, looking at each type of extra-curricular activity, more females had participated in each kind of activity during the high school years than had males.

On the other hand, males had somewhat more semesters of high school science classes (including physics, chemistry, biology, earth sciences, environmental science, engineering and computer science) (Table I); further analysis showed that their main advantage was having more semesters of computer science the females In all other sciences, the gender differences were not statistically significant. Males and females were also equally likely to have had lab experience in high school.

TABLE I

HIGH SCHOOL BACKGROUND

	Male Students	Female Students
Mean score on Verbal SAT	584	585
Mean score on Math SAT	653	635
% "Mostly A's" in high school science classes	44.4	50.0
% "Mostly A's" in high school math classes*	51.9	68.2
Mean # semesters of high school science**	3.8	2.8
Mean # semesters of high school math	3.0	3.7
% participated in 2 or more extra-curricular math or science activities in high school***	21.2	42.4
(n)	(266)	(66)

*Chi-square significant at p<.10 **T-test significant at p<.05

***Chi-square significant at p<.05

Therefore, in terms of academic preparation, the main disadvantage the female students had was having fewer computer science courses before college, while their main advantages were in terms of extra curricular activities, participation in honors math and science classes, and grades in high school science classes.

Both male and female students had strong support for their engineering pursuits on the part of mothers, fathers, friends, high school teachers and counselors (Table II). There were virtually no gender differences in this. The only statistically significant gender differences found were that mothers of female students were somewhat less supportive than mothers of male students (78% of the female students' mothers were "strongly supportive" of their being in engineering, compared to 89% of the male students' mothers; these mothers made up for it by being "moderately supportive", with less than 5% of either male or female students' mothers being less than supportive). High school counselors, while equally positive for both males' and females' pursuit of engineering, were slightly more likely to be negative regarding females' pursuit of engineering.

Few of the students' fathers (8.5%) and none of the students' mothers were engineers. However, it is interesting that a slightly higher percentage of female students' fathers were engineers (14.1%) than were male students' fathers (7.2%).While there were no significant gender differences in proportion whose brothers were in engineering or another science or math field, significantly more sisters of female engineering students were in engineering or another science or math field.

TABLE II

SUPPORT FOR ENGINEERING PURSUIT

(% POSITIVE OPINIONS ABOUT THE STUDENT PURSUING ENGINEERING MAJOR OR CAREER)

	Male Students	Female Students
Mother**	92.0	86.2
Father	90.0	90.8
Best friends	75.5	71.9
Boyfriend/girlfriend	69.3	67.8
Most influential teacher	86.7	86.2
High school counselor**	74.7	74.6
(n)	(266)	(66)

**Chi-square significant at p<.05

To the extent that there are gender differences in family and academic science and math background, most of the differences are in the direction of the female students having a stronger high school background and more role models in their family. The female students appeared to be somewhat disadvantaged compared to the male students, mainly in that they had fewer computer science classes in high school.

GENDER DIFFERENCES IN SELF-CONFIDENCE AS ENGINEERING STUDENTS, SATISFACTION WITH THE FIELD OF ENGINEERING AND COMMITMENT TO ENGINEERING

Despite their strong background, there were a number of ways in which the female students appear to be less committed to engineering than their male counterparts (Table III). While not all gender differences are statistically significant, most reinforce the same pattern of difference. Fewer females are strongly satisfied with their college major, and a higher proportion of female students disagree that they are well suited for their choice of a college major. Fewer females say they have no desire to change their major, slightly more females than males can think of a more rewarding major, and a significantly higher proportion enjoy liberal arts courses more than math and science courses. Almost a third of the female students, like a third of the male students, strongly agree that they are well-suited for the [engineering] career. However, fewer females express a high level of interest in engineering, and fewer of the females agree that the rewards of an engineering degree, or the future benefits of studying engineering, are worth the effort.

Further, despite their strong preparation and previous achievements, a smaller proportion of females are strongly confident in their engineering abilities, fewer feel they will

TABLE III

ENGINEERING SELF-CONFIDENCE AND SATISFACTION

(% STRONGLY AGREEING)

	Male Students	Female Students
SELF-CONFIDENCE AS ENGINEERS		
Able to handle this year's course work	27.4	19.7
Overwhelmed by the workload in the engineering courses*	11.8	21.2
Will do well in this year's math, science and engineering courses	29.4	21.2
Well-suited for choice of college major**	32.3	27.7
Well-suited for chosen career	32.8	31.8
Competent in skills required for their major	28.6	21.5
Mechanically inclined**	36.3	16.7
Technically inclined**	34.5	20.0
Good at designing things	29.7	16.9
SATISFACTION WITH ENGINEERING		
Personally satisfied with my choice of a college major*	45.8	36.4
No desire to change to another major**	49.0	37.9
Engineering is right major for me**	40.7	30.3
Advantages of studying engineering outweigh the disadvantages	39.3	39.4
Future benefits of studying engineering worth the effort	52.5	47.0
High level of interest in engineering	36.5	28.8
Enjoy the subjects of science and math the most	32.1	27.9
Enjoy taking liberal arts courses more than math and science (% disagree)	20.2	9.1
Rewards of getting an engineering degree not worth the effort (% disagree)	50.0	40.9
(n)	(263)	(66)

