AC 2008-232: ENGINEERING CLASSROOM ENVIRONMENTS: EXAMINING DIFFERENCES BY GENDER AND DEPARTMENTS

Rose Marra, University of Missouri
ROSE M. MARRA is an Associate Professor in the School of Information Science and Learning Technologies at the University of Missouri. She is PI of the NSF-funded Assessing Women and Men in Engineering (AWE) and Assessing Women In Student Environments (AWISE) projects. Her research interests include gender equity issues, the epistemological development of college students, and promoting meaningful learning in web-based environments.

Barbara Bogue, Pennsylvania State University
BARBARA BOGUE is Co-PI of AWE and AWISE and Associate Professor of Engineering Science and Mechanics and Women in engineering. Her research interests include STEM programming, career development and assessment.

Engineering Classroom Environments: Examining Differences by Gender and Departments

Abstract

This paper reports on one year of data from a study of classroom learning environments in three engineering departments, which differ in size, discipline and pedagogical methodology, at a large eastern university. This study uses a quasi-experimental design to confirm or deny what is commonly cited in engineering education literature about gender differences in preferences for teaching and learning activities (e.g. cooperative teams). The results show that the differences found among students in the three different departments studied were based on departmental differences and do not support the commonly held view that men and women experience teaching and learning activities differently based upon gender. Departmental differences between engineering students are also supported by other current studies.

Introduction

Differences in the way males and females experience the classroom learning environment are often discussed as being critical in the recruiting and retaining of women in engineering programs. Yet high quality data to support this idea is not readily available. This paper reports on year one results of the NSF-funded Assessing Women in Student Environments project (AWISE). This project is using validated instruments to collect gender and departmental comparative data on men and women engineering students' experiences in engineering classrooms.

The need to tap into the talent pool of women students to meet the needs of the engineering workforce of the future is well documented[1, 2]. Effective efforts to accomplish this goal must be undertaken at the institutional level and involve all stakeholders. Women in Engineering (WIE) programs to enhance the recruitment and retention of women engineering students remain an important component of our nation's efforts to accomplish this goal.[3, 4] As or more critical to the success of women students studying engineering is gaining an understanding the impact of classroom learning environments on students and devising ways to improve those environments.

The AWISE project addresses the need for gender-comparative survey assessments and research of specific core engineering curricular experiences that impact male and female students differently (e.g. team interactions, student to student interactions). AWISE uses a multi-year student and faculty self-report survey methodology to examine perceptions of classroom climate and student reports of learning activities and their effectiveness within three departments representing 30% of the total undergraduate engineering students at a large eastern United States engineering school. This paper examines the results of the first year of data collection for AWISE and addresses whether there are differences in perceptions, perceived value, impact of classroom activities between men and women, among ethnic minority and majority students, and in the experience of all students in engineering departments of differing disciplines, size and pedagogical methodologies.

Background and Framework

This study examines gender differences and differences among three representative departments in several instructional methods that have both been discussed widely in education research[5, 6] but also have been promoted in engineering education as helping to develop skills necessary for being an effective practicing engineer[7, 8].

This study's justification comes from research and theory based on the effectiveness of use of different types of classroom interactions (among students and between students and faculty) including teaching practices and classroom learning activities that promote student engagement that are commonly promoted by ABET and in general use in engineering classrooms. The combination of these factors creates the "climate" of the classroom. Studies indicate that climate factors can impact both recruitment and retention of women in STEM fields[9], [33].

The use of small groups and cooperative learning in engineering classrooms has fluctuated over the years, with recent gains[10] in part spurred by ABET's Engineering Criteria 2000 which stated that graduates must demonstrate an ability to function on multi-disciplinary teams [11, 12]. Recent publications have described the process and influences that spurred ABET to not only shift to outcomes-based assessment but also to promote the use of team-based and active learning strategies in the classroom[12, 13].

