AC 2009-685: GENDER DIFFERENCES IN THE ATTITUDES OF STUDENTS IN FRESHMAN ENGINEERING COURSES

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Abstract

Engineering is still struggling to recruit and retain female students. Particular majors have more female students, such as environmental engineering where women earned 44.5% of the U.S. Bachelor's degrees in the 2006-2007 academic year, compared to an average of 18.1% across all majors. The reasons for these differences are not fully understood. This study compares the attitudes of female and male students in freshmen engineering courses in relation to how engineering benefits society. These traits were assessed using written surveys administered in first year engineering courses in environmental engineering (EVEN), civil engineering (CVEN), and general engineering (GEEN) at the University of Colorado at Boulder from 2004 to 2008. The surveys began with basic demographic questions (gender, race/ethnicity, major) and then presented a series of questions that students responded to on a Likert scale. Male students had a more favorable view of engineers' role in society than female students, based on responses to questions from the Pittsburgh Freshman Engineering Attitudes Survey (PFEAS). Because previous studies have indicated that females want to benefit society through their work, the continuing poor perception of engineering as a helping profession among females may reflect recruiting problems. More revealing information was found in the reflective essays that the students write at the end of the semester summarizing their feelings about engineering and whether they plan to stay in the major or switch majors.

Background

The engineering profession needs to recruit more students, and this problem is expected to worsen in the future as changing demographics in the U.S. will reduce the population from which engineering has typically recruited the most students; i.e. white males. Strong efforts to recruit and retain female students in engineering began in the 1980s with the creation of various Women in Engineering programs on campuses nationwide. While initially successful, these efforts recently appear to be losing ground. The overall average percentage of female enrollment in undergraduate engineering degrees in the U.S. of 17.24% in 2005 and 2006 has declined from the peak of 19.8% in 1999. [1] Particular majors have more female students, such as environmental engineering where women earned 44.5% of the Bachelor's degrees in the 2006-2007 academic year. [2] However, the percentage of females in civil engineering has remained much smaller at 24%.[2] The reasons for the differences in female percentages in different majors are still not fully understood. Therefore, the purpose of this study was to improve our understanding of why some engineering majors attract and retain more female students. Specifically, this study determines if there are differences in the attitudes of female students that may account for some of this disparity in the representation of women across different engineering majors.

The national trends in gender diversity in engineering have been similar to those at the University of Colorado at Boulder. Across the entire College of Engineering, over the past 10 years the percentage of the entering freshmen who are female has ranged from a low of 14.4% in

2003 to a high of 23.0% in 2007. There are not overall trends with time, just significant variability each year. In contrast to recruiting female students, the retention trend is disheartening. Graduation rates of the incoming students from engineering after 6 years peaked at 60% for female students who started in 1998 and have been steadily declining to 49% for the students who entered in 2002 (the most recent numbers available). The percentage of female undergraduate students varies significantly in different engineering majors. For example, in fall 2007 the highest female representation was in chemical & biological engineering (CBE) at 49%, followed by environmental engineering (EVEN) at 35%. Civil engineering (CVEN) was about average at 16%. The lowest representation of women was in electrical engineering at 5%. What accounts for these differences?

It has been postulated that women may not be attracted into engineering because they don't see a strong human connection of the profession, and desire to positively impact society through service.[3] For example, students entering the Master's International Program at Michigan Technology University to earn an M.S. in civil or environmental engineering were interviewed. The students who had first degrees in engineering, but not in civil or environmental engineering, indicated they were seeking a connection between engineering and social welfare.[4] Widnall[5] indicated this lack of connection was one reason why women do not go into engineering. Further, an International Senior Design course in civil/environmental engineering at Michigan Tech enrolled 55% women from 2001-2005 (of 110 students); this is higher than the total percentage of civil and environmental engineering degrees awarded to women of 31%.[6] The EPICS program which offers students a service learning opportunity has also reported higher representation of women in EPICS than the comparator populations.[7] For example, 20% ECE and Mechanical Engineering students in EPICS were women compared to 10-12% women in these majors. This paper conducted semi-structured interviews with six female students and attributed the causes of female abundance in EPICS to factors such as applying theory to the real world rather than the "service" aspect. However, the small number of students interviewed limits the confidence in generalizing these results.

