WEPAN PILOT CLIMATE SURVEY
Exploring the Environment for Undergraduate Engineering Students

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ABSTRACT

The primary purpose of the WEPAN Pilot Climate Survey was to develop a method to assess engineering student perceptions of the educational climate at colleges and universities in the U.S. More than 8000 male and female undergraduate engineering students from 29 institutions responded to the survey. Participating institutions used their individual reports to gain insight into specific aspects of the environment on their campuses that require attention for all students. Aggregate data yielded interesting findings regarding gender differences in areas related to student self-confidence and self-esteem that require further study.

INTRODUCTION

In the US, the demand for engineers and computer scientists is growing. During the past four years, actual engineering employment increased from 1,717,000 to 2,051,000, a growth of almost 20%[1]. What is alarming is that the number of bachelor's degrees earned in engineering has fallen by more than 14 percent since 1987[2]. Demographic trends indicate that by the year 2000, 68% of the new entrants into the US labor force will be women and minorities[3]. Yet, the field of engineering has traditionally been and continues to be primarily occupied by men with women representing just 8% of the engineering workforce[4]. Given the anticipated trends in the workforce and the decreasing interest in majoring in engineering among all students, one area that requires further research are the factors that deter women from completing engineering degrees.

Although the percentage of females who received bachelor's degrees in engineering from 1992-1998 increased from 15.7% to 18.6%, the total number of women increased by only 824 students[5]. In fact, in 1998, for the first time in 6 years, there was a decline of 1% representing 364 female students in just one year. Women drop out of engineering at higher rates than men do. The persistence rates of men in science, math and engineering majors varies between 39 to 61 percent and for women it varies between 30 to 46 percent, depending upon the type of institution[6]. The research indicates that women's educational experiences differ considerably from men, even when they attend the same institutions and the same classes. According to the 1998 report, *Women and Men of the Engineering Path,* women and men earn similar grades in engineering courses; and the women who leave engineering have higher grades than the men who leave. Women who leave engineering do not leave because of poor academic performance, though they do evidence a higher degree of academic dissatisfaction[7]. What contributes to this higher degree of academic dissatisfaction? The WEPAN Pilot Climate Survey, funded by the Engineering Information Foundation conducted a survey to identify some of these factors.

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[1] Campbell, G. (1997). Engineering and Affirmative Action: Crisis in the Making. *NACME Research Letter, Special Edition*. New York, NY. (7).

[2] Engineering Workforce Commission of the American Association of Engineering Societies, Inc. (1999). Engineering and Technology Degrees 1998. Washington, D.C. Annual Series.

[3] Changing America: The New Face of Science and Engineering. (1989, December). Final Report of the Task Force on Women, Minorities, and the Handicapped in Science and Technology. National Science Foundation,
Washington, DC.

[4] Engineering Workforce Commission (1995, April). *Engineers*. American Association of Engineering Societies. Washington. D.C.

[5] Engineering Workforce Commission of the American Association of Engineering Societies, Inc. (1999). Engineering and Technology Enrollments 1998. Washington, D.C. Annual Series.

[6] Strenta, C, et al. (1993) Choosing and Leaving Science in Highly Selective Institutions: General Factors and the Questions of Gender. New York: Alfred P. Sloan Foundation.

[7] Adelman, C. (1998). Women and Men of the Engineering Path: A Model for Analyses of Undergraduate Careers. U.S. Department of Education and The National Institute for Science Education. Washington, DC.

RELATED RESEARCH

Research indicates that the largest drop out rate for women is at the end of the freshman year and beginning of sophomore year. A six-year longitudinal study of female undergraduates in engineering has found that the primary reasons for switching are a combination of losing interest in science and engineering, being attracted by another field, and being discouraged by academic difficulties and low grades[8]. Not surprisingly, the reasons for leaving are also the most frequently reported concerns or barriers to progress reported by women students who persist: fear of losing interest, intimidation, lack of self-confidence, poor advising, and not being accepted in their department. Seymour and Hewitt suggest that, for many women, experiencing engineering education as a distinct minority automatically puts them at a psychological disadvantage with regard to a lack of confidence[9].

Grandy found that women who received engineering degrees found their courses more difficult and less enjoyable than did men[10]. In addition, women rated their study skills higher than did men, while the opposite was true in self-assessment of problem-solving skills and in self-image as future engineers. The University of California at Davis conducted a survey of 400 undergraduate engineering students[11]. In their study, they found there were no differences between men and women in their positive responses to treatment of faculty members as fair, and their comfort level in requesting help from instructors outside of class. However, twice as many of the women (30% vs. 15%) indicated significant discomfort about participating in class as well as successfully completing their degree.

