

On the Recruitment of Female Students to the Systems Engineering Department at the U.S. Naval Academy

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Abstract

The Systems Engineering Department at the U.S. Naval Academy is seeking to increase the number of female students enrolled in the major. Currently, female students comprise 7% of the 336 Systems Engineering majors as compared to 19% of engineering students nationally. This distribution is not surprising within the unique environment of a military service academy because women comprise only 15% of the total student body. Given the high caliber of the student body, it is believed that a number of female students who possess the ability to succeed do not choose an engineering major. The authors seek to identify the reasons capable female students are not choosing the Systems Engineering major. Enrollment numbers from the Naval Academy and its peer military and civilian institutions are compiled to quantify the under representation of female students in Systems Engineering and engineering in general. This paper proposes several recruitment strategies for use at the U.S. Naval Academy and peer institutions. These strategies are based on the results of a discussion session with the junior and senior female Systems Engineering majors and the unique factors that affect the students in choosing a major at the Naval Academy. The authors conclude that effective recruitment methods should provide positive role models for prospective female engineers, but that these recruitment efforts should avoid obvious reference to gender.

1 INTRODUCTION

In the recent *Land of Plenty* report of the Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development [1], the commission concluded that America needs to cultivate more diversity among students and professionals in science, engineering, and technology to maintain a competitive edge in these fields. At the collegiate level, there are a number of female students who possess the ability to succeed in engineering but do not choose an engineering major. The goal of this paper is to assess the current state of gender diversity within the Systems Engineering department at the United States Naval Academy (USNA) and develop appropriate recruitment strategies.

An important first step in assessing gender diversity within a department is an understanding of the campus climate. All Naval Academy students, men and women, are called midshipmen, which is a rank between chief warrant officer and ensign in the Navy. A midshipman first class is a senior, second class a junior, third class (youngster) a sophomore, and fourth class (plebe) a

freshman. The student body is the Brigade of Midshipmen, or simply the Brigade. The Brigade is divided into six battalions and each battalion is divided into five companies. The midshipmen command structure, headed by a first class midshipman designated Brigade Commander, is responsible for much of the Brigade's day-to-day activities as well as the professional training of midshipmen. The living arrangements at the Academy are quite different from the typical college or university. Midshipmen stand watches, march to meals and wear uniforms for almost every activity. All midshipmen live in Bancroft Hall, a huge dormitory complex. Women first joined the Brigade during the summer of 1976 ending a 131-year all-male tradition and, currently, comprise 15% of the Brigade.

The Brigade of midshipmen is predominantly male. Therefore, female midshipmen constitute a token subgroup as described by Kanter [2]. According to Kanter, token groups within a dominant social group are subject to higher visibility. They tend to capture more attention because both observers and members of the social group are more aware of their presence. Not only do token groups capture more attention, but observers and members are more aware of the distinctions between the two groups. This is true regardless of the make-up of the token and dominant subgroups (the distinction could be gender, race, or ethnicity). Additional attention or distinction can be unwelcome to a group that is already in the spotlight. In the book *First Class*, Sharon Hanley Disher chronicles the four years at the Academy for the women of the class of 1980, the first class with women to graduate from the Academy [3]. While attitudes and traditions have changed over the past 20 years, a continued desire for acceptance is epitomized by an anecdote in Disher's book. Disher recounts an event from September of 1979 when all female first class midshipmen were notified of a mandatory meeting. One of the students responded to a friend "... 'any little thing, like a separate meeting, that calls attention to us as women seems to make life a little more difficult.'"

Obviously, recruitment strategies should avoid making students feel uncomfortable. To further assess the current situation, the authors held a discussion session with the junior and senior female Systems Engineering majors. Based on the results of the discussion session and the enrollment data, the recruitment strategy is to provide role models for female students without obvious reference to gender.

It is important to note that the applicability of the proposed recruitment strategy is not limited to USNA or other service academies. The development of diversity as suggested by the *Land of Plenty* report [1] will require targeted recruitment methods aimed at under represented groups. While service academies are unique institutions of higher education, the issues are not necessarily unique. Regardless of gender, race, or ethnicity, students have a wide range of activities occupying their time and may avoid recruiting efforts that bring them undue differentiation from their peers. Therefore, recruitment methods will have to account for the aversion to attention that under represented groups may feel. The proposed recruitment strategy incorporates this sensitivity and can serve as an example for other institutions.