Besterfield-Sacre[8] administered the Pittsburgh Freshman Engineering Attitudes Survey (PFEAS) in 1998-1999 at 17 institutions with 6180 respondents (21.9% female). In this study female students started with a lower perception of how engineers contribute to society compared to male students. There was not a statistically significant difference in these perceptions in the same post-survey, administered at the end of the first semester (10 schools) or the end of the second semester (5 schools). Ten years later do these differences persist? Recent engineering-related events that have garnered prominent news coverage may impact students' views: the bridge collapse in Minneapolis in August 2007; the levee failures in New Orleans during hurricane Katrina in 2005 and in the Midwest during summer 2008; Salmonella contaminated water in Alamosa, CO, in spring 2008; arsenic contamination of water in Bangladesh; etc. Do perspective students realize that engineers are involved in these projects? If so, do they blame engineers for these failures, which might be reflected in responses on the PFEAS survey?

Hilpert[9] received 374 responses to the PFEAS survey in fall 2007 from mechanical and aerospace engineering majors at a large, public university (16.7% women). Upon data analysis, the questions related to students' perception of how engineers contribute to society were clustered into a "work and society" factor that was part of a three factor solution that was

structurally valid. They present new data on the mean and standard deviation of the PFEAS results, but do not break the results down on the basis of gender. These data provide a point of reference for other studies, although student major and other factors may impact student perceptions.

Along these same lines, Kilgore[10] conducted a study to look for emergent themes in discussions with freshmen engineering students. They found that 27% of the 153 students described engineering's value to society; gender differences in this response rate were not discussed. They did note a small but suggestive difference that women were less likely than men to use terms related to the perception that engineering is intrinsically valuable (e.g. fun, interesting, exciting); 63% of all of the students used at least one term describing these intrinsic values.

This paper explores the attitudes of freshmen students towards the positive role that engineers play in society. The goal was to determine if there are differences based on major and/or gender that could be relevant to recruiting and retention. These students were primarily enrolled in civil engineering (CVEN) and environmental engineering (EVEN) courses. Because these students are freshmen and have not yet formed a strong understanding of or identity as civil versus environmental engineering, the results may indicate why women are attracted to the major.

Methods

A specific study to evaluate gender differences in student attitudes was not designed. Rather, the author has been teaching freshman engineering courses at the University of Colorado at Boulder on a fairly regular basis since 1996. A number of surveys have been administered to the students over the years, and it was decided that mining this data for information on gender differences could potentially reveal useful insights. Written surveys to which students responded on a Likert scale were administered in the first three weeks of fall semester in the 1-credit introductory courses for Civil Engineering (CVEN), Environmental Engineering (EVEN), and General Engineering (GEEN; undeclared engineering majors). These courses are designed to inform incoming students about the major. The survey was also administered in the first week of one section of the 3-credit GEEN first-year projects course (PROJ) in spring semester. Although most of the students are in fact first year students majoring in engineering, some transfer students and students in other disciplines (Arts & Sciences, for example) sometimes take these courses to explore the potential of changing majors. The basic demographics of the students in these courses each year are summarized in Table 1. There were far fewer women in the Civil Engineering (CVEN) course than the Environmental Engineering (EVEN) course.

To evaluate attitudes related to how engineering benefits society, four questions from the Pittsburgh Freshman Engineering Attitudes Survey (PFEAS)[10,11] were used. The full text of these questions is provided in Table 2. Students in 2004 were given the complete PFEAS, while in 2006 and later only the four questions related to engineering's perceived role in society were included on the survey (PFEAS4 in Table 1). A total of 415 students completed the assessment in-class via a written survey at the start of fall semester and 47 students at the beginning of spring semester. The percentage of the survey respondents who were female was 22% overall; in the EVEN, CVEN, and GEEN courses the percentage of female survey respondents were 44, 16, and 16, respectively. Overall, ~82% of the students in these courses were incoming first-year

students majoring in engineering, although there were also a small percentage of older transfer students and students considering engineering as a major.

Table 1. Demographic information on the courses and number of students for whom data is available from different evaluation instruments

Course	Year	% 1st year students	% engineering majors	# females responded to PFEAS4	# males responded to PFEAS4	# female essays coded	# male essays coded
CVEN	2003	70	75	NM	NM	4	47
CVEN	2004	88	79	6	50	5	36
CVEN	2006	69	80	6	43	5	40
CVEN	2007	81	95	10	33	NM	NM
CVEN	2008	88	86	9	31	10	43
EVEN	2006	62	62	13	13	14	15
EVEN	2007	75	80	15	27	15	28
EVEN	2008	76	88	21	22	30	27
GEEN	2006	95	84	19	97	NM	NM
PROJ	2006	71	100	4	24	NM	NM
PROJ	2008	79	95	0	19	NM	NM
TOTAL		**82**	**84**	**103**	**359**	**80**	**188**