Crawford and MacLeod report that low self-esteem inhibits the performance of women in all fields in higher education[12]. Female students tend to feel less confident of their intellectual abilities and tend to feel they must be very prepared and know a great deal before expressing their ideas in class. Women often do not interact in classrooms out of fear that they "might appear unintelligent in the eyes of other students"[13]. Rayman and Brett also found that women have lower self-confidence, perceived ability, and self-reliance than men, even though their grade point averages are equal to or higher than men[14].

These studies identify the challenges that face women in the classroom. However, according to McIlwee and Robinson, women are more successful in the classroom than in the laboratory, but the latter is an integral part of engineering education[15]. In 1982 the Association of American Colleges (AAC now AAC&U) Project on the Status and Education of Women published their report, *The Campus Climate: A Chilly One for Women?*[16] The AAC report concluded that the learning environment on campuses negatively impacts the self-confidence of women and

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[8] Brainard, S.G. and Carlin, L. (1998, October). A Six-Year Longitudinal Study of Undergraduate Women in Engineering and Science. *Journal of Engineering Education*, 87 (4), 369-375.

[9] Seymour, E. & Hewitt, N.M. (1997). Talking About Leaving: Why Undergraduates Leave the Sciences. Boulder, Co: Westview Press.

[10] Grandy, J. (1994). Gender and Ethnic Differences Among Science and Engineering Majors: Experiences, Achievement, and Expectations. RR-94-30. Princeton, NJ: Educational Testing Service.

[11] Henes, R., Bland, M.M., Darby, J., & McDonald, K. (1995). Improving the Academic Environment for Women Engineering Students Through Faculty Workshops. *Journal of Engineering Education*, 84 (1), 59-67.

[12] Crawford, M. & MacLeod, M. (1990). Gender in the College Classroom: An Assessment of the "Chilly Climate" for Women. *Sex Roles* 23, (¾), 101 – 122.

[13] Ibid., 116.

[14] Rayman, P. & Brett, B. (1995). Women Science Majors: What Makes a Difference in Persistence after Graduation? *Journal of Higher Education*, 66 (4), 388–414.

[15] McIlwee, J.S. & Robinson, J.G. (1992). Women in Engineering: Gender, Power and Workplace Culture. Albany, NY. State University of New York Press.

[16] Sandler, B. & Hall, R. (1982). The Classroom Climate: A Chilly One for Women? Washington, DC: Project on the Status and Education of Women, Association of American Colleges.

diminishes their academic and professional aspirations during and after college[17]. Since then, institutional climate studies have been conducted at institutions such as Stanford University, the University of Michigan, Purdue University, Georgia Tech, George Washington University, the University of Arizona, Penn State and many others. Most studies were initiated by presidential commissions and attempted to identify policies, practices or perceptions that impact women on campus. As research in this area has developed, climate studies have become more specific, and address issues such as, the climate for gays and lesbians, students with disabilities, ethnic minorities, and women in science and engineering [18] [19].

Institutional studies use a variety of methods including focus groups, surveys, interviews and secondary analysis of existing databases such as salaries, hiring and retention rates, and sexual harassment policies. Although limited in scope, research has been conducted across institutions using existing databases. Ernest Pascarella and his associates[20] attempted to measure the link between climate and student's cognitive development using data from the National Study of Student Learning. Linda Sax[21] used data from the Cooperative Institutional Research Program to examine factors that might predict the student enrollment in science, math and engineering graduate programs.

Institutions have also used national instruments that measure student satisfaction such as ACT's College Outcomes Survey or Student Opinion Survey, the College Student Experiences Questionnaire developed by George Kuh, or the College Student Survey developed by the Astin's[22] at UCLA. The advantage of the instruments mentioned above is that they allow institutions to determine how well they are doing relative to other institutions that have used the same instrument. However, the instruments are inadequate for determining student perceptions about the campus climate for women and men in engineering.