Johnson, Johnson and Smith[14] define cooperative learning as "the instructional use of small groups so that students work together to maximize their own and each other's learning" (p. 12). Cooperative learning has often been proposed as a solution to the adverse effects of the lecture-based learning environment upon women. The work of Carol Gilligan usually provides the research basis for this assertion. In *The Chilly Classroom Climate* Sandler, Silverberg and Hall[15] cite Gilligan's work to indicate that "many more women than men define themselves in terms of their connection to others," and thus suggest cooperative learning is more effective for women than lecture (cited in (15), p. 42). However, more recent work has called into question both Gilligan's methods and the interpretations of her work[16, 17, 18]. Specifically, Gilligan's theory is based only on two small studies (both n = 25) that have never been replicated (even in studies using similar groups[19] and because neither study included males there is no evidence that men's and women's moral decision-making differs in the ways she claims.

Other cooperative or team learning research also shows mixed results concerning gender differences. Kaufman and Felder[20] found no gender differences in male and female student self-ratings of team performance in Chemical Engineering courses. Further, even Seymour and Hewitt's[21] seminal work does not show a clear preference of women for collaborative classroom environments. Both male and female students who left STEM disciplines (switchers) indicated that pedagogy was a significant concern and further shows that female undergraduates were actually less inhibited by the lack of collaboration and competitive environment in their disciplines than their male counterparts. Further the studies commonly cited to support the claim that girls prefer collaborative learning[22, 23, 24] are studies of pre-college students studying math or science (rather than engineering). And lastly, influential studies such as the Women's Experiences in College Engineering Women's Experiences in College Engineering (WECE) report have legitimately focused only on women[4, 25] but have thus left a need for gender comparative results.

The authors do not discount the importance of this literature and agree that cooperative learning can be effective for both genders[26]. Further we recognize that some research has been conducted in engineering classrooms on this topic[27, 28]. However sample sizes are small, results have been mixed and conclusions are based on non-validated instruments. This study provides the further work to systematically examine the impact of these key learning environments for women engineering students and the poorly supported associated beliefs such as:

a. Women are more collaborative than men[15]
b. Women prefer working in collaborative activities over individual work[27, 22, 29]
c. These experiences not only provide important professional skills[7] but also help to retain women and other underrepresented groups[30].

Methods

Student Population

All subjects are engineering students admitted to one of three engineering majors at a large eastern United States engineering school during the 2006-07 academic year. This institution is one of the largest engineering programs in the country and offers a rich environment for a gender-focused study due to its relatively large number of women engineering students. It has a diverse student body, with more than 1000 women enrolled in engineering programs and, in 2004, this institution was ranked 6th in the U.S in the number of women earning engineering baccalaureate degrees (225 women degrees; 19% of total degrees awarded). Since most women engineering students graduate from similar institutions, the data will prove valuable beyond this institution. The college also offers one of the largest varieties of engineering majors, allowing for the selection of a diverse set of engineering departments that offer very different undergraduate curricular experiences.

We collected data in the Engineering Science and Mechanics (ESci), Mechanical and Nuclear Engineering (ME), and Industrial and Manufacturing Engineering (IE) departments. These departments represent 30% of the total undergraduate engineering majors at this institution and were chosen for their differences that will help to identify and measure the impact of student classroom experiences including curricular approach (e.g. lectures, individual projects versus team projects), class size, percentage of women in the major and admission standards to the academic major.

For each department we worked with department undergraduate curriculum coordinators to identify eight courses per department that represent a variety of instructional components including labs, multi-week team-based projects, lectures and student-centered instructional strategies.

Instruments

Data were collected using four instruments – two for students and two for faculty. We briefly describe all four instruments (see Table 1) however our results at this time only consider data from the student instruments. All instruments were in an online format.

Instrument	Description
Student background	• Provides student demographic data and data on non-course specific experiences in their engineering department. • Collected once per student during study.
Student Classroom activities	• Gathers student perceptions of what occurs in a specific designated class (pedagogical activities, instructor to student, and student to student interactions) and perceived value of these activities. • Collected for all students in courses designated for study during the project.
Faculty Background	• Provides faculty demographic data and data on their teaching load, assignments and overall approach to teaching. • Collected once per faculty during study.
Faculty Course Activities	• Gathers faculty information on activities in a particular course being taught. • Completed by faculty for each offering of a course designated for study during the project.