NM = not measured

Other written surveys were also administered to the freshman classes and may provide interesting information. The MGUDS-S[12,13] cultural competency assessment was completed by 99 female and 319 male students in CVEN, EVEN and GEEN in 2006 to 2008. Eight author-created questions to evaluate the students' awareness of the importance of community and cultural differences on engineering solutions were given along with the MGUDS-S survey. [14,15] The full 61 question Community Service Attitudes Scale (CSAS) survey[16,17] was completed by 28 EVEN students in 2007; Wilde's Cognitive Style survey[18,19] derived from Myers-Briggs personality types was completed by 76 EVEN students in 2007 and 2008. Potential differences in the cognitive style preferences of students based on gender will not be discussed in this paper.

In addition to the quantitative data from the various surveys, the students in the CVEN and EVEN first-year courses write reflective essays at the end of the semester. They comment on their attitudes about engineering, how these have changed, and if they intend to change majors. The guidelines for the essays are very general, so the information that the students choose to include in their essays are particularly revealing about what is most relevant in their own minds. Kilgore[10] writes: "When called upon to reflect more freely about engineers and engineering, first-year students revealed richer and more complex perspectives on engineering ways of thinking than when asked closed-ended quantitative or qualitative questions. The mixed analytical methods presented here both support one another and also provide nuanced insight into men's and women's perspectives of what kinds of thinking would be involved in the study and practice of engineering." Student essays from CVEN have been coded in Fall 2003, Fall 2004, Fall 2006, and Fall 2008 (missing years are when the course had a different instructor). Journals from EVEN have been coded in Fall 2006, 2007, and 2008.

Results and Discussion

Students Attitudes toward Engineering's Benefit to Society

Student responses to the four society-related questions from the Pittsburgh Freshman Engineering Attitudes Survey (PFEAS) reveal their attitude regarding engineering's benefit to society. In this study, males had a more favorable view of engineers' role in society than female students based on their answers to two of the PFEAS questions and the overall average response to all four PFEAS questions (based on $p<0.05$ from 2-tailed student's T-test in Excel). Because previous studies have indicated that females want to benefit society through their work, the continuing poor perception of engineering as a helping profession among females may reflect recruiting problems.

Table 2. Average and Standard Deviation of Student Responses to PFEAS Questions on 5-point Likert Scale; T-test results comparing female vs. male students are also shown

Study and student participants	Q1: Engineers contribute more to making the world a better place	Q2: Engineering is more concerned with improving the welfare...	Q3: Engineers have contributed greatly to fixing problems in the world	Q4: Technology plays an important role in solving society's problems	Average of 4 PFEAS Ques-tions
Female, n=99	3.19 $\pm$ 1.20	3.19 $\pm$ 1.26	4.22 $\pm$ 0.73	4.07 $\pm$ 0.81	3.67
Male, n=317	3.58 $\pm$ 0.94	3.40 $\pm$ 1.01	4.24 $\pm$ 0.73	4.07 $\pm$ 0.89	3.82
Male vs Female t-test p values	*0.00*	*0.02*	*0.57*	*1.00*	*0.00*
Hilpert[9], n=374 (16.7% women)	3.81 $\pm$ 0.98	3.40 $\pm$ 0.93	4.23 $\pm$ 0.64	4.27 $\pm$ 0.77	3.93
Besterfield 1999[8] Large; n=3210					3.34

In the Besterfield[8] study using 1998 data from 1353 female and 4827 males at 15 different schools, males had a significantly more positive perception than females at 5 schools. This difference was only about 0.3 points higher; although it was very difficult to read the graphs in the paper to extract quantitative information.

Among the female students there were small (but not significant) differences in the ratings based on major: EVEN majors were slightly more favorable, followed by CVEN majors, and OPEN engineering majors. The small number of female students in this study may limit the ability to detect these differences (33 EVEN, 17 CVEN, 22 OPEN). The PFEAS question with the greatest difference was Q4, where the p value for EVEN vs OPEN female students was 0.10. Among the male students, PFEAS scores were highest among CVEN majors, followed by OPEN majors, and finally EVEN majors; these differences were not statistically significant. Students generally have not yet established a strong identity with a particular engineering major in their

first semester, and often have only a vague understanding of different majors, so the lack of effect of declared major is not surprising.

