CHAPTER I-A

INTRODUCTION

The under-representation of women in engineering and other sciences has been a topic of national concern (Brainard, et. al., 1998; NSF, 2000; Rosser, 1995; WEPAN, 1993). A general decline in engineering enrollment has led to societal concern regarding a shortage of engineering professionals, and women, who continue to be seriously under-represented in the profession, are one of the potential sources for future engineers which have been targeted for cultivation (Bergvall, et. al., 1994; CAWMSET, 2000; National Science Board, 1993; Oakes, 1990). From the individual women's point of view, the under-representation of women in training for engineering undermines their qualifications for a lucrative, rewarding profession (Bergvall, et. al., 1994; Hanson, 1996). Efforts have therefore been taken to recruit and strengthen the retention of female engineering students beyond the current national average representation of 15% of engineering students being women (Anderson, 1994; Johnson, 1993). However, despite these efforts, a high proportion of women avoid science concentrations and engineering in particular, have a higher rate of attrition from college engineering programs (Adelman, 1998; Huang, et. al., 2000; Strenta, et. al., 1994), have a higher attrition rate than males from the profession after graduation (see for example, Boyce et. al., 2002; CAWMSET, 2000; National Research Council, 1994), and continue to be underrepresented in these professions.

The process resulting in the under-representation of women in engineering has been likened to an extensive "leaky pipeline" beginning in childhood, continuing through elementary, junior high and high school experiences, and continuing up through labor force employment and promotion. The under-representation of women in undergraduate engineering education is one critical segment along this pipeline. This under-representation reflects greater difficulty in recruiting female engineering students as well as greater obstacles for women during the years of undergraduate education (CAWMSET, 2000; Hanson, 1996; Rayman and Brett, 1993).

Our focus in this project is on gender differences in the experience of undergraduate engineering education. Our research is based on the engineering program at Rowan University, which seems to have addressed many of the problems women encounter. Even more importantly, its program has been designed as "best practices" in undergraduate engineering education for all students, not just for women. Therefore, it is important to evaluate how this educational model works for women, and why it succeeds when it does.

In this introduction, we will review the literature on the major sources of problems for women in engineering that stem from institutional factors. We follow with an introduction to the elements of the Rowan program, describe the study in more detail, and describe the student population we have studied. We then present the results of the study in terms of students' involvement in engineering activities at Rowan, engineering self-confidence, satisfaction with the program, and perceived problems for women in engineering. We show the outcomes of academic achievement and retention of the female students, compared to the male students. Our analysis of how women experience and react to the main aspects of this program, compared to men, allows us to reach conclusions about how "female-friendly" the program really is. We conclude with suggestions for engineering programs that would like to build on the Rowan model to incorporate an inclusive pedagogical design, and suggestions for further research to further validate the claims suggested by our findings.

REVIEW OF THE LITERATURE

Much research and rhetoric has been devoted to trying to understand why a higher proportion of women opt out of undergraduate engineering programs, and to pinpoint the alienating features of traditional programs. The major deterrents at the institutional level to women's persistence at the undergraduate level can be grouped into programmatic and climate issues, summarized below and in Table IA-1.

TABLE IA-1

CHARACTERISTICS OF UNDERGRADUATE ENGINEERING WHICH DETER WOMEN

PROGRAMMATIC ISSUES DIFFICULT FOR WOMEN IN TRADITIONAL ENGINEERING EDUCATION

- Competitive atmosphere; lack of cooperative pedagogy or group work
- Inadequate opportunities for hands-on experience
- Inadequate attention to contextual and social implications; narrow, fragmented scope of application
- Lack of validation of women's experiences

CLIMATE ISSUES DIFFICULT FOR WOMEN IN TRADITIONAL ENGINEERING EDUCATION

- Impersonal faculty-student relationships
- Lack of "community"
- "Male" communication patterns
- Few female role models
- Women perceived as "other"

PROGRAMMATIC ISSUES DIFFICULT FOR WOMEN IN TRADITIONAL ENGINEERING EDUCATION

Competitive Pedagogy

Many women, even if they are highly qualified, do not respond well to highly competitive "weeding out" pedagogy and have cited it as a major reason for leaving science, math and engineering fields (Seymour & Hewitt, 1997; Center for Education of Women 1992 cited in Ross; Rosser 1991; Hollenshead et al, 1996; Etzkowitz et al, 2000 Ch. 4). A strong emphasis on individualized competition has been found to be alienating to women not only in engineering but in other fields as well (Kramarae and Trieichler, 1990). As Ross (1994) summarizes, research suggests that males are socialized to be more comfortable with competition and to possess both the experience and personal resources to promote themselves in such an atmosphere; therefore, women respond more negatively to this kind of pedagogy than do men.

Further, large, impersonal classrooms relying on competition for individual achievement have been found to discourage women (Nair and Majetich, 1995). When women's inadequacies are emphasized at an early stage of the curriculum, women are more likely to be alienated and uncomfortable in the program (Anderson, 1995). Such pedagogy serves not only to discourage women, it also fails to empower them by not giving them tools to fight gender discrimination and prejudice that they might encounter in their education or employment (Mayberry, 2001).

On the other hand, cooperative and collaborative pedagogy appears to be a style which is much more comfortable, on the average, to women (Busch-Vishniac and Jarosz, 2003; Haller et. al., 2000; Lazarus & Nair, 1996; Ross, 1994). Positive results have been reported for women working in collaborative teams, and therefore cooperative learning has specifically been advocated as a means of retaining women in engineering (Haller et. al., 2000).

Hands-On Experience

Because “tinkering” and experimenting informally with laboratory and computer equipment is less common among women’s pre-college experiences, women often lack the familiarity and comfort-level that men have doing the kinds of activities required in an undergraduate engineering program (Margolis & Fisher, 2002; Davis & Rosser, 1996). As a result, multiple opportunities for hands-on experience, including remedial and voluntary activities, are expected to help females overcome their apprehension and lack of ease in the scientific methods (Davis & Rosser, 1996).

Female engineering students in particular tend to lose confidence and self-esteem with regard to their scientific and engineering pursuits if they are not given adequate hands-on experiences, in contrast to males, whose confidence apparently derives from a greater number of extra-curricular activities (formal and informal) in these areas (Nair and Majetich, 1995; Sonnert, 1995), as well as positive societal expectations and role models like them in the field. Hands-on opportunities help women feel more secure about their transition to the workplace and how they will apply their degree, which keeps them committed to engineering (Ross, 1994).

Holistic Approach, Contextualized Applications

The social benefits of science and technology seem to be much more important to females than to male students in similar fields (Sax, 1994; Harding, 1991). The majors women choose tend to be those whose benefit to society is apparent (see also O’Hara, 1995). Providing meaningful contexts for problem solving and applications has been suggested as a means of attracting and retaining women in engineering (Davis & Rosser, 1996). Further, investigating problems of holistic, global scope, with interdisciplinary methods, appeals to women's need for a broader context to maintain interest and motivation (Davis & Rosser, 1996; Farrell, 2002).

Women as "Other"

A lack of female role models, either among graduates, faculty, or successful fellow students, reinforces women's doubt that they belong in these fields ((AAUW, 1992; Bergvall, et. al., 1994; Davis and Rosser, 1996; Dresselhaus et. al., 1994; Ginorio, 1995; Nair and Majetich, 1995; NSF, 1994; Sonnert, 1995)). While large, impersonal settings are alienating to women in particular, apparently a "critical mass" of women aids in establishing an identification with the engineering community (Sonnert, 1995)[1]

The "otherness" of females does not stem only from numbers, however. Pedagogy which does not incorporate women's experience as an integral part of the curriculum, or which treats women as "other" either through fragmentation of presentation, omission, or segregation, runs the risk of alienating women. Henes et al (1995) claim that women in engineering have difficulty because examples in required courses often are not drawn from examples familiar to women's experience. Perception by students that engineering is a male profession results in the marginalization of women not conforming to this culture (Tonso, 1998). This marginalization may result in "stereotype threat", which may

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[1] Sax (1996) disputes the importance of this critical mass of women in a major, showing that its positive effects disappear once student characteristics, aspects of the college environment, and particular field have been controlled. She does acknowledge that within a particular field (such as engineering) the proportion of women may still have an impact on student outcomes.

affect intellectual identity and academic performance (Steele, 1997). As Widnall (2004) put it: “We must recognize that women are differentially affected by a hostile climate. Treat a male student badly and he will think you’re a jerk. Treat a female student badly and she will think you have finally discovered that she doesn’t belong in engineering.” Schlossberg (1989) posits that students who feel marginal, as if they do not matter, are less likely to persist in their studies.