Table 1. Description of instruments

Data Collection

Data were collected from students enrolled in the courses designated for study once during each of the fall 2006 and winter 2007 terms. We collected data during weeks 10 – 12 of a fifteen-week term. This timing both allows students more experience in the designated class that they could use as the basis for their responses and yet avoids the end of semester period when students have projects and exams and would be less likely to respond.

Students were contacted by email and invited to participate in the study. Faculty teaching the courses where data collection occurred also described the study to students and encouraged them to complete the survey instruments. Students received weekly reminders to complete the instruments during the data collection time period. Women and minority students in the designated courses also received an extra email message encouraging them to complete the instruments from personnel from the Women and Minorities in Engineering program. Additionally, for the Spring 2007 term, some faculty provided incentives for survey completion such as points on a homework assignment or course extra-credit.

Results

Demographic Results

Table 2 summarizes the student responses for the fall 2006 and spring 2007 data collections. For purposes of data analysis we consider only students for whom we have collected *both* a classroom activities survey *and* a background survey; these are labeled "matched" responses in Table 2.

	Fall 2006	Spring 2007
Matched responses	219	382
Male	136 (62%)	302 (79%)
Female	83 (38%)	80 (21%)
Minorities	20	57
Courses data collected (3 departments)	20	20
Response rates	19% classroom activities 28% background	27% classroom activities 47% background
GPA range	65.5% in 3.01 – 4.00	62.1% in 3.01 – 4.00

Table 2. Demographic results and response rate overview

Due to special data collection reminders for women and minority students, for both semesters – but especially for Fall 2006 -- our representation of women respondents was greater than the overall population of women in the college, thus aiding in our gender differences analysis. We note as well that our response rates improved for the spring 2007 data collection when we worked directly with each faculty member asking him or her to send students reminders and, in come cases, provide extra credit or points towards homework for completing the instruments. Although not all faculty used these incentives, enough did to improve response rates.

Gender differences

For both semesters of data, statistically significant gender differences were infrequent. We conducted t-tests to examine gender differences for individual item responses. For Fall 2006 we found statistically significant gender differences ($t < .05$) for only 5 out of 100 items where students provided ratings of course experiences. Table 3 shows these items. In all but one case gender differences reflected the female respondents as being more positive or demonstrating more productive learning activities than males.

Item (Responses: 1=never; 4= almost always)		**N**	**Average**	***t***	**Sig**
12k. The instructor delivers the course content too quickly	man	132	2.02	2.98	.003
	woman	58	1.64		
12l. Homework assignments are about the right level of difficulty	man	132	3.00	2.30	.023
	woman	55	3.27		
13e.When working in groups, some male students treat female students differently from male students	man	117	1.26	2.99	.003
	woman	56	1.59		

15g. I am encouraged to show how a particular lab concept can be applied to an actual problem or situation.	man	36	2.97	2.85	.006
	woman	20	3.60		
15h. I have opportunities to practice the skills I'm learning in the lab.	man	36	2.75	2.46	.017
	woman	20	3.35		

Table 3. Fall 2006 items with statistically significant gender differences

As shown in Table 4, the extent of gender differences was similar in the spring 2007 data set although the exact items where significant differences occurred varied.

Item		**N**	**Average**	***t***	**Sig**
12e. There is a level of competition among students in this class that makes me uncomfortable (1=never; 4= almost always)	man	292	1.61	4.0	.000
	woman	75	1.32		
… select the choice that best reflects how much progress you have made in each area as a result of taking this course (1 = None .. 4 = A Great Deal)					
18c. Understanding of the non-technical aspects of an engineering career (e.g. economic, political, ethical, and/or social issues).	man	290	2.55	2.197	.029
	woman	77	2.29		
… select the amount you have changed as a result of taking this course for the described item or activity.(1 = None .. 4 = A Great Deal)					
19l. Develop ways to resolve conflict and reach agreement in a group.	man	291	2.54	2.5	.012
	woman	75	2.24		
Indicate your preference for each of the learning activities: (1 = Strongly Prefer .. 5 = Strongly Do Not Prefer)					
21b. Team projects	man	244	2.51	2.2	.032
	woman	59	2.19		
21f. Lectures	man	287	2.90	1.98	.048
	woman	72	2.63		

Table 4. Spring 2007 items with statistically significant gender differences

Additionally for spring 2007, four items approached statistically significant differences with t values between .05 and .10. For three of the four, the women's average response was lower than the male. These were:

- there were opportunities to work in groups
- in groups, white students treat ethnic minorities differently
- (progress I have made in this course on) .. understanding of what engineers do

For the fourth item, women responded that "lab instructors call students by name", with a higher average than the males.