*Chi-square significant at p<.10 **Chi-square significant at p<.05

do well in their math, science and engineering courses this year; and fewer feel competent in the skills required for their major. Fewer females agree that they are mechanically inclined or technically inclined, and fewer agree that they are good at designing things. Nearly double the proportion of females as males feel overwhelmed by their workload in engineering (also Table III).

Nevertheless, more female than male students intend to complete M.A. or M.S. degrees, not only undergraduate degrees (70% of the females vs. 58% of the males).

POSSIBLE EXPLANATIONS OF FEMALE STUDENTS' WEAKER SELF-CONFIDENCE AS ENGINEERS AND WEAKER COMMITMENT TO ENGINEERING

We have begun to explore several possible explanations for the female students weaker self-confidence as engineers and weaker satisfaction and commitment to engineering.

One possibility is that the women's preparation and earlier achievements have less effect on their initial self-confidence than similar background has on the male students. If so, female students, even with strong backgrounds, would start out with a weaker self-confidence in their future as engineers which is reinforced during the undergraduate years. However, we have some indication to the contrary.

When the students compare themselves to the average student their age, a quarter of both the male and female students place themselves in the highest 10% in rating their own self-confidence (Table IV). The male and female students also tend to rate themselves similarly when it comes to mathematical ability, interest in science, communication skills, and drive to achieve. Thus, the female students appear to have as strong self-confidence in their academic abilities as do the males; their weaker self-confidence is focused more on engineering subjects and abilities.

TABLE IV

STUDENT RATINGS COMPARED TO AVERAGE STUDENT THEIR AGE

(% SAYING THEY ARE IN "HIGHEST 10%")

	Male Students	Female Students
Academic ability	25.6	25.8
Self-confidence**	23.4	24.2
Mathematical ability	34.9	28.8
Interest in science	28.4	24.2
Communication skills	19.1	19.7
Drive to achieve	26.8	37.9
(n)	(263)	(66)

**Chi-square significant at p<. 05.

One gender difference that has been asserted in previous studies is that females tend to attribute their academic successes to external, temporary phenomena (such as luck), while males tend to attribute their success to internal, stable factors (such as their ability); in contrast, females tend to blame their failures on internal, stable factors, while males tend to blame their failures on fleeting external circumstances ([7], [22]; and reviewed in [24]). Such differences in attribution have been used to explain girls' weaker self-confidence even in the face of objective success (e.g., grades) similar to their male counterparts. However, some previous studies have indicated that once they have selected higher education in math or science courses, gender differences in attribution are not present and are not related to self-confidence [2]. The current study supports these findings. The Rowan students were asked to rate the reasons for their previous year's grades in science and mathematics. The female students are not less likely to attribute their previous year's grades to their own ability or effort -- in fact, the women are more likely to attribute their grades to their own effort than are the male students (Table V). On the other hand, less than 2% of the women attribute their grades to luck, compared to 10.7% of the men.

Another gender difference that has been posited in previous literature is that females prefer to learn in non-competitive, cooperative, group settings; while males prefer settings emphasizing individual achievement recognized hierarchically [11]. Because engineering classes frequently emphasize the latter type of learning situation, this is one of the ways women are thought to be at a disadvantage [24].

However, few such learning preferences have actually been documented at the college level nor among students who have actually chosen the mathematical, science or

TABLE V

ATTRIBUTIONS OF SUCCESS/FAILURE FOR LAST YEAR'S GRADES

(% "MOST IMPORTANT")

	Male Students	Female Students
My ability**	19.1	19.7
How much effort I put in**	31.7	40.9
Luck	10.0	1.5
Ease/difficulty of material	10.7	15.2
Quality of teaching	30.3	27.3
(n)	(262)	(66)

**Chi-square significant at p<.05

engineering fields of study [12]. Further, as mentioned before, Rowan's pedagogical style emphasizes interdisciplinary teamwork and cooperation, which would not put students preferring this learning style at a disadvantage.

We asked the Rowan engineering students to express their preferences for learning and studying styles (Table VI). The majority of both female and male engineering studentsat Rowan enjoy group assignments in class and studying in groups better than studying alone, and the female engineering students at Rowan do not show more of a preference for group work than males do. None of the gender differences in this respect are statistically significant. Thus, this probably does not explain the gender differences in commitment to engineering or satisfaction with it.