Perceiving women as “other” affects not only the way the women perceive themselves, but also how their peers and faculty interact and treat them. For example, part of the “otherness” of females in the engineering culture stems from the dominant male communication patterns, which may be unfamiliar or less comfortable to females, on the one hand, and on the other, result in faculty and peers devaluing female communication patterns as different (Hall & Sandler, 1982; Davis & Rosser, 1996). Further, if a male culture is dominant, males may have an advantage in terms of communication style, familiarity with examples used in class, and any other form of interaction with faculty and peers that may come more naturally to the male majority.

Programs sensitive to this issue incorporate communications techniques and ethics into their programs, to increase the sensitivity to diversity in communications, and prepare all students with the basic communications tools necessary for a career in engineering. Women’s experiences need to be incorporated and validated in classroom discussions and laboratory exercises, so that they are seen as an integral part of the field, not a marginal concern (Rosser and Davis, 1996). Mayberry (2001) even raises a question about the effectiveness of collaborative learning when it does not challenge the dominant masculinist assumptions about knowledge and education or power relations embedded in the wider society. McIntosh (1983) and Fausto-Sterling (1991) posit a stage beyond "female-friendly sciences" as sciences reconstructed to "include us all".

Reflective Pedagogy

Because the pedagogical issues affecting the retention and commitment of women to engineering are interactive and require feedback, only by institutionalizing a process of self-reflection on the teaching and learning processes can the needs of the students, as well as the standards of professionalization, be met. Lazarus & Nair (1996) thus emphasize the need to incorporate a process of self-reflection in the pedagogical process.

CLIMATE ISSUES DIFFICULT FOR WOMEN IN TRADITIONAL ENGINEERING EDUCATION

Faculty-Student Relationships

Satisfaction and commitment to math, science and engineering are enhanced by positive faculty-student relationships. Faculty-student interaction was found to be more strongly associated with undergraduate satisfaction than any other factor having to do with characteristics of the student or institution (Astin, 1985), and in their research focusing specifically on science majors, Astin & Astin (1992) found that student orientation by faculty was a central predictor of satisfaction and commitment (for male and female science majors alike). This research reinforces findings from more general literature on student attrition from college.[2]

However, the quality of faculty-student interaction among engineers appears to be troublesome. In a nation-wide sample of institutions, faculty-student interaction in the field of engineering was found to be less favorable than in other fields of study (Astin & Astin, 1993), and faculty-student interaction was found to have some negative effects on students', and especially women's, math self-concepts (Sax, 1994). McIlwee & Robinson (1992) report that half of the women engineers they interviewed had experienced difficulties with their engineering professors, and nearly a quarter had "avoided their professors and felt intimidated by them" (p. 59). Further, women complain about a lack of appropriate advisement (Anderson, 1994) and mentoring (Brainard, 1989). Lazarus & Nair (1996) call for increased sensitivity on the part of faculty to the implications of their

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[2] "Meaningful interaction with faculty both outside and inside the classroom significantly impacts the student's decision to remain in college" (Sax et al 2000 citing Pascarella and Terenzini, 1977, 1979, 1980; Terenzini and Pascarella, 1977, 1978). See also Pascarella & Wolfle (1985), Tinto (1993), Stage (1989), Terenzini & Wright (1987b).

interactions with women students in particular, both in the classroom and in laboratory settings.

Sense of “Community”

Higher college attrition rates for women in engineering have been attributed to a “chilly climate” for women, particularly in fields in which women are a minority (such as engineering) (AAUW, 1992; Bergvall, et. al., 1994; Collins et. al., 1996; Crawford and Macleod, 1990). Again, this echoes more general findings on factors importance to student persistence, which emphasizes the importance of student “integration” through personal contacts (both peer and faculty) (e.g., Tinto, 1993). This “chilly climate” stems not only from a lack of sensitivity to women's sensibilities and needs, but a lack of integration with the engineering community, as well (Bergvall, et. al., 1994; Ginorio, 1995: Nair and Majetich, 1995; Seymour and Hewitt, 1997). This lack of satisfaction with the interpersonal climate can affect the professional persistence and success in the field even among those who graduate (Robinson and Reilly, 1993).

Studying women in engineering (but not comparing men and women), Goodman et al (2002) found that many women undergraduates

> need to feel they are part of a larger community in engineering. Community allows students to build networks and to feel that their presence in engineering is important to others. Networking can counteract the isolation that women experience—providing them with information, support, and the knowledge that they’re not alone in the challenges they face.” (p. xii)

Seymour & Hewitt (1997) found that women’s persistence in science, math and engineering was facilitated by their comfort among male peers and their bonding with other women in similar majors. This bonding apparently enables persisters in the major to seek help from many sources when it was needed. In contrast, a strongly competitive atmosphere separates students from each other and mitigates against alliance and bonding, which women in particular respond to negatively. Therefore, attrition has been found to be more common among those alienated from others in the science, math or engineering field they had been in (Goodman et. al., 2002; Seymour & Hewitt , 1997). It may reinforce women's feeling of "otherness" stemming from more formal parts of the curriculum.

ATTRIBUTES OF A FEMALE-FRIENDLY PROGRAM

To combat these issues which have been raised about traditional math, science and engineering curriculum, the following attributes have been suggested to characterize a program that is more "female-friendly" (see especially Busch-Vishniac and Jarosz, 2003; Nair and Majetich, 1995; Davis and Rosser, 1996):

- Cooperative pedagogy, with teamwork well integrated into the learning process, and decreased emphasis on individual competition and weeding out strategies
- Ample opportunities for hands-on experience at an early stage of the program, to reinforce or build skills as well as confidence
- Holistic approaches which provide broader social contexts for the applications learned, showing the societal relevance of the learning content
- Inclusiveness of experiences more common to females (or other non-white male minorities)
- Awareness of different styles of communication and their impact, and a break-down of barriers resulting from these differences

- Positive, personal faculty-student interaction both within and outside the classroom
- Strong peer bonding and sense of "community"
- Female role models

Many of the female-friendly reforms called for actually overlap with the recommendations put forth by engineering bodies for across-the-board engineering education reform. ABET guidelines for incorporating multidisciplinary teamwork, an understanding of professional and ethical responsibility in a global and national context, the need for a broad educational basis, the importance of effective communication abilities, echoed by recommendations from NSF, ASEE, and EEB, all overlap with recommendations for making engineering programs more female-friendly (see also Rosser, 2001).

THE ROWAN STUDY

With these considerations in mind, our attention was focused on the impact of the engineering program at Rowan University. Coming of age in the late 1990's, the program was designed in accordance with the latest guidelines for engineering education. Not targeting women per se, its basic hallmarks –perhaps inadvertently--directly address a number of the institutional factors cited as diminishing women's persistence in the engineering field.

The current study was designed to assess whether Rowan's institutional environment does indeed prove favorable to women's retention, self-confidence, satisfaction and commitment to engineering. The intent was to evaluate whether the program could successfully serve as a model for making mainstream engineering more inclusive, without raising the familiar objections of singling women out as a category of “others”.

The next chapter (Chapter IB) describes the Rowan program and discusses those features of it expected to make it “female-friendly”. Chapter IC describes what we did in our study; and Chapter ID describes the population of the study (Rowan students). Part II of the report presents the findings. Chapter IIA presents the analytical model we used to conceptualize the process students go through during their undergraduate years to become an engineer. The rest of Part II focuses on the components of this model which are addressed in the study. Part III provides a summary and conclusions deriving from the findings of this study.