Departmental differences

Statistically significant differences (ANOVA tests with $p < .05$) between students in the three departments were prevalent. Tables 5 and 6 list the items for which significant differences were found. For Fall 2006 nearly half of the tested items (43 of 103) showed statistically significant differences between responses of students in different departments. For Spring 2007, nearly a third (31 of 103) of the items showed statistically significant differences between departments, with very few statistically significant gender differences. In each table the *Post Hoc* column shows the significant differences between departments from the *post hoc* analysis. For example for item 12c in Table 5, "ESC< IE&ME" is interpreted as the Engineering Science mean being significantly lower than both the Industrial and Mechanical Engineering means.

Item	F	p	PostHoc
12c. I work cooperatively with other students on course assignments(1=never; 4= almost always)	18.61	.000	ESC< IE&ME
12f. There are opportunities to work in groups (1=never; 4= almost always)	11.88	.000	ESC< IE&ME
12h.I have opportunities to practice the skills I'm learning in the course (1=never; 4= almost always)	6.57	.002	ESC< IE&ME
12i. I discuss ideas with my classmates (either individuals or in a group) (1=never; 4= almost always)	4.44	.013	ESC< IE&ME
12j. I get feedback on my work or ideas from my classmates (1=never; 4= almost always)	5.30	.006	ESC< IE&ME
12k. The instructor delivers the course content too quickly(1=never; 4= almost always)	11.59	.000	IE< ESC&ME
12p. The instructor gives me **enough** feedback on my work(1=never; 4= almost always)	3.33	.038	ME< ESC&IE
12q. I am encouraged to challenge the instructor's or other students' ideas (1=never; 4= almost always)	4.12	.018	IE< ESC&ME
13a. The instructor encourages students to listen, to evaluate, and to learn from the ideas of other students (1=never; 4= almost always)	4.05	.019	IE< ESC&ME
13d. Some white students treat ethnic minority students differently from white students (1=never; 4= almost always)	5.67	.004	ESC< IE&ME
13e. When working in groups, some male students treat female students differently from male students (1=never; 4= almost always)	5.01	.008	ESC< IE&ME
13f. When working in groups, some white students treat ethnic minority students differently from white students (1=never; 4= almost always)	7.13	.001	ESC< IE&ME
13g. The instructor calls on students by name. (1=never; 4= almost always)	10.76	.000	ME< ESC&IE
15a. Assignments and lab activities are clearly explained (1=never; 4= almost always)	3.61	.033	ME< ESC&IE
15c. I work cooperatively with other students on lab assignments (1=never; 4= almost always)	11.03	.000	ESC< IE&ME
15d. Students informally instruct each other, ask each other questions, and/or learn from each other (1=never; 4= almost always)	9.91	.000	ESC< IE&ME
15g. I am encouraged to show how a particular lab concept can be applied to an actual problem or situation.(1=never; 4= almost always)	4.00	.023	ME< ESC&IE
15j. I get feedback on my work or ideas from my classmates .(1=never; 4= almost always)	4.70	.013	ESC< IE&ME