The remainder paper is organized as follows. In Section 2, enrollment statistics from USNA and

its peer institutions are compiled and compared. Section 3 summarizes the results of the discussion session with the current female Systems Engineers. The proposed recruitment methods are presented in Section 4. Concluding remarks are given in Section 5.

2 ENROLLMENT STATISTICS

The *Land of Plenty* report [1] concluded that America needs to cultivate more diversity among students and professionals in science, engineering, and technology to maintain a competitive edge in these fields. In examining the prospects for achieving diversity, the report stated that the “measure of success is parity with respect to population distribution in enrollment, academic performance, and graduation rates of all groups at each level.” With this objective in mind, the goal of the proposed recruiting methods is to increase the female enrollment in Systems Engineering (without decreasing the male enrollment) to achieve the same representation of male and female students in Systems Engineering as in the student body at USNA. “Equal representation” in the sense defined above has not been achieved at the national level or at USNA. It should be noted that achieving equal representation implies an overall increase in engineering students as female students are drawn from other fields of study. In this section, enrollment data from USNA and peer institutions are used to assess the current situation and to describe the relative change needed. This analysis will provide a means for measuring the effectiveness of the recruitment efforts.

2.1 USNA Enrollment

To assess the situation at USNA, the current enrollment numbers are summarized in Table 1. Given that 15% of the eligible students are female, equal representation is achieved if 15% of students in Systems Engineering (and Engineering, in general) are female. Table 1 shows that females are under represented as Engineering majors and as Systems Engineering majors.

Table 1: Current enrollment numbers at USNA¹

USNA Classes '01 – '03	Male	Female
Total Students	2547	448
% of total	85.0	15.0
Engineering majors	945	113
% of Eng. Majors	89.3	10.7
Systems Eng. Majors	314	22
% of Systems Eng. majors	93.5	6.50

¹Data was obtained from the USNA Registrar.

2.2 Comparisons with Peer Institutions

The National Science Foundation's report "Women, Minorities, and Persons with Disabilities in Engineering 2000" [4] demonstrates that this situation is not unique to USNA. Using the most recently reported data from 1996, women comprised 55.9% of all students enrolled in undergraduate institutions but only 19.1% of all students enrolled in engineering programs.

Many believe that women will never hold the same interest in engineering that men exhibit. However, Sheila Widnall, the vice president of the National Academy of Engineers, has made an interesting assessment of the importance of women in engineering [5]. Widnall states, "If women don't belong in engineering, then engineering as a profession is irrelevant to the needs of our society. If engineering doesn't make welcome space for them and embrace them for their wonderful qualities, then engineering will become marginalized as other fields expand their turf to seek out and make a place for women." One can argue as to how to define "welcome space". Analyzing the percent increase necessary to achieve equal representation is one way of quantifying how "welcome space" is being achieved within the context of a particular institution.

The comparison of statistics can be treacherous and may lead to flawed conclusions. In regards to equal representation, a single measure will be used to compare the enrollment statistics. The measure is the percentage increase in enrollment of female students required to achieve equal representation. Using the USNA enrollment data, there are 945 male students and 113 female students in engineering. At USNA, female students comprise 15% of the eligible student body. To achieve equal representation, there should be 167 female students in addition to the 945 male students to achieve 15% female representation in engineering. Therefore, this goal requires an increase of 54 female students or 47.8%.

From the NSF report, 12,424,570 students were enrolled in undergraduate institutions and 2.87% of these students (356,177 students) were enrolled in engineering programs in 1996. Nationally, 19.1% of engineering students are female and, therefore, in a population of 1000 students, there will be 29 engineering students (23 male, 6 female). To achieve equal representation, female students should comprise 55.9% of engineering students according to NSF enrollment data. Specifically, in this population of 1000 students, there should be 29 female engineering students in addition to the 23 male engineering students. This level of enrollment requires an increase of 23 female engineering students (in a population of 1000 students) or an increase of 383%. It follows that USNA is much closer to achieving equal representation than the undergraduate population nationally.