BACKGROUND OF WEPAN CLIMATE PILOT SURVEY

The Center for Women in Science & Engineering (WISE) and the Office of Educational Assessment (OEA) at the University of Washington (UW) designed a survey in 1993 to assess the climate in engineering for undergraduate engineering students at the University of Washington. This survey has been administered each year since 1993 [23]. The survey, referred to as the Quality of Engineering Education Survey, is administered to male and female students to identify if differences in perceptions of barriers exist; and, if so, to then identify programs and policies to address those barriers. Topics of the survey include student perceptions of the quality of: teaching assistants, teaching, engineering labs, departmental assistance, and curriculum.

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[17] Sandler, B. & Hall, R. (1984). Out of the Classroom: A Chilly Climate for Women? Washington, DC: Project on the Status and Education of Women, Association of American Colleges.

[18] DeVries, D.B., & LaSalle, L. (1993). Research Informing Praxis: Addressing the Campus Climate for Lesbians, Gay Men, and Bisexual People. *Proceedings of the American Educational Research Association*, Atlanta, Georgia.

[19] Hurtado, S., Allen, W., Milem, J., & Clayton-Pedersen, A. (1998, Spring). Enhancing Campus Climates for Racial/Ethnic Diversity: Educational Policy and Practice in Review of Higher Education, 21 (3), 279–302.

[20] Pascarella, E., Whitt, E., Yeager, P., Edison, M, Terenzini, P., Nora, A. & Hagedorn, L.S. (1997, March/April). Women's Perceptions of a "Chilly Climate" and Their Cognitive Outcomes during the First Year of College. *Journal of College Student Development*, 38 (2), 109–124.

[21] Sax, L. (1996, November). The Impact of College on Post-College Commitment to Science Careers: Gender Differences in a Nine-Year Follow-up of College Freshmen. Paper presented at the Annual Meeting of the Association for the Study of Higher Education.

[22] Bauer, Karen. (1998, Summer). Campus Climate: Understanding the Critical Components of Today's Colleges and Universities. *New Directions for Institutional Research*. San Francisco: Jossey-Bass.

[23] Brainard, S.G., Laurich-McIntyre, S., & Carlin, L. (1996). Retaining Women in Science and Engineering. *Journal of Women and Minorities in Science & Engineering,* 2, (4), 255–267.

Modeled after the University of Washington's survey, a national pilot survey was designed by WEPAN, Women in Engineering Programs & Advocates Network and funded by the Engineering Information Foundation. The objectives of this project were to:

- Provide data to participating institutions that would help them identify areas that required attention to improve the academic climate for all students.
- Provide data to participating institutions regarding student attitudes and on gender and ethnicity differences.
- Provide aggregate data to participating institutions to provide opportunities for benchmarking.

METHODOLOGY

An announcement was sent on WEPAN's listserve inviting institutions to participate in this survey. Thirty-five institutions responded. Twenty-nine institutions that were willing to take on the responsibilities associated with the distribution and collection of the surveys were selected to participate. The WEPAN Student Experience Survey focused on the following major areas: quality of teaching, quality of teaching assistants, quality of labs, quality of departmental assistance, general questions about engineering, and demographic data. Pilot sites were able to add several questions that could be tailored to their institution. Those questions are not analyzed in this report, but appear in the individual institutions' reports.

Surveys were mailed to the contact person at 29 pilot sites. A total of 29,840 surveys were distributed. Pilot site contacts identified the appropriate student sample which included all female Caucasian, African American, Hispanic and Native American undergraduate engineering students, and an equally matched (by class level) random sample of males. In addition, all under represented minority males had to be included in the male sample. Surveys were distributed in March and April of 1998, approximately four weeks prior to any major exam period to facilitate a better response rate and a less strenuous time period for students. Each pilot site was given the option of having students mail in their individual survey to the OEA (Office of Educational Assessment, University of Washington) in a postage paid envelope, or collecting the surveys in a central location(s) and mailing them back to OEA all at once. Some pilot sites used incentives such as coupons or raffles. Each pilot site was also required to send a follow-up postcard or e-mail to students who did not respond within 10 days.

The survey instrument contained 45 items by which the students evaluated various aspects of their educational experiences and how they were being affected by these experiences. The items were rated on a Likert scale from 1 to 5 (lowest to highest). Seven additional items addressed demographic information. Institutions also had the opportunity to add 7 questions specific to their university. The results of the institution specific questions were not included in the aggregate data.

The large sample size of the survey provided the basis to consider only differences that exceeded $p < .001$ significance level. For statistical analyses, independent t tests were used to compare male and female responses. One way analyses of variance were used to test differences among class levels and ethnic groups and a linear trends analysis was used to report any significant increases over class levels.