CHAPTER I-B

THE ROWAN PROGRAM

In this chapter we describe the basic features of the Rowan engineering program, and discuss which features have led us to expect the program to be "female-friendly". Information about the engineering program was compiled from (a) written material from the Engineering College, material posted on their web page (www.rowan.edu/engineering), and papers published about features of the program[3]; (b) interviews with the founding Dean of Engineering (in office 1996-2000) and the current Dean of Engineering (in office since Summer, 2000), the Associate Dean, the Outreach Coordinator, and the part-time Assessment consultant; (c) interviews with faculty, including all department chairs (and acting chairs), four of whom had been among the formative and founding faculty, all female faculty, three of whom had been with the College from its beginning; and two other male faculty members who had been active in the formation of the program; and (d) focus group interviews with three sets of female students.

The setting for the Rowan Engineering College is a comprehensive, state-supported institution, with an enrollment of approximately 9,000 (8,000 undergraduates) whose primary mission has been undergraduate education since the 1920's. As Rowan's newest College, the engineering program accepted its first matriculated class of undergraduates in the fall of 1996. [4] Beginning with its first undergraduate class at about 80 students, it

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[3] Several papers discuss various aspects of Rowan's engineering clinic. See especially Farrell, et. al. (2001), Hesketh, et. al. (1997), Jahan et. al. (2001), Johnson et. al. (2001), Marchese et. al., (1997, 2001a, 2001b),, Schmalzel et. al. (1998)

[4] In the first few years of the program, there was also a "general" category for first year and sometimes second year students for students who had not yet decided on a specialization. This "general" category was a catch-all for students not yet committed to a

built itself up into a full-fledged four-year (and later, master's) program in engineering, with approximately 350-400 undergraduate students. There are four disciplines incorporated in the program: chemical, civil and environment, electrical and computer, and mechanical engineering, each of which has achieved ABET accreditation. All disciplines share a common core course, Engineering Clinic, which is an eight-semester multi-disciplinary sequence required of all students. The Clinics average 2-4 weekly hours every semester (out of the 16-18 hours the average engineering student takes each semester) over the four years

It is important to note that the program was developed to reflect the "best practices" in undergraduate engineering education, not with the intention of making a program suitable especially for women; rather, the intention was to make this program cutting edge for all students, and it is in this vein that the engineering faculty present the program to their peers[1]. Its newness means that the engineering program came into being at about the same time that the Accreditation Board of Engineering and Technology (ABET) was developing its 13 criteria of accreditation that would eventually become the cornerstones of EC2000; the Rowan program, initially developed by a national team of consultants, was designed to integrate all of these guidelines in the rubric of one program. It is a not unwelcome by-product that the program has incorporated features that address the concerns that have been identified as obstacles for women in engineering (outlined in the previous chapter). And it is precisely because it is a program that is developed for all students that it enables us to address the question, "Will EC2000 Make Engineering More

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particular major, but because of its amorphous nature it was more difficult for these students to be connected to faculty and other students. The disadvantages of this outweighed the benefits of not making an early decision about discipline, and therefore it was gradually phased out, finally eliminated in 2002.

Female Friendly?" (Rosser, 2001). In the following we discuss in more detail those features of the program that led us to expect it to be female-friendly.

Teamwork Emphasis

Teamwork is a central part of the core course required of every engineering major each semester of the four-year program. The teams are multi-disciplinary, representing multiple engineering specialties. In these teams, students learn in their first and second years of the program to effectively solve open-ended problems as a team and to develop and deliver reports on these projects; in their junior and senior years, the teams work on projects, many of which have corporate sponsors, and to deliver reports on their end products to the wider engineering community and corporate sponsors. Faculty emphasized in their interviews that other schools may have teamwork, but not usually on a continuous basis throughout the program: they pointed out that many schools have senior design projects that are team-based, and some have incorporated teaming into first-year programs, but Rowan's incorporation of teamwork into every year of the program prepares students for the team environment they will encounter in the contemporary engineering environment. At the end of each semester, both participants and faculty evaluate the team experience, and grades on the teamwork are given after many factors are taken into account.

Cognizant of research indicating possible damaging effects of having women or ethnic minorities being alone on a team of white males, most faculty try to set up teams, at least in the first year, which do not have only one female or one minority student. There is no overall policy regarding this, and the practice has varied from instructor to instructor and year to year. Some faculty have extended this gender- and minority-sensitive policy to sophomore year clinic as well.[5] However, students generally self-select their project teams in the junior and senior years, and both faculty and students expressed in interviews that they felt this arrangement was appropriate, as by the third year in the program the students know each other well enough to decide with whom they could work best.

Teamwork is often required outside of the required Clinic course as well. The teamwork is perceived as building camaraderie and involvement among the students, as well as preparing them for the work environments they will encounter as engineers.

Interdisciplinary Nature

The interdisciplinary nature of the clinic teams has been noted above. It is seen as a way of introducing the students to the other disciplines, so that students make informed decisions about their own specializations, as well as giving them practice communicating with specialists from other disciplines as they would in a workplace.

The interdisciplinary aspect of the program is not limited to Clinic. Faculty regularly cooperate on research projects between disciplines, and students from multiple disciplines work on these research projects. Some majors have joint required classes with other majors (for instance, a number of the Mechanical Engineering and Electrical Engineering required courses are the same).

The faculty, not only the student teams, models the interdisciplinary nature of the Clinic. The clinic itself is team taught with faculty from multiple engineering majors.

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[5] The past two years, experimentation was done in freshman and sophomore clinics forming teams using scores on the Learning Combination Inventory, without attention to gender or ethnic composition, and evaluation of this is currently underway. Since it was done after the current survey data were collected, it is not affecting the students' opinions that we analyze.

While the actual running of the classes varies by the particular faculty members involved, each faculty team has the responsibility to decide collectively on the material to be covered, the projects to include, and the procedures to follow, including how groups will be formed. Faculty may segment the course, each taking responsibility for part, or share the responsibility for each section. In the Sophomore clinic, for instance, not only do the engineering faculty come from different engineering disciplines; the course also integrates faculty from the College of Communications, who are responsible for instruction and evaluation that pertains to written and oral communication skills. At times the Sophomore clinic has been segmented, with engineering faculty teaching part of the course and communications faculty teaching another part of the course; at other times, the two types of faculty have been integrated into several lectures and assignments. Whatever the internal arrangement, all clinic faculty discuss and determine students' grades collectively at the end of the semester, with the rest of the faculty team. This set up thus models the integrative learning that only a handful of engineering schools have taken up (Busch-Vishniac and Jarosz, 2003).

Continuous "Hands-On, Minds-On" Projects

Engineering Clinic institutionalizes at least one hands-on course each semester. However, Rowan faculty like to refer to the projects in these clinic courses as "hands-on, minds-on". The curriculum of the more theoretical courses is integrated with the Clinic sequence, so that each semester students are getting a chance to apply the more abstract principles they are learning in other classes. A "just-in-time" pedagogy insures that the concepts to be applied in the Clinic projects have just been introduced in other courses, so that the material is still fresh in the students' mind (Farrell, et. al., 2002). The faculty work together to continuously create and re-create a coherent curriculum experience that incorporates hands-on experience every semester. This gives the opportunity for any student less practiced in the lab to get ample experience in the early years so that the more complicated laboratory sequences in the junior and senior years are less intimidating.

Integration of Communication Skills

As mentioned above, the focus of the sophomore clinic is on technical communications skills, which are taught by faculty from the Department of Communications in collaboration with the engineering faculty. The writing and speaking components of the general education requirements common to the rest of the University are thus incorporated in a setting unique to engineering. Students are given presentation tools (such as Power Point) as well as presentation opportunities before the general engineering faculty as well as industry representatives. This set-up addresses any disadvantage a student may have in terms of being unable to communicate in a professional style acceptable in the wider world of engineering. It also forces the students to communicate among themselves in order to get to an acceptable presentation of their team product.