15n. The lab instructor encourages students to be active participants in the teaching and learning process. (1=never; 4= almost always)	11.47	.000	ME< ESC&IE
15q. I am encouraged to challenge the lab instructor's or other students' ideas. (1=never; 4= almost always)	3.66	.032	ME< ESC&IE
15r. In addition to lectures and demonstrations, the lab instructor guides or coaches students' learning activities. (1=never; 4= almost always)	9.53	.000	ESC< IE&ME
15s. During lab activities, the lab instructor emphasizes the design process and design activities. (1=never; 4= almost always)	8.92	.000	IE> ESC & ME
15u. I interact with this lab instructor **outside of class** (office hours, email or discussion boards). (1=never; 4= almost always)	5.06	.009	ESC< IE&ME
16g. The lab instructor calls on students by name. (1=never; 4= almost always)	9.30	.000	ME< ESC&IE
18a. Understanding of what engineers do in industry. (1= None, 4= A Great Deal)	10.19	.000	ESC< IE&ME
18b. Understanding of what engineers do as faculty members. (1= None, 4= A Great Deal)	6.97	.001	ME< ESC&IE
18c. Understanding of the non-technical aspects of an engineering career (e.g. economic, political, ethical, and/or social issues) (1= None, 4= A Great Deal)	8.21	.000	ESC< IE&ME
18d. Knowledge and understanding of the **language** of design in engineering (1= None, 4= A Great Deal)	5.10	.007	ESC< IE&ME
18e. Knowledge and understanding of the **process** of design in engineering (1= None, 4= A Great Deal)	5.85	.003	ESC< IE&ME
19a. Design a process, component of a system or a product. (1= None, 4= A Great Deal)	13.53	.000	ESC< IE&ME
19c. Synthesize multiple points of view that arise during group problem solving (1= None, 4= A Great Deal)	5.23	.006	ESC< IE&ME
19d. Apply an abstract concept or idea to a real problem or situation. (1= None, 4= A Great Deal)	5.01	.008	ESC< IE&ME
19g. Develop several approaches that might be used to solve an open-ended problem (1= None, 4= A Great Deal)	4.90	.008	ESC< IE&ME
19i. Visualize what the product of a design project might look like. (1= None, 4= A Great Deal)	5.64	.004	ESC< IE&ME
19j. Weigh the pros and cons of possible solutions to a problem. (1= None, 4= A Great Deal)	16.85	.000	ESC< IE&ME
19k. Figure out what changes are needed in prototypes so that the final engineering project meets design specifications. (1= None, 4= A Great Deal)	8.54	.000	ESC< IE&ME
19l. Develop ways to resolve conflict and reach agreement in a group (1= None, 4= A Great Deal)	9.04	.000	ESC< IE&ME
19m. Make sure that all group members have the opportunity to contribute to group activities and outcomes. (1= None, 4= A Great Deal)	12.15	.000	ESC< IE&ME
19n. Organize information relevant to a problem solving activity (e.g. writing reports, sharing research with other group	7.98	.000	ESC< IE&ME

members, etc.) so that it is easily understandable to others. (1= None, 4= A Great Deal)			
19o. Ask probing questions that clarify facts, concepts, or how things inter-relate(1= None, 4= A Great Deal)	4.56	.012	ESC< IE&ME
21f. Lectures (1= Strongly do not prefer, 5= Strongly prefer)	3.60	.029	ME< ESC&IE
21h. In class exams	3.67	.028	ME< ESC&IE
21j. Instructor or TA-led study or review sessions	4.09	.019	ESC< IE&ME

Table 5. Fall 2006 – Items statistically significant differences by department

Item	F	p	Post Hoc
12c I work cooperatively with other students on course assignments (1=never; 4= almost always)	14.81	.000	ESC< IE&ME
12d Students informally instruct each other, ask each other questions, and /or learn from each other	3.52	.031	ESC< IE&ME
12e There is a level of competition among students in this class that makes me uncomfortable	4.41	.013	ESC< IE&ME
12f There are opportunities to work in groups	10.10	.000	ESC< IE&ME
12i I discuss ideas with my classmates (either individuals or in a group)	5.51	.004	IE< ESC & ME
12m I need more help (e.g. study sessions, exam review, etc.) to complete course requirements	5.36	.005	ESC< IE&ME
12r In addition to lectures and demonstrations, the instructor guides or coaches students' learning activities	3.86	.022	IE< ESC & ME
12t I feel comfortable asking the instructor questions in this class	4.12	.017	IE< ESC & ME
12u I interact with this instructor **outside of class** (office hours, email or discussion boards)	4.74	.009	ME< ESC & IE
13c Some male students treat female students differently from male students.	2.99	.051	ESC< IE&ME
13d Some white students treat ethnic minority students differently from white students.	5.39	.005	ESC< IE&ME
13g The instructor calls on students by name.	7.62	.001	ME< ESC&IE
13h The instructor treats all students with respect	6.95	.001	IE< ESC & ME
15a Assignments and lab activities are clearly explained. (1=never; 4= almost always)	4.66	.012	ESC< IE&ME
15f There are opportunities to work in groups.	9.50	.000	ESC< IE&ME
15g I am encouraged to show how a particular lab concept can be applied to an actual problem or situation.	3.11	.049	ME< ESC&IE
15h I have opportunities to practice the skills I'm learning in the lab.	3.65	.030	ME< ESC&IE
15n The lab instructor encourages students to be active participants in the teaching and learning process.	17.87	.000	ESC< IE&ME