Table 2: Current enrollment numbers at USNA, USAFA, USMA²

Classes '01 – '03	USNA	USAFA	USMA
Total male students	2547 (85.0%)	2587 (84.6%)	2486 (84.6%)
Total female students	448 (15.0%)	472 (15.4%)	451 (15.4%)
Male engineering majors	945 (89.7%)	731 (91.5%)	837 (92.6%)
Female engineering majors	113 (10.7%)	68 (8.5%)	67 (7.4%)
Percent increase (%I)	47.8	95.7	127

As a military service academy, USNA is very different from most undergraduate institutions and a comparison based on national averages is not very meaningful. A more reasonable comparison can be made with the United States Military Academy (USMA) and the United States Air Force Academy (USAFA). All three service academies draw from the same pool of prospective students and have similar percentages of male and female students. Table 2 shows the number of male and female students in the student body and in engineering majors. The percentages of the total students or engineers are shown in parentheses. From these data, the percent increase in female engineering students required at USNA is large but lower than that at the other academies.

While USNA is a military service academy, the engineering program is similar to engineering programs at civilian institutions. The US News & World Report rankings are used to identify peer civilian institutions. The most recent rankings [6] grouped the three service academies with Bucknell University and the Rochester Institute of Technology as the 4th best undergraduate engineering programs without Ph.D. programs. Bucknell University and the Rochester Institute of Technology (RIT) offer interesting points of comparison for the service academies. Bucknell is very similar to the academies in total enrollment with about 3500 undergraduate students whereas RIT is much larger than the academies with about 11,750 students (including 2250 part-time students)³. The five institutions have similar percentages of students that select an engineering major: Bucknell 20%, RIT 26%, USAFA 26%, USMA 31%, and USNA 35%.

Table 3 shows a comparison of the enrollment numbers at USNA, Bucknell, and RIT. This data demonstrates that the percent increase in female engineering students required at USNA is lower than that at Bucknell or RIT. Two conclusions can be drawn from the data in Tables 2 and 3. First, USNA is closer to achieving equal representation than its peer civilian institutions for engineering. Second, the military academies as a whole require a lower percent increase in female engineering students than their peer civilian institutions. The second conclusion may be due to the high confidence levels of female students at the military academies (see Section 3.2) and to the potential career options in the

²Data was obtained from the Registrars at USNA, USAFA, USMA.

³Data was obtained from the Registrars at Bucknell University and Rochester Institute of Technology.

military. It is important to note that the percent increase is a relative measure and these conclusions may obscure the fact that Bucknell has been very successful in recruiting female students to engineering. Their engineering program has a 25% female enrollment as compare to 19.1% nationally.

Table 3: Current enrollment numbers at USNA, Bucknell, RIT

Classes '01 – '03	USNA	Bucknell	RIT
Total male students	2547 (85.0%)	1753 (51.5%)	7075 (65.8%)
Total female students	448 (15.0%)	1650 (48.5%)	3671 (34.2%)
Male engineering majors	945 (89.7%)	534 (75.0%)	1001 (86.1%)
Female engineering majors	113 (10.7%)	178 (25.0%)	161 (13.9%)
Percent increase (%I)	47.8	183	223

