

Student Retention Strategies
Gender Clustering

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ABSTRACT

Virginia Polytechnic Institute and State University currently requires its incoming freshman and transfer students to take two introductory engineering courses - - EF1005 and EF1006. In an effort to improve the retention rates of women in its engineering programs, the Office of Minority Engineering Programs has instituted voluntary gender clustering in the first of these classes -- EF1005. Women comprise about 17% of our entering engineering students and they are still in the minority in their classes. Therefore, women students are preferentially registered in 8 of the 35 sections of EF1005, an introductory course in engineering problem solving. This clustering is not intended to produce women-only sections of EF1005, but to produce multiple sections of EF1005 each of which has women in greater numbers. The clustering is intended as a means for these freshman students to initiate friendships and establish study groups with their gender peers. The clustering program is supported by academic workshops, conducted by a cadre of trained workshop leaders. Seven of the eight clustered sections of EF1005 have as their professors faculty members who have attended training sessions on minority issues.

This paper deals with Virginia Tech's experiences with this first year of gender clustering, including enrollment issues, faculty attitudes, acceptance by students, and preliminary results.

INTRODUCTION

Virginia Polytechnic Institute and State University will award bachelor degrees to roughly 4300 students this academic year. Of these degrees, about 42% or 1800 will be awarded to women. Virginia Tech's College of Engineering will award 950 bachelor degrees along with 450 Masters and over 100 Doctorates. Of these Bachelor of Science Degrees in various engineering disciplines, only 160, or roughly 16% will be awarded to women.¹ Nationwide, more than 10,000 women will earn engineering degrees this year, whereas over 50,000 men will attain this academic level.² Despite the fact that women are over 50% of the population of the United States, engineering school enrollments do not reflect this gender dominance, and the engineering profession remains a predominantly white male bastion.

Gender equity progress has been made in the 100+ years since Kate Gleason entered Cornell University, and Elmina Wilson earned her civil engineering degree from Iowa State University.³ Societal changes and associated legal and infrastructure changes have opened more and better technical opportunities to women. The percentage of women engineers enrolled as first year students doubled from 9 percent in 1975 to 18 percent in 1992.⁴ In that same time frame, the total number of undergraduate engineering women increased from 16 thousand to over 57 thousand.

Undergraduate enrollment at Virginia Tech, currently at over 19 thousand per year, has seen a markedly consistent male to female ratio for the past six years. It is anticipated that Tech's 1996

enrollment statistics will show nearly 11,500 men and 7,600 women, matching the 6 year ratio trend of 60/40 male/female. Not surprisingly, the male to female ratio is higher in the College of Engineering. This ratio has also remained steady over the past six years at 83 percent male, 17 per cent female.

Numerous studies have been conducted over the past decade addressing low enrollment rates and poor retention rates among females in the engineering field. Dr. Betty Vetter, Executive Director of the Commission on Professionals in Science and Technology, provided enlightening gender statistics at the American Society for Engineering Education's centennial.⁵ Dr. Vetter's statistics show 156 thousand working female engineers in an engineering population estimated at 1.7 million -- a 9 percent share. In 1987, women were fewer than 3 percent of the faculty in engineering and engineering technology programs. These statistics lead to the observation that 'women already employed as engineers do not see female role models to indicate that advancement for women is possible.'⁶ (The American Society for Engineering Education (ASEE) recognizes ten women as engineering deans.⁷ Dr. Vetter referenced other studies that : 1) 'found that women in engineering are under-utilized, and that their career advancement is stymied by a number of remedial barriers. '; 2) 'Women are leaving engineering because they aren't allowed to succeed'; and 3) 'Networking and support groups for women are not encouraged.' Dr. Vetter's first recommendation for 'removing the barriers' was that 'women should form or join networks for women. Employers should encourage, rather than discourage such activity, developing formal mentoring programs to provide greater opportunities for networking.'⁸