15o The lab instructor clearly explains what is expected of students in the course.	12.54	.000	ESC< IE&ME
15p The lab instructor gives me **enough** feedback on my work.	5.25	.007	ESC< IE&ME
15qI am encouraged to challenge the lab instructor's or other students' ideas.	9.32	.003	ESC< IE&ME
15r In addition to lectures and demonstrations, the lab instructor guides or coaches students' learning activities.	25.86	.000	ESC< IE&ME
15s During lab activities, the lab instructor emphasizes the design process and design activities.	19.45	.000	ME< ESC&IE
15t I feel comfortable asking the lab instructor questions in this class.	3.25	.043	ESC< IE&ME
15u I interact with this lab instructor **outside of class** (office hours, email or discussion boards).	16.39	.000	ME< ESC&IE
16a The lab instructor encourages students to listen, to evaluate, and to learn from the ideas of other students. (1=never; 4= almost always)	7.57	.001	IE< ESC & ME
16c Some male students treat female students differently from male students	5.30	.006	IE< ESC & ME
16d Some white students treat ethnic minority students differently from white students	6.34	.003	IE< ESC & ME
16e When working in groups, some male students treat female students differently from male students	6.26	.007	IE< ESC & ME
16f When working in groups, some white students treat ethnic minority students differently from white students.	5.23	.007	ME< ESC&IE
16g The lab instructor calls on students by name	27.38	.000	ME< ESC&IE

Table 6. Spring 2007 – Items statistically significant differences by department

Ethnicity differences

Due to the low number of minority student responses (and specifically the very few numbers of students in the under-represented minority categories), we were not able to analyze data by student ethnicity. Focus groups are planned for the second year to try to capture the experience of these students.

Discussion

The data for both semesters show very few statistically significant gender differences in these three departments. As noted, there were only five items (out of over one hundred) where we found differences between male and female students for each semester. For the fall 2006 data (see Table 3), in all but one of the five cases gender differences reflected the female respondents as holding more positive beliefs about their classes or demonstrating more productive learning activities than males. For instance, females agreed more than males with the statement that the “homeworks are about the right level of difficulty”, and reported at a higher rate that they “have the opportunities to practice skills I’m learning in labs”. Although the total item set reflects that male and female responses are much more similar than different, it is noteworthy to see that females do report that “when working in groups some male students treat female students differently from male students" – thus indicating that in some situations females feel they are being treated differently (this result did not reoccur in the spring 2007 data set).

For spring 2007, items with statistically significant gender differences were also infrequent (see Table 4), however two specific items were notable in that they are in conflict with popularly held views about women engineering students' preferences for certain learning activities. Item 12e describes levels of competition; women perceived that uncomfortable levels of competition occurred less frequently than men. Similarly, item 21b shows that women indicated a lower preference for team projects than did men, however they also indicated a lower preference for lectures than men (item 21f).

For both data sets, we believe the *relatively few* gender differences stems from the fact that these students are already admitted into their specific engineering major. Engineering students at this institution – like many other campuses – are admitted to a specific engineering major and/or begin taking the bulk of major-related courses at the beginning of their junior year. Prior to that point they are simply "engineering" and must apply to a specific major. Retention data at this institution indicates that differences between male and female engineering student retention are the highest in those first two years *prior to being admitted to a specific engineering major*. Other engineering institutions also report a similar retention phenomena[31].