The more recent Hipert[9] data shows a more positive view of the students than the earlier Besterfield[8] study, although the Hilpert[9] participants were not specifically students in first year courses so they may have been older. The data from the male students in the current study agrees well with the Hilpert[9] data. Based on the male students in this study there were not significant differences in the response of first semester students compared to older students.

Other Survey Data

It is possible that there may be correlations between students' attitudes toward the beneficial role of engineering in society and other attitudes or aptitudes. The author self-created eight questions to help understand students' awareness of the importance of cultural differences on appropriate engineering solutions to community problems. This is particularly important in view of the popularity of Engineers Without Borders (EWB) on our campus and the stated interest of many students in EWB and our associated Engineering for Developing Communities (EDC) program. These questions have not been validated or evaluated for reliability but the results are still somewhat enlightening. Example findings are summarized in Table 3 below. The results indicate that female students appear more aware of cultural differences and their importance to the success of engineering projects.

Table 3. Summary of student responses to questions on a Likert scale from 1 (strongly disagree) to 6 (strongly agree)

Question	p-value from M v. F t-test	Female students		Male students	
		Average $\pm$ stdev	n	Average $\pm$ stdev	n
It is important for engineers to consider the broader potential impacts of technical solutions to problems on minority racial and ethnic groups in the effected population.	0.00	4.98 $\pm$ 0.87	93	4.58 $\pm$ 1.04	255
The technology that is used in the U.S. is likely the best technology to use to solve similar technical problems in other countries.	0.00	3.38 $\pm$ 1.06	93	3.77 $\pm$ 1.20	255
Technical constraints and criteria are the most important element determining the success of an engineered solution.	0.08	3.70 $\pm$ 1.06	93	3.92 $\pm$ 0.94	255

The results in Table 3 which specifically relate to the potential effects of culture on engineering are mirrored in the results from the MGUDS-S survey. The MGUDS-S instrument was developed to evaluate universal-diverse orientation (UDO). UDO is "an attitude toward all other persons which is inclusive yet differentiating in that similarities and differences are both recognized and accepted."[12] Subscales of the instrument assess relativistic appreciation of self and others, seeking diversity of contact with others, and a sense of connection with larger society or humanity. In this study, females had significantly higher cultural competency scores in all 3 subareas and overall UDO (p values < 0.00). So this supports the thinking that females are more aware of differences between cultures and comfortable with these differences.

On the Community Service (CSAS) survey there was a significantly higher Phase 3 Defense score of the female students.[20] This reflects the students' reassessment of potential responses to community needs, and includes an evaluation of the costs of helping, the benefits of helping, and the seriousness of the need. This generally agrees with the results from the Bauer et al. study[21] that found minimal differences in attitudes due to gender. In their study, the only significant difference was that females had a higher Phase 1 awareness score than males, although they pooled the student and faculty data for this comparison. Similar to the Bauer study, female students in the first-year EVEN course in 2007 (n=14) had a more favorable attitude toward community service than males (n=14) on all aspects except Phase 1 ability (recognition of the ability to help); however, these differences were not large enough to be statistically significant. Further results from a larger number of male and female students might determine that these differences are significant. However, the results are suggestive that incorporating service learning projects into engineering courses could help retain female students.

Information from the Reflective Essays

In addition to the quantitative data from the Likert-based surveys, the students in the CVEN and EVEN first-year courses write reflective essays at the end of the semester. They comment on their attitudes about engineering, how these attitudes may have changed, and if they intend to change majors. The guidelines for the essays are very general, so the information that the students choose to include in their essays provides insight into about what is most relevant in their own minds. Many of the EVEN students commented that they were surprised at how much of EVEN is devoted to protection of human (public) health and safety rather than the environment. Many CVEN students commented that they were surprised that CVENs were concerned with protection of human health and the environment, versus just building structures. Both sets of students also seemed surprised that regulations, public comment, and a balance of factors including costs, safety, etc. were such a big part of the job rather than merely technical constraints. While these aspects appealed to some students, many others appeared dismayed at the complexity and lack of certainty, and noted they would have preferred technical-driven design.

Coding individual student essays to identify the frequency that themes emerge is a time consuming process but can yield useful quantitative results from qualitative information. This requires reading a number of essays, developing a scoring rubric, and then re-reading all the essays. This exercise can be somewhat stream-lined when students submit their essays electronically by searching for key words in their essays. However, this process does not take into context word usage, student misspellings, etc. The EVEN essays were targeted for detailed coding because of the higher percentage of women in these courses. However, this major is more likely to select students who care about people and society than other engineering majors that are perceived as more technically focused. The CVEN student journals have not been coded as rigorously. The 2003 and 2004 essays were coded in 2005 by a graduate student with follow-up verification by the instructor. However, additional themes emerged from the EVEN essays in 2006, and the older CVEN essays have not been re-read for these themes.