Dr. Raymond B. Landis, Dean of Engineering and Technology at California State University, has propounded collaborative learning techniques. He instituted a highly successful program at his institution for enhancing the retention of minority students. He has offered his expertise and experience through a series of workshops. Through funding provided by NSF's SUCCEED (Southeastern University and College Coalition for Engineering Education), two engineering faculty from Virginia Tech attended Dr. Landis 'NSF Chautauqua-Type Short Course for College Teachers' entitled 'Achieving Excellence in Minority Engineering Education: Improving the Academic Performance and Graduation Rates of Minority Engineering Students.' Although this particular short-course was directed at racial minority retention and graduation rates, the techniques and programs espoused should be applicable to all students. One of the main tenets of this process is the availability of academic help through 'your peers, your instructors, and tutors and other campus resources.'⁹ Dr. Landis further notes that 'the "lone wolf" approach to academics may have worked in high school, but it is doubtful that it will work in engineering study where the concepts are much more complex and the pace much faster.'¹⁰

Dr. J.B. O'Neal in his paper 'Engineering Education as an Ordeal and its Relationship to Women in Engineering' presents a compelling rationale for the current status of enrollment and retention rates of women in engineering. The origins of engineering education in military organization has led to educating engineers through 'ordeal' -- 'learning how to deal with difficulty and failure, to go beyond what one thought was possible. A student learns to keep trying when things go wrong. One learns discipline by striving, and failing and striving again and finally succeeding. Some will learn how to do things that no one else has done.'

'The ordeal in engineering education has three primary parts -- students are asked to do homework and quiz problems that are often beyond their ability, they receive grades that are generally below their expectations, and must spend what many consider to be an inordinate amount of time on their studies and laboratories. The ordeal is usually administered by faculty who have high standards and challenge students to do their very best.'¹¹ Dr. O'Neal suggests that, for women, the 'ordeals in engineering education may be inappropriate, discouraging, and counterproductive.' If one accepts this concept of engineering education as ordeal, then collaborative learning, group study, voluntary support groups, peer pressure and peer support -- all aspects of white male experiences during their

engineering education's -- would appear to be fertile grounds for improving the retention and graduation rates of women engineers.

Collaborative learning processes have received extensive study. One study was initiated in the Fall of 1992 at Virginia Tech, funded through SUCCEED, to investigate the effects of voluntary collaborative learning or group study among freshman engineering students. Although many collaborative learning programs are structured, requiring students to participate and attend scheduled study-group sessions, Virginia Tech's program was voluntary. Two goals of the clustering program were to 'shape students into a supportive group in which every student knows the others.....and has a sense of group spirit and cohesiveness' and 'to encourage students to study together.'¹² Dr. Landis' approach to collaborative learning emphasizes an environment in which:

1. Students must be enrolled in the same courses
2. Students are enrolled in the same sections of these courses.
3. Students know each other
4. Students are formally presented the benefits of collaborative learning.

Although the result of Virginia Tech's voluntary collaborative learning study was statistically inconclusive, the results suggested:¹³

1. those who participated frequently felt very positive about the advantages.
2. study group sessions provided students with a source for discussing problems.
3. few students voluntarily study in a group all the time.

GENDER CLUSTERING

Virginia Tech instituted a pro-active minority engineering program in 1992. This program was aimed generally at increasing the enrollment, retention, and graduation rates of racial minorities within Virginia Tech's College of Engineering. Success with this program has resulted in its expansion to include all under-represented groups, including women of all races.

Beginning with the Fall 1995 entering class, the Office of Minority Engineering Programs within the College of Engineering has directed this study. Funds had been provided in the previous year to send two of Tech's professors of Engineering Fundamentals -- Tech's introductory engineering classes -- to one of Dr. Landis' training sessions for college teachers involved in minority education. These two instructors would then be responsible for teaching the anticipated eight clustered sections of Engineering Fundamentals EF1005.