SUMMARY OF RESULTS

The institutions serving as pilot sites and the number of male and female respondents from each are listed in Table 1. As indicated in this table, 8076 students responded to the survey. Eliminating the 2% who failed to answer or marked "other", 21% of the respondents indicated their class level as freshmen, 21% sophomores, 26% juniors, and

37% seniors. The sample included 43% male students and 57% female students. Assuming that surveys were sent to an equal number of each gender, females are clearly over-represented in the sample. Also, there was considerable variation in the number of enrolled engineering students who were sampled at each institution. Consequently, the numbers of respondents varied widely, from 869 at the University of Michigan to 25 at Dartmouth University. The overall response rate was 27% with response rates at each pilot site varying from 14% to 61%.

Table 1
Institutions and Response Frequencies

	Male		Female		Not	
	Number	Percent	Number	Percent	Indicated	Total
Arizona State University	116	35.9	207	64.1	2	325
California-Berkeley, University of	249	58.9	174	41.1	1	424
Colorado School of Mines	188	45.9	222	54.1	2	412
Colorado-Boulder, University of	94	36.7	162	63.3	3	259
Cornell University	171	45.8	202	54.2	3	376
Dartmouth University	14	56	11	44	0	25
Idaho, University of	46	47.4	51	52.6	2	99
Illinois Institute of Technology	17	27.9	44	72.1	0	61
Illinois-Chicago, University of	67	39.2	104	60.8	4	175
Iowa, University of	103	42.9	137	57.1	5	245
Kansas State University	100	37.7	165	62.3	2	267
Kentucky, University of	90	44.1	114	55.9	0	204
Maryland, University of	76	37.1	129	62.9	2	207
Michigan School of Technology	179	42.6	241	57.4	5	425
Michigan, University of	350	40.6	512	59.4	7	869
Minnesota-Duluth, University of	21	40.4	31	59.6	0	52
Mississippi State University	132	52.8	118	47.2	3	253
Missouri-Colombia, University of	79	41.4	112	58.6	4	195
Northeastern University	63	46.3	73	53.7	3	139
Pittsburgh, University of	126	49.2	130	50.8	2	258
Purdue University	308	38.5	493	61.5	4	805
Rhode Island, University of	23	37.1	39	62.9	1	63
Rose-Hulman	56	40.3	83	59.7	0	139
San Jose State University	59	38.8	93	61.2	1	153
Stevens Institute of Technology	74	46.3	86	53.8	2	162
Tennessee, University of	114	45.6	136	54.4	3	253
Texas-Austin, University of	202	36.2	356	63.8	4	562
Virginia Polytechnic Institute	194	43.1	256	56.9	3	453
Washington, University of	153	58.4	109	41.6	5	267
Total	3464	43.0	4590	57.0	73	8127

Each participating institution received a report of the student responses analyzed by various demographic variables including gender, for their students and for all students in the sample. In addition, each institution received an electronic copy of the entire data set with their students flagged. At this stage of development, cross campus comparisons were not within the scope of this project. However, looking across the 29 institutions surveyed, a large number of statistically significant differences were evident. This survey was able to differentiate strengths and weaknesses on each campus, pointing to areas of needed improvement.

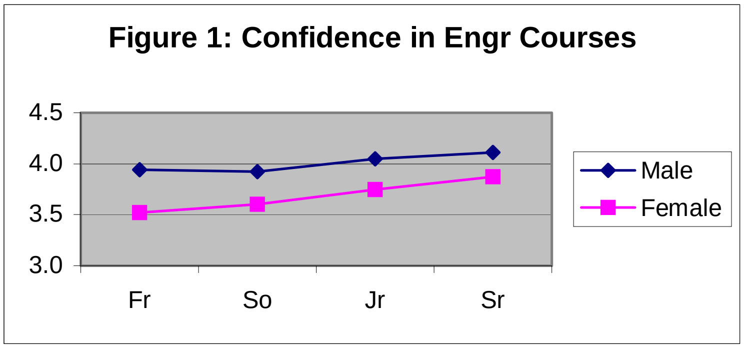
The objective of this survey and of this report does not warrant a full analysis of all items. The focus here will be on differences in responses between female and male students. In making this comparison, many items achieved statistically significant, although given the large sample size, not all of these differences were meaningful. For this report, highlighted are several items that the literature and the experiences in this survey indicate differentiate the two genders.