Partnerships with Industry

Rowan has a special “Clinic Affiliates Program” through which industrial partners in the region provide technical issues for study and financial sponsorship for a team of engineering students, together with a company liaison and college faculty, to work on the issue and feed the results back to the industry. Students are thus exposed to “real-world” problems to work on, as well as intermingling with the corporate liaisons.

Cooperation with local industry includes sponsorship of summer internships for a high proportion of the junior and senior students, and occasionally students at lower levels. The PRIDE program (Partners with Rowan in Developing Engineers) provides scholarships and internship opportunities by local and international companies. A full-time Outreach Coordinator, who works on internship and career placement, reports that 90% - 100% of the graduates seeking engineering employment after graduation have been placed from the first three graduating classes.

Personal Faculty-Student Interaction

With a student to faculty ratio of approximately 17:1, and class sizes not exceeding 35, personal faculty-student interactions are facilitated. Faculty offices are walled in glass, most frequently with open doors. As one faculty member put it, “The biggest strength [of the Rowan engineering program] is the faculty-student interaction. It’s pretty unique in an engineering program. Not every student needs it, but it’s good to have it.” Faculty know by name each of the students in their major, and develop strong personal relations with students both in the Clinic setting and in advisory capacities, as well as in research activities and informally. The policy of accessibility to students extends well beyond the classroom, including but not limited to faculty-student soccer and basketball games, after-school dining and drinking, faculty and student participation in professional conferences, faculty advisement of student chapters of professional organizations.

Not only faculty are impressed by this relationship. In focus group interviews, students also emphasized their close relationships with faculty. Department chairs report that students, in their exit interviews (before graduation), mention the faculty-student interaction as a major strength of the program.

Strong Cohort Solidarity

Because the curriculum is tightly structured, most of the students take many of their courses together. By sophomore year, each disciplinary cohort has formed a strong bond, which often extends into other disciplines because of the interdisciplinary Clinics. In the focus groups, students reported that it often feels more like high school than what they had imagined as college, because of the strong personal ties between students. Up to now, few transfer students have entered the cohort, minimizing any break in this cohesiveness. Solidarity is facilitated by active student chapters in each of the disciplines (IEEE, the Institute of Electrical and Electronic Engineers, AiChE, American Institute of Chemical Engineers, ASME, American Society of Mechanical Engineers, ASCE, American Society of Civil Engineers, SWE (Society for Women Engineers), and most recently SAE, Society of Automotive Engineers, and NJE, the New Jersey Epsilon Honor Society).

Reflexive and Flexible Pedagogy

The engineering faculty and staff are committed to excellence in teaching and the scholarship of teaching and learning, and this distinguishes it from many traditional engineering programs. Nearly every faculty and staff member mentioned this in their interviews with the principal investigator. Many of the faculty are young, with new outlooks on engineering education, and all have been recruited expressly to further the pedagogic ideals of the new College. The number of publications discussing the pedagogy (see footnote 1 to this chapter), and a number of awards earned by faculty from the American Society of Engineering Education, suggest this is not an empty commitment, but actually reflects active engagement.

Assessment has been incorporated into the very design of the Rowan curriculum and is carried out meticulously each semester, overseen by an assessment specialist on the College staff. Careful attention is given to student feedback, and faculty reevaluate course offerings and pedagogy every semester. The voices of all students (including women's) are heard and respected.

The faculty is also flexible in terms of meeting student demands. For instance, in response to student requests, one instructor set up a voluntary evening machining class for women.[6] The class has been repeated every semester, upon popular demand.

THE FIT BETWEEN ROWAN'S PROGRAM AND "FEMALE FRIENDLY" GUIDELINES

Rowan's infrastructure addresses many of the key issues that have been flagged as problematic for women in engineering (summarized in Table IB-1). Its interdisciplinary, team-based, hands-on Engineering Clinic addresses the need for more cooperative learning and women's feelings of inadequacy with respect to hands-on and laboratory performance. Its intention to nurture each student to graduation, rather than weed out students in the first year or two, minimizes the competitive atmosphere between students and fosters a camaraderie among members of a cohort who take most of their coursework together semester after semester. Because the projects the students work on are often actual problems provided by industry, and because the students must work up

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[6] While there have been requests to open the class to men as well, the class has been limited to women to help them to become more comfortable with a part of the curriculum they felt they needed more practice in. It has been renewed for three semesters for women only.

presentations convincing to practicing engineers, including the marketing aspect, students are made aware of the societal and contextual implications of their applications. Ross (1994) suggested that when the culture of an engineering school is oriented toward industry and undergraduate education, being a woman might be less of a liability than in a program oriented strongly toward graduate education. She suggests that hands-on laboratory training, internships and co-op experiences, help women feel more secure about the transition to the workplace and possess more information about what engineers really do on the job. She laments that freshmen and sophomores have little opportunity to participate in such programs. The Rowan program incorporates such an emphasis throughout the undergraduate career.

TABLE 1B-1

FEATURES OF THE ROWAN PROGRAM AND HOW THEY ADDRESS NEEDS FOR WOMEN IN ENGINEERING

WHAT FEMALE-FRIENDLY PROGRAMS SHOULD INCLUDE	FEATURES OF THE ROWAN PROGRAM THAT ADDRESS THESE NEEDS
▪ Cooperative pedagogy	▪ Teamwork built in to Engineering Clinic each semester; lack of "weed-out" competition on individual level
▪ Adequate opportunities for hands-on experience	▪ Hands-on project integrated with classroom learning every semester
▪ Attention to contextual and social implications and applications	▪ Real-world projects sponsored by industry; marketing presentations developed in Clinic
▪ Broader context, interconnections	▪ Interdisciplinary teamwork, classwork, faculty cooperation
▪ Inclusive communication patterns	▪ Communication skills incorporated in Sophomore Engineering Clinic
▪ Internship, employment opportunities facilitated	▪ Partnerships with industry
▪ Reflexive teaching and pedagogy	▪ Faculty commitment to undergraduate education, and scholarship of teaching and learning
▪ Personal faculty-student relationships	▪ 17:1 student-faculty ratio; accessible faculty
▪ Women's concerns can be heard	▪ Flexibility, feedback
▪ Sense of "community"	▪ Strong cohort develops through common core curriculum
▪ Adequate female role models	▪ >20% faculty female, female Dean

In addition to these features, Rowan has more than the expected share of female role models in the Engineering College. More than 20% of the faculty is female – higher than the national average (see, for example, Farrell, 2002; Young, 2004), and the current Dean is female. There has been at least one female department chair. Further, many of the students who receive awards or make the Dean's list are female. Female students make up a disproportionate percentage of the officers of the student chapters of professional organizations. In addition, there is an active SWE (Society for Women Engineers) chapter on campus, which sponsors speakers several times during the academic year, field trips, participation in regional and national conferences, and service projects.

Designed for all students, the Rowan program appears to have reached McIntosh's (1983) Stage IV, "science reconstructed to include us all", at least on face value. The question we address is whether it works. Is reconstructing the infrastructure enough to make women feel like they belong in the field as much as men do? This is the focus of this study and the rest of this report.

CHAPTER I-C

THE POWRE STUDY

To assess the experience of female engineering students in the Rowan undergraduate program, to determine the impact of the features of the Rowan program on them, and to explore the differential impact of the program on males and females, surveys were conducted, focus group interviews given, and objective data collected for each student. Interviews with faculty and administration and printed information from the College of Engineering provided greater insight into the nature of the program and the educational climate.

Surveys

All Rowan students were surveyed for the study. The first full set of surveys was administered toward the beginning of the Fall of 2000; the second full set of surveys toward the end of Spring, 2001. The beginning of the year survey gathered background data on family background and support, pre-college preparation both formal and extra-curricular, self-assessments of strengths and weaknesses, and learning style preferences to be used as control variables in the analysis of gender differences. It also queried 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. The end of the year survey repeated most of the questions about self-confidence in engineering related skills, satisfaction with engineering as a major and a career, perceptions of difficulties for women in engineering, and future plans and commitment to engineering. Students were asked about their involvement in extra-curricular activities during the course of the academic year and their satisfaction with many aspects of the program they had experienced during the year. Each questionnaire had close to 150 variables for analysis. A summary of the topics asked at each time of survey can be found in Table IC-1. All questionnaires used can be found in Appendix A.