Virginia Tech strongly encourages its entering freshman engineering students to attend a three day orientation period during the summer prior to their first fall semester. During this period, engineering faculty provide advice to students and their families, producing a schedule of classes for each student for the fall semester. This process provides the immediate benefit to the individual student of having a completed and (generally) valid schedule of classes. Because of the vast differences in the backgrounds of entering freshman, this process is complicated administratively. Placing students in the correct math and English sequences based on transfer credit, AP test credit, or 'diagnostic scores' generated by the University Registrar is a main outcome of this orientation process. As budgets have been cut state-wide within Virginia, enrollment in individual sections of offered courses has increased as under-subscribed sections and courses are dropped. Freshman engineering courses have traditionally been completely filled -- if engineering enrollment has not been sufficient to fill every seat in every introductory engineering course, the general population of the University ('University Studies' students) have provided more than enough demand to fill extra seats. The Division of Engineering Fundamentals currently offers 40 sections of EF1005, the fall semester offering in the introductory engineering sequence. The computer-based classrooms for these classes are limited to 32 (in some cases 28) students.

Before the orientation process begins, students are pre-registered in their EF1005 classes. During the summer of 1995, the Office of Minority Engineering Programs (OMEP) identified and contacted entering female engineering students. They were queried to their interest in participating in voluntary support groups, and in clustering in special sections of their introductory engineering class (EF1005). About half of the contact students responded with an interest in participating. Whenever necessary to accommodate student desires and scheduling conflicts students were shifted to other EF sections. With an entering engineering class of 1466, about 150 above normal, scheduling difficulties were exacerbated. The difficulties involved with scheduling the female students for particular sections further added to the administrative problems encountered during orientation. Schedules for female students were further affected by the scheduling of study groups and introductory meetings in the afternoon twice a week -- meetings that were scheduled much as other 'free time' requests such as athletics.

The cluster schedules were devised to provide a reasonably representative proportion of females in their engineering classes. The intent was to provide a 50-50 ratio in the clustered sections. In prior years, typical class make up has resulted in three or four female students in any one section of EF. This proportion is not seen as conducive to promoting non-organized clustering of female students. With only a handful of gender peers in each section, it is unlikely that these students would share similar schedules, the same sections of their other 6 freshman classes, residence in the same dorm or on the same floor, racial similarities, or other factors which would normally promote clustering among their male counterparts. The males in each class (at least the white males) have a much larger population of gender peers from which to generate study groups. Clustered sections were therefore devised with 10 or more females in each -- intended to be sufficient to provide the same clustering opportunities enjoyed by males. It was explicitly intended that no sections be women only. On the other hand, clustering the majority of the women in 8 sections of these introductory classes effectively reduced the number of women in the other 32 sections of these classes. The result is that although more group study opportunities were presented to the majority of the freshman women, those that did not enter a clustered section were more gender-isolated.

Upper class female engineering students were recruited as mentors and group leaders for the clustered sections of EF1005. These groups met twice a week to discuss learning techniques and study habits, to engender friendships and peer support, and to provide direct engineering tutoring. Participation in these meetings was not mandatory, and attendance after the first few weeks dropped substantially. The number of participants in the workshops for the fall semester was 45. This number represented both women and ethnic minorities. Approximately fifty percent on these participants were women. Workshop participation for the spring semester was reduced by roughly one half, although no statistics have been compiled for this semester. This reduction may reflect the success of clustering -- the female engineering students had established study groups outside the workshops, and no longer felt the need for the structured meetings.