There were interesting differences in questions that concerned students' perception of academic confidence. Students were asked to rate *How confident are you in your abilities in your college: engineering courses? chemistry courses? math courses? physics courses?*

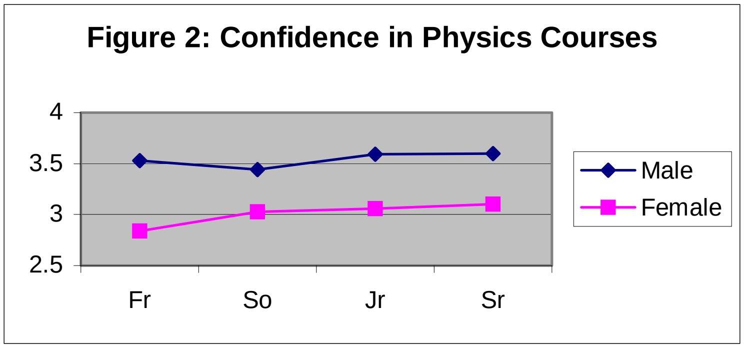
- There were no differences by gender or class for confidence in math courses.

- There was no overall difference in average ratings of confidence in chemistry courses between females and males. There was a slight tendency for these ratings to decrease over the four classes.

- Males exhibited higher average ratings than females in confidence in engineering courses at all class levels ($p < .001$) and both groups showed a gradual increase over four years (See Figure 1).



The difference between males and females for confidence in physics courses was significant across all classes ($p< .001$). The gap between males and females was largest for the freshman and smallest for the sophomores (See Figure 2).



Students were also asked to rate how their academic self-confidence had changed since entering college. The 5-point scale went from decreased (1) to stayed the same (3) to increased (5). The results by class level are found in Figure 3. Differences by gender and class were significant ($p < .001$). The ratings of males exhibited higher average increases than females at all points. Furthermore, the differences between average male and female ratings were constant over the four classes, and both males and females indicated higher average increases with each successive class

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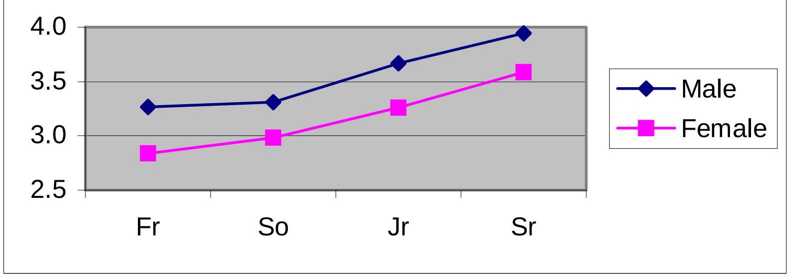
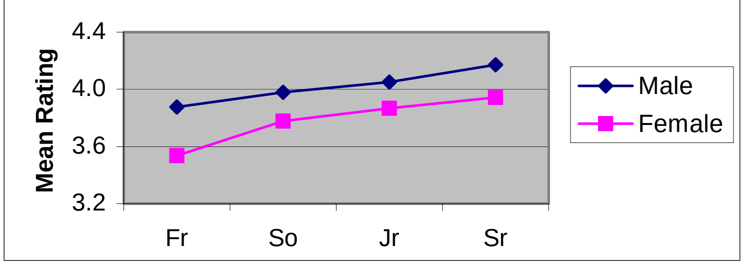
Figure 3: Academic Self-Confidence



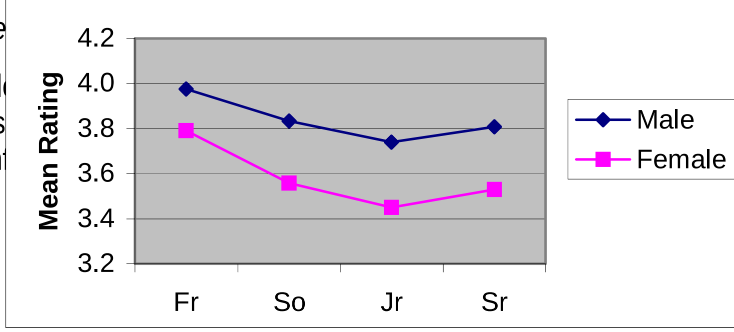
One other question related to confidence is: *Are you confident that engineering is the right major for you?* The average rating across class levels for males and females is presented in Figure 4. Both the increases in ratings and the differences between the genders are statistically significant ($p < .001$). Males show higher average ratings than females at all points. The difference is greatest among freshman; however, females fail to gain much ground. Generally, more advanced classes feel more positive about their choice of engineering as their major.