Questionnaires were developed after studying previous survey instruments. Those most comparable to the survey instrument developed include: the WECE questionnaire (especially for extra-curricular activities and support of significant others), the WEPAN questionnaire (especially for perception of the interpersonal climate and learning environment), the Pittsburgh Survey (especially on evaluation of the program at the end of the Spring semester), the Pathways survey (including perceptions of problems for women in math, science and engineering; high school background questions; and attribution of academic success or failure). Where available, comparisons are included between the Rowan survey and other survey results for comparable questions.

TABLE IC-1
SURVEY TOPICS INCLUDED BY SEMESTER OF SURVEY

TOPIC Semester of Survey:	Fall 00	Spring 01
Background		
Demographic information (age, sex, family status, race/ethnicity, parents'/siblings' education, occupation)	√	Partial
High school background (math/science classes and extra-curricular activities, SAT scores)	√	
Evaluation of adequacy of high school preparation		√
Support for engineering pursuit from significant others and high school staff	√	√
University Experience		
Major	√	√
Year	√	√
Living arrangements	√	√
Participation in student organizations and activities (non-engineering)		√
Work experience	√	√
Academic Performance (Overall GPA and engineering GPA	√	√
Engineering-Related Experience and Attitudes		
Participation in extra-curricular engineering-related activities		√
Preference for group/individual learning	√	√
Attribution of academic success/failure	√	√
Engineering self-confidence		√
Satisfaction with major		√
Satisfaction with specific elements of program		√
Contact with faculty outside of class (including research)		√
Satisfaction with student-faculty relationships		√
Satisfaction with peer relationships		√
Perception of problems in field for women/men	√	√
Commitment to engineering	√	√
Job expectations		√
Future Plans		
Highest degree expected	√	√
Financial concerns about university education	√	√
Plans for pursuing engineering employment in future		√
Preparations for post-graduation (for seniors)		√

Additional Information from University Sources

Additional information from university records was added to student's data for those students consenting to link their survey information up to school records (see consent letter in Appendix A).[7] This information included: GPA's and whether the student made the Dean's List, from university records, results from the College of Engineering survey of computer background of incoming freshmen in the Fall of 2000 and participants in summer internships arranged by the College. Retention data collected by the Institutional Research office provided additional insight.

Focus Group Interviews

In order to better understand the meaning of the survey questionnaires, particularly for the women's experience of the engineering program, four focus groups with a total of 19 female students were run. Another faculty member with experience joined the principal investigator to conduct these. The first three groups spanned a cross-section of majors and years. Students were asked about how they got into engineering and when they decided upon the major, how being female had affected their experiences at Rowan, whether they or other students they knew had felt any advantages or disadvantages due to their gender, how confident they felt about themselves in engineering, how they thought their future as an engineer would be affected by their gender, whether they would encourage other women to major in engineering, and what they would recommend to change at Rowan to improve the experience of female engineering students – or students in general. (The interview questions can be seen in Appendix A.) The last focus group was for senior women only, to probe how they felt as

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[7] IRB approval was granted for the study in September, 2000.

the program neared its end, what were the most challenging and most rewarding aspects of the program for them, whether they would recommend other women to major in engineering, how they felt about their post-graduation plans, what concerns they had and how they thought those concerns were being or could be better addressed at Rowan.

Faculty and Staff Interviews

Interviews were conducted with all female faculty, all department chairs (and acting chairs), the Dean of Engineering, the Associate Dean of Engineering, and faculty members who helped found the program and had seen it evolve from its inception. A total of 15 faculty and staff were interviewed, each interview lasting at least one hour. The Associate Dean provided guidance throughout the study and was the major contact for the faculty, arranging protocol for the survey, supplying written information, and answering numerous questions about the program and the students.

Faculty were asked what they saw as the major strengths and special features of the program, how they had seen the program change (in ways which might be affecting the different cohorts), what gender differences they perceived, whether there were any gender issues among the faculty, and how they saw the program evolving in the future. (The interview questions can be seen in Appendix A.) In addition, the principal investigator met with several of the engineering departments to explain the study in depth and enlist their cooperation.

Printed Information

Written material provided by the College of Engineering and posted on their website added to the understanding of the special features of the program. Papers published on the program were also helpful. References to the program are available through the website: http://www.rowan.edu/engineering.

CHAPTER I-D

THE ROWAN ENGINEERING STUDENT POPULATION

This chapter describes the Rowan engineering student population. The students can be seen as the "raw material" entering the Rowan engineering program, and understanding their characteristics sets the stage for understanding initial gender differences and the role of Rowan in addressing these gender differences. We can also get a sense of the extent to which Rowan students are unique or representative of the broader population of engineering students. We begin by describing the study population in terms of gender, year in school, and engineering major. We follow with a description of the students' academic background and family background data gathered in the Fall, 2000 survey.

THE POPULATION OF THE SURVEY

During Fall, 2000 and Spring, 2001, 352 students were surveyed for this study. As some were surveyed in the Fall but not the Spring, and some were surveyed in the Spring but not the Fall, a total of 283 repeated the survey in Fall and Spring[8]. A breakdown of the students surveyed by year in school is presented in Table ID-1. The percentage in parentheses indicates the percentage of students completing the survey out of the total who were actually enrolled in this category in the Fall of 2000.

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[8] For those students who were surveyed for the first time in the Spring, some demographic and background information was collected which could be used for analysis even though not all of the Fall questionnaire was repeated.

TABLE ID-1

SURVEY SAMPLE BY SEMESTER, YEAR IN PROGRAM, AND SEX
(Response rate out of total enrolled in parentheses)

	Semester of Survey		
Year in Program	**Fall 2000**	**Spring 2001**	**Completed Both Surveys**
First-year	102 (84%)[a]	85	83
Sophomore	99 (84%)	91	84
Junior	82 (100%)	62	60
Senior	49 (80%)	65	59
Total	332 (86%)	303	283

[a] Number in parenthesis indicates percentage out of total enrolled in this cell at time of survey.

Questionnaires were distributed in required classes, thus ensuring a high response rate (average of 86%). However, some students were absent and could not be reached within a reasonable amount of time to complete the survey. An effort was made to track the missing students (through email and phone contact) to give them the survey at a special time within the next two weeks. Some of the students were not enrolled in required classes and thus missed the survey; some were not enrolled in any engineering classes and in fact were only formally still enrolled in the major; some were ill or had taken a leave of absence. All in all, this is a more complete cross-section of students than many of the recent surveys conducted in engineering schools (for instance, Thorsen et. al. report response rates of under 20% for their 1997 engineering student survey and for their 1993 senior engineering women survey. Cunningham et. al. (2002) report a higher response rate of 66% from their web-based survey, but only women are included in their study).

The rest of this chapter is based on responses to the Fall survey, when the demographic information was collected.

GENERAL CHARACTERISTICS OF THE ENGINEERING STUDENTS

Gender

Twenty percent of the engineering students answering the survey were female, quite comparable to the national average of 19.7% in undergraduate engineering at the time (NSF, 2000) (Table ID-2)[9].

TABLE ID-2
YEAR IN PROGRAM BY GENDER
(%'s)

	Male	Female	Total (n)
First year	79.4	20.8	100.0 (102)
Sophomore	79.0	21.0	100.0 (99)
Junior	83.1	16.9	100.0 (82)
Senior	75.4	24.6	100.0 (49)
Total	79.4	20.6	100.0
(Total n)	(281)	(71)	(352)[a]

[a] Includes data on students who were added in the Spring.