The Office of Minority Engineering Programs WEST program (Women in Engineering Support Team) is designed to ease the freshman transition to the University. Each female engineering student that is new to the University is part of a support team consisting of other women engineering students. The Team Leaders are upper level women engineering students who serve as role models, conveying information on how to successfully navigate the first year of the engineering curriculum. Teams meet on a regular basis, and encourage a collaborative learning environment through participation as a team, both academically and socially. The teamwork is intended to provide the students with a sense of belonging that may otherwise be difficult to develop without this support. The OMEP's 'Academic Excellence Workshops' are scheduled meetings, 2 hours per day, twice a week. This time is set aside for group work on problem sets associated with a particular subject or course. These periods provide exposure to a disciplined learning environment that helps the students improve their technical communication skills, experience group learning activities, and increase their mastery of their

technical subjects. These sessions are not intended, nor do they serve, as homework sessions. Homework assignments are specifically excluded from the scope of these meetings, in conjunction with Virginia Tech's Honor Code. The sessions, however, provide the skills and confidence necessary for successful completion of the freshman engineering curriculum.

Of the eight sections of EF1005 that were intended to be gender clustered sections in the fall of 1995, only one had a 50% female enrollment. Three others had roughly 30% females, and the remaining 4 sections, fewer than 10 female students. In addition, instructor scheduling conflicts resulted in the two Chautauqua-trained instructors teaching 7 of the clustered sections, with the 8th taught by another member of the faculty of the freshman division. None of the spring semester EF1006 classes were intentionally gender clustered. At least one section had a greater than 50 percent female membership, in part due to the tendency of students to request the same instructor and class time for the second semester EF class. This may also be a successful result of the clustering begun in the fall semester. Female students in fall semester study groups may have attempted to schedule the same sections of their engineering classes for the second semester.

RESULTS

Results, at best, can be described as tentative. In the fall semester, participation in the WEST workshops was less than had been anticipated. Results from the first departmental test in this course do not show a clear trend. Instructors in clustered sections have not, intentionally, modified their approaches to the topics to accommodate these students. Because of the administrative difficulties of registering these students in special sections of EF1005, and the associated complications with the rest of their academic schedules, faculty support of the clustering process has not been overwhelming. More than one faculty member felt that 'all students should be treated *exactly* the same.' Questions need to be addressed as to whether this year's entering freshman class is a statistical norm, as evidenced by SAT's, high school class rank, and college level success. Following the end of the spring semester, the results of the clustering will be examined in greater detail.

The attached tables provide some preliminary insight into the results of clustering, relative to previous trends. The tables show success and failure rates for non-clustered sections (academic years '94 and '95), for clustered sections (academic year '95), and for workshop participants. Except for the last table, male/female (M/F) ratios given are in number of students. The summary table lists percentages. The results shown are for students enrolled in the fall EF1005 sections taught by the two Chautauqua-trained Engineering Fundamentals faculty. No data is available at this time for the spring semester EF1006 classes. Those students listed as 'Non-Motiv'd' represent students who either did not take the final exam, did not complete the term project, or missed more than half of their classes. The 'class averages' do not include these students, however, the number of failing grades (F's) do. The summary table provides an entry excluding these non-motivated students from the calculations.

A rigorous statistical analysis of this preliminary data has not been attempted, however a cursory examination of the summary table shows a counter-productive trend to clustering. The clustered sections showed an increase in the number of 'non-motivated students', a decrease in the percentage of both males and females performing 'A' level work, and an increase in the percentage of both males and females failing. A number of corollary issues cloud this picture. All clustering was done in academic year 1995. During this academic year the student's required computer package was beset with major hardware and software problems which were not resolved until the 10th week of a 16 week semester. Success in introductory engineering classes at Virginia Tech is highly dependent on the student's developing computer expertise. Additionally, Virginia Tech's freshman class was 10% larger than

normal due to an increase in the number of acceptances by prospective students. Many of these students had qualifications below the traditional norm for the College of Engineering.