Figure 4: Engineering Is Right Major



The results of three other items are of particular interest in assessing the differences between the way in which males and females experience the engineering curriculum. These items address topics that have often surfaced in research and in discussions with female engineering students.

Figure 5: Comfort with Lab Equip.



- *How comfortable are*

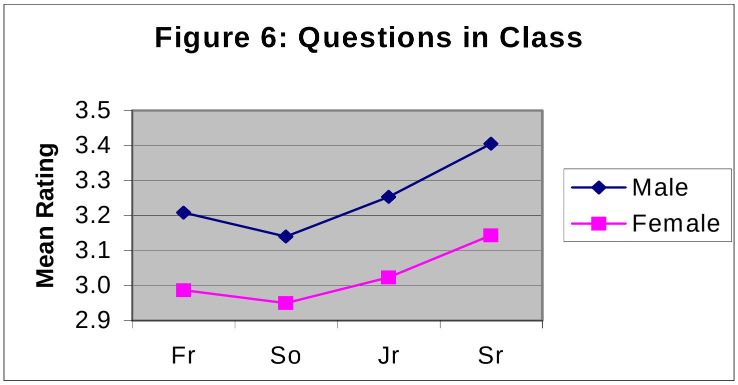
Females rated this item l … ach class level (See Figure 5). Both groups s … some gain back by seniors. Juniors are the least con…

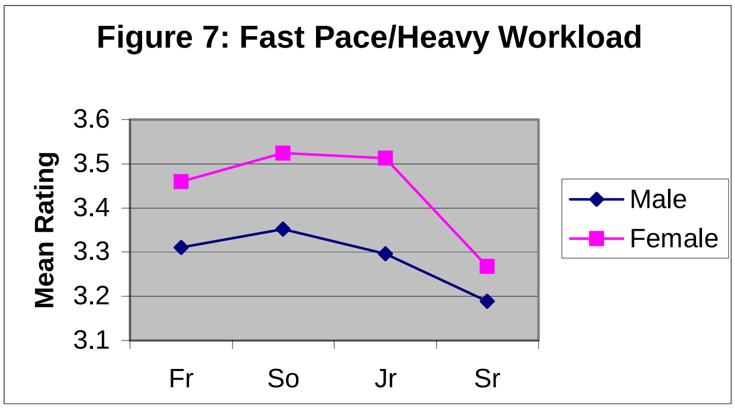
- *How comfortable do you feel asking questions in class?*

Figure 6 presents the mean ratings on this item for males and females within each class level. Females feel less confident in asking questions in class (p < .001). The least confident group was sophomores, but thereafter confidence increased for both genders.

- *Do you feel overwhelmed by the fast pace and heavy workload?*

Females feel more overwhelmed by the fast pace and heavy workload than males (p < .001). As Figure 7 indicates, both males and females feel least overwhelmed in their senior year, where the difference between the genders is smallest, and most in their sophomore and junior years, where the differences are the greatest.





There were also interesting responses to questions concerning participation in study groups and student professional societies. When asked, *How involved are you with study groups?*, the average response of female students 3.07, while male students responded with an average rating of 2.72 ($p < .001$). Active participation in student professional societies and engineering related activities was rated low by all students. However, women rated their participation at a level of 2.77 which was significantly higher than male students who rated this item at 2.38 ($p < .001$).

DISCUSSION AND CONCLUSIONS

The primary purpose in conducting the WEPAN survey at 29 campuses was to develop a method for assessing engineering student perceptions of the academic climate. In fact, participating institutions have already used their individual reports to gain some insight into specific aspects of the campuses' academic environment that needs attention for both male and female students. For example, institutions have distributed the reports to their presidents, deans, faculty, and faculty committees. As a result, task forces have been established to review curricular and programmatic changes, including strengthening of programs aimed at improving the academic and social environment for female students. Other institutions have used the data to compare teaching methods and lab instruction between departments and are considering changes as a result. Although not within the scope of this grant, the authors of this report intend to follow-up with participating institutions to determine specific actions that have been taken as a result of this project.