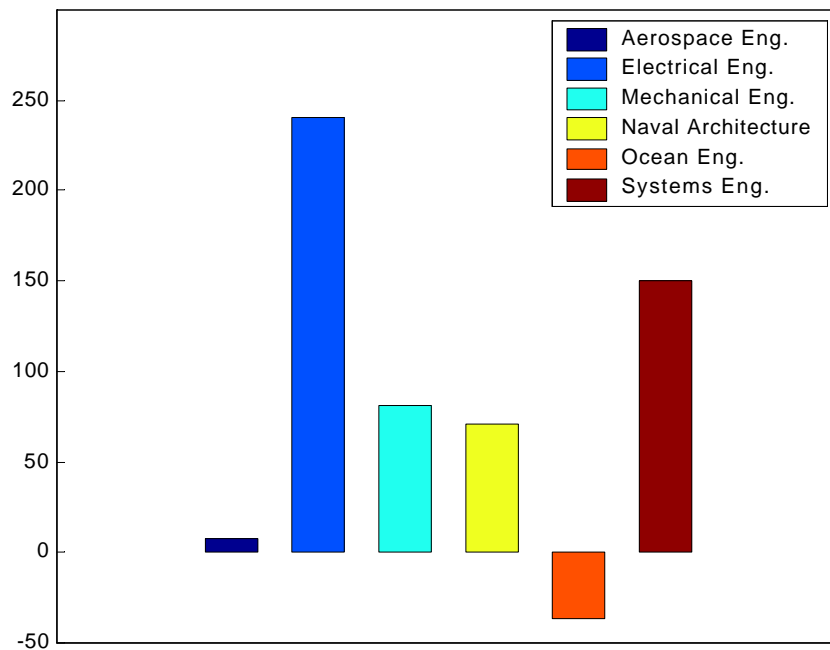


Figure 1: Percent Increase Required at Engineering Departments at USNA for equal representation

2.3 Comparison with Other USNA Engineering Departments

Systems Engineering is the largest engineering major at USNA and is the most popular engineering major among male students. Over the past three years, 12.3% of male students have chosen Systems Engineering as compared to 6.60% for Aerospace Engineering and 6.56% for Mechanical Engineering⁴. Despite this recruiting success, Systems Engineering has been only the third most popular major among female students attracting 4.91% of female students as compared to 6.25% for Ocean Engineering and 6.06% for Aerospace Engineering. Figure 1 shows a bar graph of the percentage increase required to achieve equal representation in each of the 6 engineering departments. The percentages are computed using total enrollment for the current sophomore through senior classes.

These statistics illustrate the need for renewed recruiting methods to attract female students to Systems Engineering. As the following sections will show, current female Systems Engineering majors are very satisfied with their experience. The recruitment challenge is to get female students to consider Systems Engineering as a major.

3 INTERNAL ASSESSMENT

The twelve female upperclassmen (juniors and seniors) were invited to attend an informal lunchtime discussion. The women were asked for their opinions about the major, engineering in general, and the issue of recruitment. It also provided a chance for the women to meet each other as well as the two female faculty members in the department.

3.1 Survey

Before the discussion, the junior and senior female Systems Engineering students were asked to complete a questionnaire in order to assess their opinions about their choice of major. These questions were designed to elicit answers to the following general questions.

- \$ Who and what influenced their decision to chose engineering in general and systems engineering specifically?
- Did they feel good about their choice to be an engineer?
- Were they comfortable in their systems engineering classes?

Midshipmen were asked to indicate their response on a 5-point scale ranging from “Strongly Disagree” to “Strongly Agree” (see Appendix A). A score was assigned to each answer and the average score calculated. Ten surveys were completed. Table 4 highlights the average answer to several key questions.

⁴Data was obtained from the USNA Registrar.

Table 4 Survey comparison for selected questions

Survey Question	Mean
13. I feel just as competent at engineering as my male classmates.	4.30
14. I feel more competent at engineering than my male classmates	3.40
17. I feel comfortable asking questions in Systems classes.	4.40
19. I feel that Systems professors treat female students in the same manner as they treat male students.	4.80

The results shown in Table 4 indicate that the female engineering students at the Naval Academy are very comfortable in the classroom environment and are very confident in their abilities. These results indicate a high degree of satisfaction with the Systems Engineering major.

The discussion that followed the survey echoed the results of the survey. However, the midshipmen expressed that they found themselves in a role model vacuum. One mentioned that she did not know any female engineers (student or professional) when she chose her major. Strong support was voiced for a departmental brochure that included female students (see Appendix B). One of the most popular elements of the Systems engineering program is the senior projects. The women felt that it was important to make a concerted effort to ensure that at least one example of a project team that included women be featured in departmental recruiting efforts. They also enthusiastically volunteered to assist in open houses and plebe briefs. The students reiterated that recruiting efforts should be mindful of women, but not necessarily overtly directed towards them.

The results of this discussion indicate that the women who enroll as Systems Engineering majors are pleased with their course of study. The under-representation of women does not seem to be a function of the program itself. However, a greater effort can be made to make female plebes more aware of this successful program.