TABLE VI

PREFERENCES FOR STUDYING AND LEARNING

(% STRONGLY AGREE AND AGREE)

	Male Students	Female Students
Studying in a group is better than studying by myself	62.7	54.6
I prefer studying alone	36.6	39.4
I enjoy group assignments or projects in class	68.3	69.7
(n)	(260)	(66)

One final avenue of explanation is suggested by the preliminary results. The survey asks the students how problematic for women are a number of factors in the pursuit of engineering (e.g., the long years of formal preparation, the conflict between career and family responsibility, lack of encouragement from significant others, lack of confidence, lack of competitiveness, discriminatory attitudes toward women). Seen as most problematic for the women by female and male students alike was the conflict between career and family -- over 3/4 of each saw this as problematic for women (Table VII). Discriminatory attitudes toward women on the part of teachers or others in scientific fields generally was seen as problematic for women by nearly 2/3 of the female students --- and over half of the male students; over a third of the female students saw such discriminatory attitudes as problematic at Rowan (compared to only 20% of the male students).

The lack of female role models in math and science fields was also seen as relatively problematic for the women -- this, despite the fact that nearly a third of the engineering faculty are women, and virtually all of the students had at least one or two female high school science or math teachers. This perception of problem areas for women, especially on the part of women, may be one reason for discouragement on the part of the female students.

Interestingly, there are also some items which the female students are less likely to consider problematic for women: they are less likely than the male students to see a lack of encouragement on the part of teachers or counselors, family or friends as problematic for women -- possibly because so many of the female students reported strong support for their pursuit of engineering. Female students are also slightly (but significantly) less likely to rate as problematic for women the long years of formal preparation, and the image of the sciences as unfeminine. There were no significant gender differences in how problematic for women was the need to be competitive, and women's lack of confidence.

Reasons for the gender differences (and lack thereof) in assessment of problems for women will be explored further in the focus group interviews with female students as well as the end-of-the-year survey. The role of these attitudes in fostering less self-confidence in female engineering students will also be explored in further analyses.

CONCLUSIONS

This paper has presented preliminary results from an ongoing study of Rowan University's engineering students. The male and female students seem to have entered Rowan with very similar backgrounds, differing little in terms of their academic math and science preparation, their extra curricular science and math activities, the support of their family, friends, and high school staff for their engineering pursuits, or their role models in their immediate family. Nevertheless, a higher proportion of women express weaker self-confidence in their engineering skills and ability, less satisfaction with and less commitment to the engineering major and career. The preliminary data offer some direction about possible reasons for this: initial self-confidence and attributions of success and failure do not seem to differ for male and female students, nor does preferred learning style. However the female students perceive more problems for women in the pursuit of engineering. Focus group interviews and an end-of-the-year survey will provide more insight into explanations for these findings. Further analysis will consider whether background variables and support have the same type and magnitude of effect on the male and female students' engineering experiences, and if not, why not.

TABLE VII

PERCEPTION OF PROBLEMS FOR WOMEN IN THE PURSUIT OF CAREERS IN SCIENCE, MATH OR ENGINEERING

% RATING AS SERIOUS OR NO PROBLEM (AS OPPOSED TO "NO PROBLEM")

	Male Students	Female Students
Possible conflicts between career and family responsibilities	76.0	81.5
Lack of female role models in scientific field	57.2	67.7
Discriminatory attitudes toward women on part of teachers or others in scientific fields generally**	50.4	66.2
Discriminatory attitudes toward women on part of teachers or others in scientific fields at Rowan**	19.8	35.4
Lack of information about careers in scientific field	42.4	58.5
Women's lack of confidence that they can handle the work	50.0	52.3
View that women in science or technical fields are unfeminine**	41.9	41.5
Lack of encouragement from teachers or counselors	46.8	35.4
Lack of encouragement from family or friends	45.4	33.9
Long years of formal preparation needed**	37.8	32.3
Women cannot be as competitive as science classes require	27.7	21.5
(n)	(265)	(66)

**Chi-square significant at $p<.05$

REFERENCES

[1] AAUW (American Association of University Women). 1992. How Schools Shortchange Girls. AAUW Educational Foundation and National Education Association.

[2] Amit, Miriam. 1988. "Attribution Patterns of Success and Failure in Mathematics, Gender and Career Choice. " Ben Gurion University of the Negev, ms.

[3] Bergvall, Victoria L., Sheryl A. Sorby, and James B. Worthen. 1994. "Thawing the Freezing Climate for Women in Engineering Education: Views from Both Sides of the Desk" in *Journal of Women and Minorities in Science and Engineering*, vol. 1, pp.323-346.