In the process of developing and implementing this assessment tool at 29 universities, data on student perceptions were obtained from over 8,074 students. Analyses of the data, focused particularly on differences between male and female students suggest some interesting issues. In many cases this data confirms earlier research but with a much larger, multi-campus sample. Perhaps the most important implication from this pilot survey is that institutions need to identify why women and men perceive the undergraduate engineering experience differently, particularly in areas that relate to self-confidence. More research must be done on institutional and national levels to identify specific factors, actions need to be taken, and strategies developed to address issues that contribute to attrition of women in engineering and a seemingly lower level of satisfaction with the undergraduate engineering experience.

The results of this survey suggest that the perceived levels of self-confidence of females in engineering and physics courses is lower than that of male students in these areas. In addition, females report an overall lower level of academic confidence than do males. In contrast, female students in this survey reported no differences in confidence in mathematics and chemistry. In relation to these differences, it is interesting to note that in 1996, women received 46% of the bachelor's degrees in mathematics and 40% of the bachelor's degrees in chemistry[24] [25]. In 1997, women received 18.7% of the bachelor's degrees in engineering and 17.6 percent of degrees in physics in 1995 [26] [27] (most current figures available). Feelings of isolation due to the low presence of female undergraduate and graduate students and professors may contribute to low-self confidence. Although causal statements cannot be made regarding confidence level and persistence in a field, it is an interesting finding that should be pursued with further research.

When asked to rate how their academic self-confidence changed since entering college, the ratings of males indicated higher levels of self-confidence at each grade level. Both males and females showed higher levels of self-

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[24] Hill, Susan T. (March 1999). Science and Engineering Degrees: 1966-96. Detailed Statistical Tables. National Science Foundation, NSF 99-330. Table 37.

[25] Ibid. Table 45.

[26] Engineering Workforce Commission of the American Association of Engineering Societies, Inc. (1998). Engineering and Technical Degrees Granted, 1997. Washington, DC: American Association of Engineering Societies, Inc.

[27] Science Indicators (1998). National Science Foundation: Arlington, VA.

confidence with each successive class level, which is encouraging, but women never catch up. In a study conducted by the University of Michigan, by the end of freshman year, 61% of the women in their sample experienced a decreased level of self-confidence in their ability to do science compared with a matched sample of high achieving male students[28]. This was attributed in part to men being less affected by poor teaching, poor organization of the course material and dull course content. Also relevant is the research by Adelman, cited earlier, that used data from the National Center for Education Statistics based on the graduating high school class of 1982 to conduct the study Women and Men of the Engineering Path[29]. He found that women and men earn similar grades in engineering courses; and the women who leave engineering have higher grades than the men who leave. Women who leave engineering do not do so because of poor academic performance, but they do evidence a higher degree of academic dissatisfaction.

Several of the findings of this survey appear to be related to low self-confidence. It was found, for example, that females have less confidence in asking questions in class than do male students. In most engineering and science classes, females are the minority and may shy away from drawing attention to themselves. On the other hand, if their confidence level is low, given their minority status, they may be less likely to take the risk of speaking up in class.

Females rated their comfort level with lab equipment lower than males at each class level. In fact, more than ten years ago, there was an effort to develop optional and one-credit courses that provided female students with more opportunity to get “hands-on” experience in the engineering lab. For example, Purdue University and the University of California, Davis offered courses for female students that gave them the opportunity to work with lab equipment in a non-threatening environment[30] . This may be an area that requires renewed attention for all students since recent discussions with faculty indicate that even male students do not have the familiarity or comfort level with mechanical devices that they once had. The faculty attributes this change to the pervasive use of computers in cars and other machines, which prevents or curtails tinkering. It is also interesting to note that male and female sophomores and juniors rated their comfort level with lab equipment successively less than freshmen. This drop may be due to exposure to more complex equipment at this point in the curriculum.

Another interesting survey finding concerns the differences between male and female students regarding engineering being “the right major” for them. Males show a higher rating on this question at all class levels, suggesting a greater confidence level with their choice of major. There is a somewhat greater disparity during the freshmen year. Many factors can contribute to this finding, including the feelings of isolation, lack of confidence, and lack of familiarity with lab equipment that have been highlighted earlier. Adelman offers some insight into this finding based on Seymour and Hewitt’s[31] conclusion that women who entered SMET fields are more influenced by external forces such as parents and teachers in their initial choice of major than were men. He proposes that it is not surprising that women fall away more easily since the choice was not intrinsic, and the interest not deep enough to be affirmed[32]. Using this discussion as a basis for understanding, it is also not surprising that in this survey, women report that they are more overwhelmed by the fast pace and heavy workload than are men. Interestingly, women rated their engineering related social activities, such as study groups and professional societies higher than males. It would be interesting to know if this desire to work, study or relax in a community of people is a mechanism for dealing with the isolation and lack of self-confidence experienced in other settings.