4 RECRUITING METHODS

The previous sections indicate that female students are under represented in the Systems Engineering major with respect to the distribution of female students at USNA and with respect to the distribution of female students in engineering at USNA. However, the female students in the Systems Engineering major are satisfied with their choice. As a result, the goal of the recruitment process is to have more female plebes consider Systems Engineering as a major. An impediment to recruitment is the misconception that the female students cannot succeed in a technical major. In the unique environment of USNA, the considerable military and athletic requirements make a technical major less attractive to female midshipmen than their peers at civilian institutions. The recruiting methods suggested in this section are intended to dispel this misconception by providing positive role models for prospective female engineers without making an obvious reference to gender.

The major selection process at USNA consists of several rounds of briefings by the Division of Engineering and the individual engineering departments. In the fall semester, all plebes receive a series of short (10-15minutes) briefs from each of the engineering departments. Before the start of classes in the spring semester, an open house is held where the plebes can visit representatives from any of the academic departments. After the open house, the plebes indicate their top three major preferences. Based on these preferences, the individual departments invite the interested plebes to tour the departmental facilities and to meet the faculty.

The structure of the recruiting process limits the time for interaction between the faculty and the students. The briefing at the beginning of the spring semester offers the main opportunity to recruit students to Systems Engineering. To the end of improving the recruitment of female students, three courses of action will be taken to provide student role models:

- § A promotional brochure will be distributed that highlights several senior Systems Engineering projects involving male and female students.
- Efforts will be made to include upper class Systems Engineering students (male and female) at the plebe briefings.
- A special informational session will be organized for all female plebes that have indicated a some interest in Systems Engineering.

The recruiting strategy is to provide the plebes with examples of successful students. The promotional brochure serves to highlight the students' involvement in exciting and ambitious Systems Engineering senior projects (see Appendix B). An emphasis is placed on their additional military and/or athletic positions such as leadership positions in the Brigade of Midshipmen or involvement in Varsity sports. The intent is to show that selecting an engineering major does not preclude involvement in high-level military and/or athletic activities. The presence of the upperclass Systems Engineering majors at the briefing reinforces this image and provides the plebes (especially females) an opportunity to discuss their concerns with their peers. By relating their own experience, the female upper class Systems Engineering majors can dispel the common misconceptions that might prevent female students from considering engineering as a major. While the focus is on recruiting female students, the above methods satisfy the original objective of presenting positive role models without obvious reference to gender.

After the plebes have indicated their major preferences, the recruiting effort is focused on retaining those students interested in Systems Engineering (having indicated that Systems is their 1st, 2nd or 3rd choice). These efforts are targeted towards the female students because they are at the greater risk of being dissuaded from choosing an engineering major. The special informational session for all female plebes interested in Systems Engineering will be organized via e-mail to allow for anonymity. This session will be informal and will allow the female students an opportunity to meet one another and develop a sense of community with female upperclassmen and professors.

5 CONCLUSION

When a department seeks to recruit women to an engineering major, it is important to consider the environment of the institution and institution-specific needs of female students. Because

women are such a small percentage of the overall student body at the U.S. Naval Academy, activities that increase the spotlight on them are not always received well. The importance of this observation is not unique to a service academy. There are a number of institutions for which a variety of minority social groups should be targeted with recruitment efforts.

The female enrollment in the Systems Engineering department at the U.S. Naval Academy has been studied. Given the limited female student population, enrollment statistics indicate that the Naval Academy is somewhat successful at attracting women to engineering majors. However, the Systems Engineering department has been less successful than other departments within USNA at attracting female students. Discussions with the junior and senior female Systems Engineering majors indicated a high degree of satisfaction with their course of study. The department will seek to develop recruitment methods that point to the success of the current female students without providing an unwelcome spotlight on their minority status. Thus, the authors have outlined several approaches that seek to provide these role models without overtly or visibly targeting just women.

Bibliography

- [1] *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology*. Report of the Congressional Commission on the Advancement of Women and minorities in Science, Engineering and Technology Development. September, 2000.
- [2] R. M. Kanter, *Men and Women of the Corporation*. New York: Basic Books, Inc., Publishers, 1977.
- [3] S. H. Disher, *First Class: Women Join the Ranks at the Naval Academy*. Annapolis, Maryland: Naval Institute Press, 1998.
- [4] Available at <http://www.nsf.gov/sbe/srs/nsf00327/start.htm>
- [5] S. Widnall, "Digits of Pi: Barriers and Enablers for Women in Engineering", *The Bridge*. Vol. 30, Fall/Winter 2000.
- [6] Available at <http://www.usnews.com/usnews/edu/college/rankings/cat13wo.htm>

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Appendix A: Survey Results

Survey Results for ten female Systems Engineering majors of the class of '01 and '02. Midshipmen were asked to circle the response that most closely agreed with their opinion. A score was assigned to each answer and the average score calculated.