[4] Blaisdell, Stephanie. 1998. "Predictors of Women's Entry into Engineering: Why Academic Preparation is Not Sufficient." *WEPAN National Conference Proceedings.*

[5] Brainard, S. G. , S. S. Metz, and G. M. Gillmore, 1998. "WEPAN Pilot Climate Survey." http://www.wepan.org/climate.html

[6] Brush, Stephen. 1991. "Women in Science and Engineering." *American Scientist* 79 (September-October).

[7] Campbell, J. 1991. "The Roots of Gender Inequity in Technical Areas." *Journal of Research in Science Teaching* 28: 251-64.

[8] Collins, Deborah, Alan Bayer, and Deidre Hirschfield, 1996. "Engineering Education for Women: A Chilly Climate?" *WEPAN National Conference Proceedings.*

[9] Cunningham, Christine, Cathy Lachapelle, Meredith Thompson, Mario Delci and Irene Goodman, 2000. "Factors Encouraging and Discouraging Undergraduate Women in Engineering: Results from a National, Web-Based Study." Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans (April).

[10] Dresselhaus, Mildred S., Judy R. Franz, and Bunny C. Clark. 1994. "Interventions to Increase the Participation of Women in Physics." *Science*, 263:1392-1393.

[11] Ginorio, A.B. 1995. *Warming the Climate for Women in Academic Science.* Washington, D.C.,: Association of American Colleges and Universities.

[12] Greenfield, Lois, Elizabeth Holloway and Linda Remus. 1982. "Women Students in Engineering: Are They so Different from Men?" *Journal of College Student Personnel* (November).

[13] Hanson, Sandra L. 1996. *Lost Talent: Women in the Sciences.* Philadelphia: Temple University Press.

[14] Hoffer, Thomas, Kenneth Rasinski, Whitney Moore. 1995. "Social Background Differences in High School Mathematics and Science Coursetaking and Achievement". U. S. Dept. of Education, Office of Educational Research and Improvement, NCES 95-206 (Statistics in Brief).

[15] Kahle, Jane Butler and Judith Meece. 1994. "Research on Gender Issues in the Classroom" in Dorothy Gable (Ed.), *Handbook of Research on Science Teaching and Learning.* New York: MacMillan Publications.

[16] Kramarae, C. and P. Treichler. 1990. "Power Relationships in the Classroom." Pp.41-59 in S. L. Gabriel and I. Smithson (Eds.), *Gender in the Classroom: Power and Pedagogy.* Urbana: University of Illinois Press.

[17] Layzer, David. 1992. "Why Women (and Men) Give Up in Science," Pp.36-47 in H. Ausell and J. Wilkinson (eds.), *On Teaching and Learning*, v.4. Cambridge, MA: Derek Bok Center for Teaching and Learning, Harvard University.

[18] Leder, G. C., and E. Fennema. 1990. "Gender Differences in Mathematics: A Synthesis," pp.188-200 in E. Fennema and G. C. Leder (Eds.), *Mathematics and Gender.* New York: Teachers College Press.

[19] Nair, Indira and Sara Majetich. 1995. "Physics and Engineering in the Classroom." Pp.25-42 in S. Rosser (ed.),*Teaching the Majority: Breaking the Gender Barrier in Science, Mathematics, and Engineering.* New York. Teachers College Press.

[20] National Science Foundation, 1994. *Women, Minorities, and Persons with Disabilities in Science and Engineering* (NSF No. 94-333HL). Washington, D.C.: National Science Foundation.

[21] Ross, Karen C. 1994. *Women in Engineering: The Undergraduate Years.* Ph.D. Dissertation, SUNY-Albany School of Education.

[22] Ryckman, D. and P. Peckham. 1987. "Gender Differences in Attributions for Success and Failure Situations Across Subject Area." *Journal of Educational Research* 81: 120-125.

[23] Sax, Linda. 1994. "Mathematical Self-Concept: How College Reinforces the Gender Gap." *Research in Higher Education* 35 (2): 141-166.

[24] Seymour, Elaine and Nancy M. Hewitt. 1997. *Talking About Leaving: Why Undergraduates Leave the Sciences*. Colorado: Westview Press.

[25] Sonnert, Gerhard. 1995. *Who Succeeds in Science?* New Brunswick, New Jersey: Rutgers University Press.

[26] Tobias, Sheila. 1990. *They're Not Dumb, They're Different*, Tucson, AZ: Research Corporation.

HARRIET HARTMAN

Harriet Hartman is an Associate Professor of Sociology at Rowan University, where she teaches gender roles, sociology of education, socialization and family. She holds a B.A. in Public Service from UCLA, an M.A. in Sociology from the University of Michigan, and a Ph.D. in Sociology from the Hebrew University of Jerusalem. She co-authored *Gender Equality and American Jews* and has published articles in the fields of gender roles, family, immigration and Jewish studies. She is an Associate Editor of *Sociology of Religion.*