The most relevant information in the present context is to look at the percentage of the students who discussed how the discipline serves and/or benefits the public and society, and in particular if this aspect of the discipline appeals to them. Results are summarized in Table 4 below. Particular care should be taken when interpreting the results from the females in the CVEN course due to the very small number of students (see Table 1). The results appear to support the idea that females are more aware of the potential beneficial impacts of engineering on society and more interested in these aspects of the profession. It also shows that engineering to serve the developing world or impoverished communities (via the Engineers Without Borders (EWB) student group on campus or in general) is of interest to more females than males.

Table 4. Percentage of male and female students discussing public service and engineering to serve the developing world in their reflective essays

		Serve the Public / benefit society		EWB/engineering for developing communities	
Course	Year	% female essays	% male essays	% female essays	% male essays
CVEN	2003	50	21	25	36
	2004	40	22	40	31
	2006	60	60	0	41
	2008	80	55	40	26
EVEN	2006	79	73	43	20
	2007	53	57	33	32
	2008	73	67	70	52
TOTAL		67	54	47	34

Examples of student interests will be illustrated by some quotes. One female student in the EVEN course wrote: "Environmental engineering also does do a lot for the greater good and can help people in poverty. This branch works more directly with the people who it serves than other branches of engineering. I really like this focus on service and in whatever I do, I want to help make the world a better place." She was deciding between a career in EVEN or becoming a doctor.

Some example quotes from female students in the Civil Engineering class include:

> "[I enjoyed] physics and math classes in high school… but I thought that a career should have a greater impact on people."
>
> "This part of engineering takes into account public welfare and works for the benefit of society by building structures that help to make the world a safer place with higher standards."

One of the female students in the Civil Engineering class stated that she was planning to change her major to political science and possibly minor in international affairs. She states:

> "I plan to work with nonprofit organizations.... I would really like to play a key role in the rebuilding of Afghanistan, Iraq, and whatever other wars that may come about and cause destruction and displacement in this lifetime. I'd be happy doing work anywhere that helps disadvantaged people."

Her goals could certainly be achieved with a background in engineering, so it is unfortunate that she is leaving engineering. The CVEN first year course included a case study of disaster relief

worker Fred Cuny[22], so the student was certainly aware of the potential application of an engineering degree to her interests. She discussed disliking the heavy workloads in her engineering courses and a preference for her philosophy course in her essay, which probably led her to consider other majors.

Summary

This study confirms previous findings that female students have a less favorable impression of how engineering benefits society than males among incoming first year engineering students. Media coverage may impact these impressions. Highlighting engineers' beneficial impacts on society during outreach events to high school students may help recruit more students into engineering. Female students appear to have a greater understanding of cultural differences and the impacts of these differences to appropriate engineering solutions to problems. A higher percentage of female students appear motivated by benefitting society, so emphasis on these impacts by all types of engineers during first year courses may enhance the retention of female students in engineering. Most of the students in this study were majoring in Civil or Environmental Engineering, and it would be worth looking at other majors to determine if similar findings result. Of even more benefit to retaining female students may be the inclusion of service learning opportunities in engineering.[7,23]

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Bibliography

1. National Science Foundation. 2009. Women, Minorities, and Persons with Disabilities in Science and Engineering. TABLE B-9. Undergraduate enrollment in engineering programs, by sex, race/ethnicity, and citizenship: 1995–2006. http://www.nsf.gov/statistics/wmpd/tables/tabb-9.xls
2. Gibbons, M.T. 2007. Engineering by the Numbers. American Society for Engineering Education. http://www.asee.org/publications/profiles/upload/2007ProfileEng.pdf
3. Bielefeldt, A.R. 2006. Attracting Women to Engineering that Serves Developing Communities. American Society of Engineering Education (ASEE) Conference and Exposition. Women in Engineering Division. June, Chicago, IL.
4. Mihelcic, J.R., L.D. Phillips, and D.W. Watkins. 2006. Integrating a global perspective into education and research: Engineering international sustainable development. Environmental Engineering Science. 23 (3), 426-438.
5. Widnall, S. 2000. Digits of pi: Barriers and enablers for women in engineering. Presented at the S.E. Regional NAE Meeting, Georgia Institute of Technology. April 26.
6. Hokanson, D.R., J.R. Mihelcic, and L.D. Phillips. 2007. Educating Engineers in the Sustainable Futures Model with a Global Perspective: Education, Research & Diversity Initiatives. International Journal of Engineering Education, 23(2), 254-265.
7. Matusovich, H., D. Follman, W. Oakes. 2006. Work in Progress: A student perspective – why women choose service learning. 36th ASEE/IEEE Frontiers in Education Conference. Oct. 28-31, San Diego, CA. Session S2G; pg. 7 - 8.
8. Besterfield-Sacre, M., M. Moreno, L.J. Shuman, C.J. Atman. 2001. Gender and ethnicity differences in freshmen engineering student attitudes: a cross-institutional study. Journal of Engineering Education. 90(4), 477-489.