Success/Failure Rates -- Non-Clustered Sections

<i>Number of Students</i>	<i>Year</i>	<i>Clustered Non-Clust</i>	<i>M/F Ratio</i>	<i>Non-Motiv'td</i>	<i>Class Average</i>	<i>Number A's</i>	<i>Number F's</i>
24	94	N/C	22/2	4/0	83	5/0	4/0
27	94	N/C	23/4	3/2	76	3/0	4/2
29	94	N/C	25/4	3/0	74	3/2	9/0
29	94	N/C	23/6	2/1	73	2/1	6/1
31	94	N/C	23/8	3/1	74	3/0	2/2
31	94	N/C	27/4	4/0	76	3/1	8/0
28	95	N/C	23/5	6/0	70	1/0	8/1
30	95	N/C	29/1	2/0	72	3/0	9/0
30	95	N/C	28/2	9/0	73	3/0	11/0
TOTALS: 259		N/C	223/36	36/4	74.4	26/4	61/6

Success/Failure Rates -- WorkShop Participants

<i>Number of Students</i>	<i>Year</i>	<i>WORK-SHOP</i>	<i>M/F Ratio</i>	<i>Non-Motiv'td</i>	<i>Class Average</i>	<i>Number A's</i>	<i>Number F's</i>
31	95	W/S	15/16	2/0	N/A	2/1	3/4

Success/Failure Rates -- Clustered Sections

<i>Number of Students</i>	<i>Year</i>	<i>Clustered Non-Clust</i>	<i>M/F Ratio</i>	<i>Non-Motiv'td</i>	<i>Class Average</i>	<i>Number A's</i>	<i>Number F's</i>
30	95	C	14/16	5/3	76	4/2	7/3
30	95	C	19/11	2/3	72	1/0	5/4
28	95	C	18/10	3/3	65	0/1	8/4
27	95	C	14/13	3/2	73	2/0	3/4
28	95	C	16/12	1/3	71	1/1	5/5

Success/Failure Rates -- Summarized by Category

<i>C/NC/ WRKSHOP</i>	<i>Number Students</i>	<i>M/F Percents</i>	<i>Non- Motiv'td</i>	<i>M/F A's Ratio</i>	<i>M/F F's Ratio</i>	<i>A's w/o Non-Mot</i>	<i>F's w/o Non-Mot</i>
Non-Clus	259	83/17	16/11	12/11	27/17	14/13	13/6
Clustered	143	57/43	17/23	10/6	35/32	12/8	21/13
WorkShop	31	48/52	13/0	13/7	20/25	15/7	8/25

Workshop participation for the spring semester has much less than anticipated. Despite initial positive responses following the fall semester, participation has dropped. Following the spring semester the clustering program will be reassessed prior to enrolling incoming freshman engineering students in August.

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¹ Projected data based on 1990 through 1994 graduation statistics. Institutional Research and Planning Analysis, Virginia Polytechnic Institute and State University

² Virginia Myers Kelly, 'Briefings', ASEE Prism, American Society for Engineering Education, 11/95.

³ LeBold, ASEE 1993 Proceedings....FILL IN THE REST

⁴ Wadsworth, 1993 ASEE page 1275

⁵ Dr. B. M. Vetter, 'Women in the Engineering Workforce: Progress in Century I', 1993 ASEE Annual Conference Proceedings.

⁶ Ibid.

⁷ ASEE PRISM, March '96, 'Briefings', pg 15

⁸ Dr. B.M. Vetter, op.cit.

⁹ Dr. R.B. Landis, Studying Engineering, A Road Map to a Rewarding Career, p. 76.

¹⁰ Ibid.

¹¹ Dr. J.B. O'Neal, 'Engineering Education as an Ordeal and its Relationship to Women in Engineering', 1994 ASEE Annual Conference Proceedings, p. 1692.

¹² Schwartz, R.A. "Working Together to Succeed", ASEE PRISM, March 1996, pg. 30.

¹³ Dr. D. D. Ludwig, et.al., 'Effects of Group Study on Student Performance in Freshman Engineering Courses', 1993 ASEE Annual Conference Proceedings

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