Year in School

There are somewhat more students in the first and second years of the program than in the junior and senior years. The main reason for this is that the majority of students who switch out of engineering do so after the first and second years. According to

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[9] These percentages are a little higher than the actual proportion of women in the engineering cohorts, because a greater effort was made to include all female students, since they were relatively few in number. Therefore the female students are slightly more represented in the survey than the male students.

institutional data,[10] an average of 19.7% switched out of engineering after the first year for the years 1996-2001; another 9.7% switched out after the second year for the years 1996-2000; and only 3.8% and 2.1% switched out during the junior and senior years, respectively. As a result, the junior and senior classes are somewhat smaller than the freshman and sophomore classes, in each cohort. Also, the 1997 cohort (seniors at the time of the survey) was smaller to begin with (n=77) than the 1998, 1999 and 2000 cohorts (beginning with 107, 115 and 117 respectively); on the other hand, few students transfer into the program. As we will show below, at any given level, surprisingly fewer women have switched out of engineering than males: totaling the cohorts from 1996-2001, 31.4% of the males who started out in engineering switched out, compared to 25% of the females who started out in engineering. This contributes to a slightly higher proportion of females in the senior cohort than in earlier years.

Major

The Rowan program has four major areas of study: chemical engineering, civil and environmental engineering, electrical and computer engineering, and mechanical engineering.[11] About a third of the students are electrical/computing engineering majors, a quarter mechanical engineering majors, a fifth of the students are chemical engineering majors, and a fifth civil and environmental engineering majors (Table 1D-3). The general major was only available for first-year students who had not decided on their major yet.

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[10] Made available to the principal investigator by Institutional Research at Rowan.

[11] The environmental emphasis was added to the civil engineering major two years after the program started, and the computer engineering emphasis was added to the electrical engineering major three years after the program started. (Adding these emphases allowed for more specialization within the major and was made possible by additional faculty and curriculum development.) For the first four years of the program, students were allowed to enter as "general" engineering majors and guided to select one of the other four majors during their sophomore year and preferably before its start. However, this general major was being phased out in the academic year 2001-2 and completely eliminated beginning Fall 2002.

TABLE ID-3
COHORT BY MAJOR
(%'s)

	Major					
Year in Program	**Chemical**	**Civil/ Environmental**	**Electrical/ Computing**	**Mechanical**	**General**	**Total % (n)**
First-year	14.2	17.9	18.9	25.5	23.6	100.0 (106)
Sophomores	21.9	21.9	32.4	23.8	na	100.0 (105)
Juniors	10.8	26.5	37.3	25.3	na	100.0 (83)
Seniors	24.0	13.8	24.1	37.9	na	100.0 (58)
Total	17.3	20.5	28.1	27.0	7.1	100.0 (352)[a]
Enrollment in major, national average, 2000[c]	*6.8*	*9.4*[b]	*36.1*	*16.9*		
B.A. degrees awarded nationally, 2000[d]	*10.4*	*16.1*[b]	*29.6*[e]	*22.0*		

[a] Includes data on students who were added in the Spring.

[b] Civil only (no data available on environmental engineering majors separated from "others").

[c] Source: CPST data from the Engineering Workforce Commission (posted on www.wepan.org).

[d] Source: National Science Foundation, Division of Science Resources Statistics (NSF, 2002).

[e] Does not include computing engineering.

The distribution across majors varies somewhat by cohort. The proportion of electrical engineering majors varies from 18.9% in the freshman 2000 cohort to 37.3% in the junior cohort; the proportion of mechanical engineering majors varies from 23.8% in the senior cohort to 36.1% in the junior cohort; the proportion of chemical engineering majors varies from 10.8% in the junior cohort to 24.0% among seniors; the proportion of civil/environmental majors varies from 13.8 among seniors cohort to 26.5% among juniors. These fluctuations result from students' choices without any formal enrollment management (because of these wide fluctuations, among other considerations, an enrollment management system was introduced beginning in Fall 2002, in order to achieve a more predictable and even balance between majors).

About 70% of the nation's engineering majors are in the four disciplines that Rowan offers[12] (CPST data via wepan.org website), and about 78% of the B.A. degrees were awarded to these four disciplines in 2000 (NSF, 2002:Table 26), which makes Rowan's engineering students quite similar to the majority of engineering students nationwide in terms of major. Rowan has a disproportionate amount of chemical, civil, and mechanical engineers, compared to the national average; and about the same or in some cohorts less than the national average in electrical/computing engineering.

Female students seem to prefer some majors to others. Since students' majors were a result of their own choice at this point in Rowan's enrollment, it is fair to assume that their distribution across majors reflects their own preferences rather than channeling by the school officials. Most of the female students are in chemical and civil/environmental engineering; fewer are in mechanical engineering and they make up even fewer (less than 10%) of the electrical/computing engineering majors (Table ID-4). The actual proportion of female students varies from cohort to cohort, but the general pattern is similar.

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[12] Plus those in environmental engineering, who were not separated out in the CPST data. These figures correspond very closely to the distribution of majors in the national sample used by Astin & Astin (1993). The other major discipline, which Rowan does not have, is aeronautical engineering.

TABLE 1D-4
PERCENTAGE FEMALE IN MAJOR BY YEAR IN SCHOOL

	Major					
Year in Program	Chemical	Civil/ Environmental	Electrical/Computing	Mechanical	General	Total (n)
First-year	26.7	42.1	5.0	18.5	17.5	20.8 (106)
Sophomores	39.1	26.1	11.8	12.0	na	21.0 (105)
Juniors	22.2	40.9	3.2	9.5	na	16.9 (83)
Seniors	42.9	45.4	0	18.2	na	24.6 (61)
Total	34.4	36.1	6.1	14.7	17.5	20.2 (352)[a]
National average[a]	*36.3*	*22.9*[b]	*15.1*	*12.4*	*na*	*19.5*

[a] Includes data from students added in Spring.

[b] Calculated from CPST Engineering Workforce Commission data on Engineering and Technical Enrollments, Fall 1990-2000 (WEPAN website www.wepan.org)

[c] Civil engineering only; statistics for environmental engineering were not available

While it fluctuates from year to year, compared to the national average of proportion female in engineering majors, Rowan's average proportions of females in chemical and mechanical engineering are similar to the national averages, the proportion of female students in civil and environmental engineering is higher than the national average (although it should be remembered that the national statistics were for civil engineering only); but Rowan has a lower proportion of females than the national average in electrical and computer engineering. These majors account for 63% of the majors of female students in engineering nationwide (CPST, 2000), and 85% of the bachelor's degrees awarded to female engineers in 2000 (NSF, 2002), which suggests an overall similarity between Rowan and female engineering students nationwide.

Because of the small numbers of women in some of the majors at Rowan, most of our analysis is not able to differentiate between the different disciplines, although we recognize that there may variation across majors on many of our indicators.

Age

In a number of ways, the Rowan engineering students are quite homogeneous, and therefore variation in these characteristics could not be studied. For example, nearly 97% of the Rowan engineering students are of “traditional” college age between the ages of 17 and 25. Less than 2% are over 30, and another 1.6% are between the ages of 25-29. There were virtually no significant gender differences in the age breakdown. Because of the small numbers of “non-traditional” students, the impact of age was not pursued in the analysis. Similarly, most (96%) of the Rowan engineering students are single, and less than 3% are currently married. Again, small numbers precluded pursuing any analysis of the impact of marital status on their undergraduate educational experience.

Race and Ethnicity

Nearly 90% (89%) of the Rowan engineering students are Caucasian, 5.6% Asian-American or of foreign nationality, and only 5.4% (n=23) are non-Asian minority (African-American, Hispanic, and Native American). When the minority students were divided by gender, there were less than 10 non-Caucasian female students. Therefore, this small number precluded any reliable analysis of minority status as it interacted with the engineering experience.

ACADEMIC BACKGROUND

In this section we present the academic background of the engineering students at Rowan. This is important in order to understand the type of students at Rowan, and also in order to determine the extent to which any gender differences in engineering outcomes might be traced to different preparation before college.