Response	Strongly Disagree	Disagree	No Opinion	Agree	Strongly Agree
Score	1	2	3	4	5

An average response less than 3 indicates disagreement.

Avg. Response	Statement
2.4	1. One of my high school teachers encouraged me to pursue engineering.
3.4	2. A midshipman in my company encouraged me to pursue engineering.
3.4	3. A family member encouraged me to pursue engineering.
2.9	4. A midshipman in one of my extra-curricular activities encouraged me to pursue engineering.
3.3	5. A midshipman in my company encouraged me to pursue <i>systems</i> engineering.
3.3	6. A family member encouraged me to pursue <i>systems</i> engineering.
2.7	7. A midshipman in one of my extra-curricular activities encouraged me to pursue <i>systems</i> engineering.
3.7	8. Someone in my immediate family is an engineer.
2.3	9. My decision to pursue engineering was influenced by the plebe briefs.
3.3	10. My decision to pursue <i>systems</i> engineering was influenced by plebe briefs.
4.5	11. I feel that I made the right choice in pursuing engineering.
1.5	12. I feel that I made the right choice in pursuing <i>systems</i> engineering.
4.3	13. I feel just as competent at engineering as my male classmates.
3.4	14. I feel more competent at engineering than my male classmates.
4.2	15. I feel comfortable in lab classes.
4.5	16. I feel comfortable in Systems classes.
4.4	17. I feel comfortable asking questions in Systems class.
4.4	18. I feel comfortable asking the professors in Systems for EI.
4.8	19. I feel that Systems professors treat female students in the same manner as they treat male students.
3.7	20. I think an effort should be made to recruit more female students in the Systems Engineering Department.

Systems Engineering

Ranked #1 in the nation

Spring 2001

Putting It All Together:

1/C Systems Engineering

Projects

As a systems major, you will develop the ability to analyze, operate, and design complete engineering systems. During your first class year, you will design, construct, and demonstrate a project of your choosing. Here is a sampling of projects being developed by the class of '01.

1/C Beth Dixon (16th Company) is developing a web-based interface to allow a user from any computer to control a mobile robot via the Internet. The robot will accept commands such as moving forward and backward, turning 180 degrees,



or turning left or right. The mobile robot is constructed using Lego Mindstorms™. These robots are used extensively in the senior elective course - *Autonomous Robot Design*.

1/C Ryan Mortimer (17th Company) 1/C Zorko Petrusa (27th Company), 1/C Scott Sloan (27th Company), and 1/C Joshua Smith (17th Company) are developing an autonomous navigation system for an industrial cart using a differential GPS and a compass. The navigational control and sensor processing will be implemented on a microprocessor board. In addition to navigation, this team hopes to develop a speed control system and an obstacle avoidance control system. This project is an excellent example of the integration of mechanical, electrical, and computer systems.



1/C Erich Jurges (1st Company) and 1/C Tracy Ritzman (24th Company) are also integrating a variety of engineering systems. They are developing



an automated welding system to control a TIG welding machine using visual feedback to weld 1/16 inch stainless steel sheet-metal. The system will take pictures from the underside of the metal, opposite the welding torch, with a black and white camera. An image processing system will monitor the weld puddle and determine the welding rate.

What is Systems Engineering?

Many modern products, from microwave ovens, stereos and automobiles to spacecraft, missiles and robots, are complex systems consisting of components from many engineering disciplines. The systems engineer seeks to combine and control diverse components in order to meet specific design requirements. The Naval Academy's systems engineering program, rated number one in the country for more than fifteen years, is accredited by the Accreditation Board for Engineering and Technology.

What do Systems majors service select?

Typical percentages are 50% aviation, 30% submarines, 10% SWO, 5% Marine (ground), and 5% other (Medical Corps, Special Ops., etc.)