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[28] Davis, J.D., Thomas, N.G., Slota, B.F., & Davis, C. (1989). An Analysis of Factors Affecting Choices of Majors in Science, Mathematics and Engineering at the University of Michigan, Center for Continuing Education of Women. *CEW Research Report 23.*

[29] Adelman, C. (1998). Women and Men of the Engineering Path: A Model for Analyses of Undergraduate Careers. U.S. Department of Education and The National Institute for Science Education. Washington, DC.

[30] Henderson, J.M, Desrochers, D.A., McDonald, & K.A., Bland, M.M. (1994, October). Building the Confidence of Women Engineering Students with a New Course to Increase Understanding of Physical Devices. *Journal of Engineering Education*, 83 (4), 337-342.

[31] Seymour, E. and Hewitt, N.M. 1997. Talking about Leaving: Why Undergraduates Leave the Sciences. Boulder, CO: Westview Press.

[32] Adelman, C. (1998). Women and Men of the Engineering Path: A Model for Analyses of Undergraduate Careers. U.S. Department of Education and The National Institute for Science Education. Washington, DC.

The relative success of single-sex colleges in attracting and retaining women in physics, computer science, mathematics and chemistry may provide some guidance on where to focus additional research[33]. The minority status and feeling of isolation do not exist in a single-sex institution where female students live and learn together and interact with many more female professors and alumnae. In single-sex institutions, faculty are encouraged to develop teaching styles and curriculum that are particularly appealing to and successful with women, such as cooperative learning techniques and using problems and examples based on content that is familiar to women[34]. Leon Lederman[35], Nobel Prize Winner in Physics, has proposed that the order that high school science and mathematics classes are taught be based on no particular reasoning or theory. Instead of offering the standard order of biology, chemistry and physics, he is experimenting in the Chicago Schools with teaching physics first, then chemistry and biology last, where physics becomes an integral part of the study of chemistry and biology. Cornell University conducted a study of 499 female students at eight universities which looked at the factors contributing to the under-representation of women in engineering fields requiring heavy physics content[36]. It is interesting to note that this study found that 35% of the physics-based engineering majors and 55% of the non-physics-based engineering majors disliked physics. Students indicated that their experiences in physics courses in high school and college played the largest role in developing students' attitudes toward physics as well as interest in specific college majors. Further, after their introductory college physics course, the students' attitudes toward physics became more negative.

The authors plan to conduct this study on a larger national group. Some of the modifications that are recommended include: 1) obtaining demographic data such as SAT scores and high school and college grade point average, to help determine if these variables differentially impact the responses of students to survey questions; 2) weighting the sample since 49% of the respondents came from 7 institutions that are the biggest producers of engineers, thus skewing the aggregate data to reflect experiences of students in these larger institutions; and 3) oversampling the students from under-represented groups to be able to analyze the data in a meaningful context. Further, this survey as with most other surveys does not answer the question "why do these differences" occur and "what are the possible strategies for eliminating the disparity in perceived experiences."

The findings from this pilot survey indicate that, while in many cases male and female students responded similarly, there are differences in male and female undergraduate engineering majors' perceptions of their college experience. It is interesting to note that on a scale of 1 to 5, the average rating for nearly two-thirds of the questions was between 2.5 and 3.5. This suggests that the students' perceptions of the overall quality of their educational experience is certainly less than optimum. At a time when interest in engineering as a college major is on the decline and the demand for a diverse and qualified technical workforce is paramount, retention of engineering students is critical. It is imperative that colleges and universities pay considerable attention to the factors that facilitate an environment where students can succeed. Identifying and addressing issues that differentially affect female students could result in an opportunity for institutions to improve the experiences for all of their students.

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[33] Rosser, S.V. (1997). Re-Engineering Female Friendly Science. New York: Teachers College Press.

[34] Ibid.

[35] Lederman, L. (April, 1996). Getting high School Science in Order. *Technology Review.* Cambridge. 3, 61.

[36] Schuck, J. (June 1997). Factors Contributing to the Under-Representation of Women in Physics-Based Engineering Fields. Cornell University. Ithaca, NY.