Academic Achievement

The level of academic achievement of students entering the Rowan engineering program compares quite favorably with other institutions in the Mid-Atlantic region (Table ID-5a). About two-thirds of the entering cohort of 2002 were in the top quarter of their high school class. Although there are more selective institutions in the area with regards to this criteria, the SAT ranges of the Rowan students are higher than the other public engineering institutions in the area for which data was available (NJIT, Pennsylvania State, College of New Jersey, University of Delaware). The more elite institutions of engineering, such as Rose-Hulman, Cooper Union, and Princeton, do not have as broad a range of students as Rowan does.

The level of the Rowan engineering students, as indicated by the average SAT scores, is considerably higher than the national average (Table 1D-5). Over 90% of both the male and female students had math SAT scores of 650 or higher, making them quite comparable to Seymour & Hewitt's (1997) sample of students whom science, math and engineering faculty "expected to be capable of handling the course work", with a minimum math SAT score of 650. In the national WECE sample of women (Women's Experiences in College Engineering; Goodman et. al. 2002:43), the average math SAT score ranged from 650-699 (a little higher than the average for Rowan engineering women), and the average verbal SAT score ranged from 600-649 (also a little higher that of the Rowan engineering women).

TABLE ID-5
NEWLY ENROLLED STUDENT CHARACTERISTICS OF VARIOUS UNDERGRADUATE ENGINEERING PROGRAMS, 2002*

College or University	**Math SAT range**	**Verbal SAT range**	**Total SAT range**	**% top 25% high school class**
Monmouth University	560-610	510-570	1100-1180	38%
Widener University	500-670	380-640	880-1310	41%
Drexel University	580-680	530-630	1120-1300	61%
New Jersey Institute of Technology	560-670	480-600	1060-1250	62%
Pennsylvania State University	Hi 659	Hi 591	Hi 1250	na
Rowan University	**550-790**	**430-750**	**1050-1450**	**64%**
LeHigh University	Hi 692	Hi 620	Hi 1312	73%
College of New Jersey	410-630	350-550	760-1180	89%
University of Delaware	Hi 663	Hi 601	Hi 1264	87%
Renssaleur Polytechnic Institute	580-680	640-720	1220-1400	91%
University of Pennsylvania	na	na	na	95%
Old Dominion University	550-740	530-650	1080-1370	na
Rose-Hulman Institute of Technology	640-720	570-670	1220-1390	96%
Cooper Union	700-800	620-800	1320-1600	100%
Princeton University	600-800	550-800	1150-1600	100%

*ASEE Survey of Engineering and Engineering Technology Colleges, 2002 (www.asee.org/publications/colleges/default.cfm)

In terms of high school achievement, Rowan females were more likely to report that they received A's in their high school science classes than were males, while males had somewhat higher math SAT scores (Table ID-6). There are no significant gender differences in verbal SAT scores; or in grades in high school math classes.

TABLE ID-6
PRE-COLLEGE ACADEMIC ACHIEVEMENT BY GENDER

(Rowan Engineering students and National NCES data)

Indicator of Academic Achievement	**Males**	**Females**
% "Mostly A's" in high school science classes (Rowan)	44.4	50.0
% "Mostly A's" in high school math classes*(Rowan)	51.9	68.2
Mean score on Verbal SAT (Rowan)	584	585
Mean score on Math SAT** (Rowan)	653	635
Mean score on SAT (Rowan total)	1237	1220
National Mean total SAT scores of "engineering path students" "completers" 1982-1993[a]	1092	1112

[a] NCES, High School & Beyond (Adelman, 1998:Table 19). "Engineering path students" have taken a minimum number of engineering courses to be considered in the major; "completers" finished their degree in engineering.

*Chi-square significant at p<.10

**T-test significant at p<.05

Type of High School

Three-quarters of the Rowan engineering students have an urban or suburban background, and even among those who were brought up in rural areas, many went to urban or suburban high schools – a total of 83% of the Rowan engineering students. Most (97%) of the students went to co-ed high schools, and 86% came from public high schools. The lack of variation in this respect precluded further analysis of the effect of type of high school background in the rest of the analysis.

High School Science and Math Background

Students were asked how many semesters of various high school math and science classes they had had. Albeit this is a rather crude measure of high school math and science background, but it is an indication of the extent of training. In terms of physics, chemistry, biology, earth sciences, environmental science, and engineering classes, the gender differences were not statistically significant. Males and females were also equally likely to have had lab experience in high school (Table ID-7). However, males did have more semesters of computer science than the females on the average.

On the average, the female students had participated in more extra-curricular science activities during high school than did male students (Table ID-7). In fact, when we looked at each type of extra-curricular activity individually (including summer programs, contests, after-school or weekend programs, and more), more females had participated in each kind of activity during the high school years than had males.

TABLE ID-7
MATH AND SCIENCE PRE-COLLEGE BACKGROUND BY SEX

Gender / Pre-College Characteristic	Males	Females
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)

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

Therefore, in terms of academic preparation, the main disadvantage the female students have is fewer computer science courses before college, while their main advantages are in terms of extra curricular activities.

FAMILY BACKGROUND

Parents' Education

One of the factors influencing students' persistence in undergraduate education is parent's education. First-generation college students are at greater risk of encountering difficulties adapting to college culture and requirements and have lower academic self-confidence (Peterman, 2000; Terenzini, et. al., 1996; Van T. Bui, 2002; Zwerling &

London, 1992). Almost a third of the parents of the Rowan engineering students had high school educations or less, making these students “first generation” college students. Another 21% had parents who did not complete an undergraduate degree. About half of the parents had undergraduate or graduate college degrees. As Table ID-8 shows, Rowan engineering students’ parents are somewhat more highly educated than the average postsecondary student (surveyed in the 2000 National Postsecondary Student Aid Study).

In national data (NPSAS:2000), parents of male postsecondary students are somewhat more educated than parents of female students. Among the Rowan engineering students, however, fathers of female and male students had similar levels of education, and the mothers of female students were more likely to have completed a college degree than were the mothers of male students (Table ID-8). Thus, the Rowan female student are not disadvantaged in terms of their parents as role models for education or in terms of the socio-economic resources parents’ education indicates. It seems that more educated mothers might be more likely to encourage their daughters to attend engineering schools.

TABLE ID-8
PARENTS' EDUCATION BY STUDENT'S SEX
(%'s)

	Rowan Students						**National Sample**		
	Father's Education			**Mother's Education**			**Education of either parent (NPSAS:2000)***		
Gender of Student	Males	Females	Total	Males	Females	Total	Total	Males	Females
High school education or less	26.2	27.2	26.5	33.1	23.1	31.1	37.1	34.6	39.0
Some post-secondary education	21.5	16.7	20.5	21.7	18.5	21.1	22.8	21.2	24.1
Undergraduate college degree	33.6	34.8	33.8	31.9	36.9	32.9	40.1	44.2	37.0
Graduate or professional degree	17.7	19.7	18.1	13.3	21.4	15.0			
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
(n)	(265)	(66)	(331)	(263)	(65)	(328)			

*Source: U.S. Department of Education, National Center for Education Statistics, 1999-2000 National Postsecondary Student Aid Study (NPSAS:2000) (http://nces.ed.gov/surveys/npsas/table_library/tables/npsas39.asp)

Parents' Occupations

Parents' occupations add to the socio-economic resources supporting a student, as well as give an indication of occupational role models the parents provide. In terms of occupation, the Rowan students' parents are disproportionately managerial and professional compared to the wider U.S. population, and underrepresented in terms of service and blue-collar occupations (Table ID-9) – as are college students' parents nation-wide (CPS, 2000). Fathers of Rowan engineering students are more likely to be in managerial/administrative positions and blue-collar jobs than are mothers; their mothers are disproportionately educators and clerical workers.

Parental occupations of male students are quite similar to those of female students. Female students are slightly more likely to have fathers in engineering, and slightly less likely to have fathers in managerial or administrative positions, than are male students (Table ID-9).