9. Hilpert, J., G. Stump, J. Jusman, and W. Kim. 2008. An exploratory factor analysis of the Pittsburgh Freshman Engineering Attitudes Survey. 38th ASEE/IEEE Frontiers in Education (FIE) Conference. Oct 22-25, Saratoga Springs, NY. F2B, 9-14.
10. Kilgore, D., K. Yasuhara, J.J. Saleem, and C.J. Atman. 2006. What brings women to the table? Female and male students' perceptions of ways of thinking in engineering student and practice. 36th ASEE/IEEE Frontiers in Education (FIE) Conference. Oct. 28-31, San Diego, CA. S2G, 1-6.
11. Besterfield-Sacre, M., M. Moreno, L.J. Shuman, C.J. Atman. 1999. Comparing Entering Freshman Engineers: Institutional Differences in Student Attitudes. Proceedings of the American Society for Engineering Education Conference, South Carolina. Session 1430.
12. Fuertes, J.N, M.L. Miville, J.J. Mohr, W.E. Sedlacek, D. Gretchen. 2000. Factor structure and short form of the Miville-Guzman Universality-Diversity Scale. Measurement & Evaluation in Counseling and Development. 33(3), 157-170.
13. Miville, M.L., P. Holloway, C. Gelso, R. Pannu, W. Liu, P. Touradji, and J. Fuertes. 1999. Appreciating Similarities and Valuing Differences: The Miville-Guzman Universality-Diversity Scale. Journal of Counseling Psychology. 46(3), 291-307.
14. Bielefeldt, A.R. and K. High. 2007. Work in Progress: Assessing the Cultural Competency of Engineering Students. Frontiers in Education (FIE) Conference. Oct. 10-13.
15. Bielefeldt, A.R. 2008. Cultural Competency Assessment. Proceedings of the American Society for Engineering Education Conference & Exposition.
16. Shiarella, A.H. and A.M. McCarthy. 2000. Development and Construct Validity of Scores on the Community Service Attitudes Scale. Educational and Psychological Measurement. 60 (2), 286-300.
17. Shiarella, A.H., A.M. McCarthy, M.L. Tucker. 1999. Refinement of a Community Service Attitude Scale. Paper presented at the Annual Meeting of the Southwest Educational Research Association. 35 pp.
18. Wilde, Douglass J. 2004. Team Creativity. Education that Works: The NCIIA 8th Annual Meeting. March 18-20. p. 77-80.
19. Wilde, Douglass J. 2007. Team Dynamics Panel, Handouts. National Capstone Design Course Conference. June 13-15, Boulder, CO.
20. Bielefeldt, A.R. 2007. Community Service Attitudes of First-Year Students and Senior Students Working on Service Learning Design Projects. Association for Environmental Engineering and Science Professors (AEESP) Biennial Conference - Interactions at the Interface: Making the Connections Between Environments, Disciplines and Nations. July 28 - August 1. Blacksburg, VA.
21. Bauer, E.H., B. Moskal, J. Gosink, J. Lucena, D. Munoz. 2007. Faculty and Students Attitudes Toward Community Service: A Comparative Analysis. Journal of Engineering Education. 96(2), 129-140.
22. "Fred Cuny (1944-1995)-Disaster Relief Innovator" Online Ethics Center for Engineering 6/6/2006, National Academy of Engineering. Accessed 2/4/2009; www.onlineethics.org/CMS/profpractice/exempindex/cunyintro.aspx
23. Barrington, L. and J. Duffy. 2007. Attracting under-represented groups to engineering with service-learning. Proceedings of the American Society for Engineering Education Annual Conference & Exposition. AC 2007-2871.