TABLE ID-9
PARENTAL OCCUPATIONS OF MALE AND FEMALE ENGINEERING STUDENTS

(%'s)

	Fathers			**Mothers**		
Gender of Student **Occupational Group of Parent**	**Total**	**Males**	**Females**	**Total**	**Males**	**Females**
Managerial/administrative	21.8	21.8	22.0	8.9	10.0	3.8
Professional	27.1	28.6	27.1	42.9	42.9	45.3
Engineering	8.9	7.4	14.8	0	0	0
Other science, math, computer science	5.0	5.0	4.9	1.9	2.3	0
Education	5.6	5.4	6.6	25.7	25.2	27.3
Technicians/related support	.3	.4	0	2.6	3.3	0
Clerical/administrative support	1.0	1.3	0	26.4	25.7	28.2
Service	5.9	6.3	5.1	5.6	5.7	5.7
Sales	9.9	9.7	10.2	9.3	9.5	9.4
Blue-collar	32.1	31.9	35.6	4.1	2.9	7.5
Precision production/craft	23.4	23.1	24.6	.4	0	1.8
Operators & laborers	8.9	8.7	9.8	3.7	2.3	5.7
Total %*	100.0	100.0	100.0	100.0	100.0	100.0
(n)	(303)	(303)	(303)	(269)	(269)	(269)

*Rounded off. May not total 100.0 due to "other" (e.g. military, farming) among the employed.

We coded the occupations of the students' parents with the latest national survey of prestige scores available in the United States, the standardized prestige scores obtained in the 1989 NORC survey (updated for census categories of 1990) (Nakao & Treas, 1994). There are no gender differences in the mean prestige scores of mothers and fathers (Table ID-10), indicating that the male and female students come from similar social classes.

TABLE ID-10
MEAN PRESTIGE SCORES* FOR OCCUPATIONS OF MOTHERS AND FATHERS, BY GENDER OF STUDENT

	Father's prestige score**	**Mother's prestige score****
Male students (n)	52.8 (237)	52.2 (211)
Female students (n)	52.7 (59)	50.6 (53)
Total (n)	52.8(296)	51.9(264)

* Using the prestige scores measured by Nakao & Treas (1994) and adapted to the 1990 Census categories by Hauser & Warren (1996).
** Based on occupations reported by the students. Students were instructed to give the parent's last occupation if the parent was currently unemployed, retired or deceased.

Role Models

The importance of role models in the field is related to two phenomena: acquaintance with the field and its practices and requirements (knowing what to expect); and an identification that someone like the student can succeed in the field. Role models may also provide needed advice or mentoring from someone that the student can identify with. The concept has come to the fore as a factor weakening women's persistence in the fields of math, science and engineering, where female role models have been scarcer and fewer females have relatives or teachers with whom to identify personally. According to previous research, female students' commitment to engineering is enhanced by having role models in the family, i.e., parents, siblings, or other relatives in engineering or another math or science field (Cunningham et. al., 2002; Seymour & Hewitt, 1997).

We looked at two types of role models: educational role models (parents or siblings who had been to college) and occupational role models (parents or siblings in the fields of engineering or related math and science fields).

As we have mentioned above, about half of the students had educational role models in their parents, who had completed college degrees. A higher proportion of the mothers of female students had completed college degrees than of male students, but there was no gender difference with regard to father's education. More of the siblings of male students were or had been in college (58.9% compared to 49.4% of the female students). Perhaps these balanced out, with females having stronger educational role models in their mothers, and males having stronger educational role models in their siblings.[13]

Most of the students' mothers worked. Nearly 85% of the female students' mothers were working at the time of the survey, and 95% of the mothers were employed at least part time while the student was in high school. Therefore, most of the females had role models of mothers working in the labor force (and the number who did not was too small to pursue analysis).

Less than 10% of the students' fathers and none of the students' mothers were engineers. However, it is interesting that a slightly higher percentage of female students' fathers were engineers (14.8%) than were male students' fathers (7.4%). Another 5% of both males' and females' fathers were in another math, science, or computing field; but only 2% of the mothers were, all of them of male students. About 24% of the students' brothers were in engineering or another math or science field, and about 18% of the students' sisters. The male students were slightly more likely to have brothers in these fields (24.6% vs. 20.4% of the females); the female students were slightly more likely to have sisters in these fields (23.2% vs. 16.2% of the males). In the focus groups, many of

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[13] Although Duggan (2001) found that sibling's educational level did not have a statistically significant effect on undergraduate retention.

the female students indicated that an uncle, aunt or close friend of the family was in engineering, and encouraged them to go into the field.

One of the well-known aspects of having fewer female role models in math and science is that a smaller proportion of high school math and science teachers are female than male. Therefore the students were asked whether they had had any female math or science teachers in high school. Perhaps it is a sign of the times, or a result of a population that had already selected engineering as a field of pursuit, that over 95% of both males and females had at least one female math or science teacher in high school (less than 2% of the female students had not). Therefore, this did not seem to be an important variable to pursue.

Thus, in terms of role models for education, female students have somewhat of an advantage in terms of mother's education. In terms of occupational role models, differences were relatively small, and focus group interviews suggested that females look beyond their immediate family for significant role models in the field.

Support for Engineering

Students were asked about the extent of support they received for their pursuit of engineering by family members, friends, and high school faculty and staff. Both male and female students said that they had strong support for their engineering pursuits on the part of mothers, fathers, friends, high school teachers and counselors (Table ID-11). There were practically no gender differences in this. The only statistically significant gender difference was that mothers of female students were somewhat less positive than mothers of male students (86.2% of the female students' mothers had “positive" opinions of their being in engineering, compared to 92.0% of the male students' mothers).

All of the support items were recoded into dichotomies, and summed, to form a composite index of support. On this measure there was no gender difference.

TABLE ID-11
SUPPORT FOR ENGINEERING PURSUIT

(% positive opinions about the student pursuing engineering major or career)

	Males	Females
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
Mean score on support index	6.58	6.61
(n)	(266)	(66)

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

In an attempt to understand whether some types of students had more support than others, we analyzed a multiple regression model with the support index as the dependent variable and the independent variables were gender (to see whether males had more support when other background differences were controlled), high school grades in math and sciences, SAT scores (expecting that students with higher achievement would receive more support for their pursuit of engineering), family members as role models (father, mothers or siblings in the field of science or math), father’s and mother’s education, and father’s and mother’s prestige scores (to see if social status was related to support). The model explained about 5% of the variance, and none of the independent variables had a statistically significant relationship with support. Thus, background variables, gender and year in school do not account for the variation in support for the pursuit of engineering.

CONCLUSIONS

There were two purposes to this chapter. The first was to provide a description of the Rowan engineering students who form the population of this study, and to allow others to assess how comparable this population is to theirs.

The second was to determine whether there were any significant gender differences that might serve at least as partial explanations for any gender differences in engineering outcomes that we find in the study. In light of previous literature, this was particularly interesting because while earlier research would lead us to expect a gender gap in pre-college preparation, family support for the pursuit of engineering, and same-sex role models (e.g., AAUW, 1992; Blaisdell, 1998; Cunningham et. al., 2000; Kahle and Meece, 1994; Kramarae and Treichler, 1990; Layzer, 1992; Leder and Fennema, 1990; Tobias, 1990), later research has shown parity at least in terms of high school math and science achievement (NCES, 2003), especially among women and men who actually go into math, science or engineering majors (Hoffer, 1995).

In terms of gender differences in background variables, the most important conclusion is that the female students are not weaker in terms of high school math and science background or achievement. In fact, they had higher grades in math and science than did males, participated in more extra-curricular activities for math and science than did their male counterparts; however, they were somewhat less likely to have computer science courses and had lower math SAT scores. In terms of family background, females' mothers had somewhat higher education, and more of their fathers were engineers; however, more of the males' siblings were in engineering or a related math or science field. Males and females shared relatively strong support from significant others for their pursuit of engineering.

The background differences, therefore, are quite minimal, and suggest an equal footing for males and females as they enter Rowan, unlike expectations from previous research.