Thus our data may reflect that once women are admitted to their specific engineering major, they have learned to cope with the climate of engineering classrooms and perceive the classroom environment in ways similar to their male counterparts. This is ultimately reflected in that they are likely to be retained at the same rate as men once in their majors (source: retention study at institution). This conclusion is supported by other studies such as the WEPAN (Women in Engineering ProActive Network) Climate Pilot study that found that gender differences regarding some curricular aspects of engineering course (e.g. fast pace and workload) were smallest for seniors[32]. Similarly, Hartman and Hartman[33] found that gender differences varied by school year in a study of student satisfaction with engineering coursework and classroom climate. In the Hartman study, however, results indicated that in some cases (e.g. satisfaction with applied aspects of the program) gender differences were greater in the early years of the curriculum while for other factors (e.g. satisfaction with course choices) the gender differences were greater for students in the latter part of their degree program.

For purposes of our study, we are also collecting data from students in their first two years of the engineering program (at the institution being studied) to determine if our hypotheses regarding differences between students who have been admitted to a major (as in the current study) and those in the "pre engineering" state are accurate.

In contrast to the small number of gender differences, we found many more items with significant differences among the three departments for both data sets. We feel the large number of items with departmental differences in fact validates what we know about the structural and curricular differences between these departments. Specifically differences in:

- Approach to practical engineering education, with ESci emphasizing one-on-one research experiences, ME industry-driven team engineering experiences, and IE manufacturing, logistics and service team experiences.

- Women enrolled. IE has a relatively large percentage of women students (varying between 24 and 30%), which arguably may impact the nature of classroom activities and thus will provide important contrasting data to the results from ME and ESci which both have low female representation (see Table 7). However ME graduated 100% and 96% of women who entered ME in Fall 2001 and 2002 – a significantly higher graduation rate than for males for the same period.
- Class size. Although the departments range in size from one of the largest in the college to one of the smallest, all offer small class size (25-30) in the hands-on courses. ME students, however, regularly experience large classes (70-90) in lecture-based courses. Table 8 shows the average class sizes for the courses for which we collected data.
- Image of major, with IE and ESci as "discovery majors," or majors that students discover once they are enrolled in the College, and ME one of the historic engineering majors.
- Additionally, ME and ESci have high academic standards for admittance to the major. The current GPA cutoff for ME is 2.85 (on a 4 point scale), and is 3.0 for ESci. Both have a high percentage of honors students. In contrast, admission to IE is more open with a 2.0 minimum GPA requirement.

Major	Total Enrollment	Women Enrolled
ESci	56	6 (11%)
ME	735	77 (10.5%)
IE	329	106 (31%)

Table 7. Engineering Science, Mechanical Engineering and IE Enrollment data -- 4-year averages

These differences between majors are in some ways similar to those found recently by Hartman, Hartman and Kadlowec[34] in their study of engineering climate in different engineering departments. Although their study surveyed first-year students, they also found many more differences among women in different departments than they did between men and women in the same departments.

	Average Class Size	
Major	Fall 2006	Spring 2007
ESci	20.4	19.3
IE	63.3	59.7
ME	94.6	114

Table 8. Department average class sizes for data collection courses.

Conclusion

The purpose of the AWISE study is to examine whether the gender differences and gender preferences that are often quoted in literature e.g [20, 21, 22, 23, 24] are actually borne out at a large engineering school in three departments of varying characteristics. Our study specifically examines gender differences in preferences for teams, cooperative experiences and perceptions of the effectiveness of other types of learning activities.

At the half-way point of the study, our findings do not show prevalent or even frequent gender differences for these aspects or for other aspects of engineering climate such as students perceptions of how instructors treat male and female students or how students treat one another.

In contrast, differences in perceptions of classroom climate and classroom teaching and learning activities *by department* are common as evidenced in tables 5 and 6. For the Fall 2006 data nearly half of the analyzed items showed statistically significant differences among the three departments and nearly a third of the items in the Spring 2007 data set showed significant differences by department.

These results confirm and validate what we know about the differences in these departments in terms of curricular design, class sizes and admission and matriculation requirements. We are not judging the quality of the students' experiences in these departments but rather noting that they are indeed different. Our findings of departmental differences are also supported by other studies such as the recent work of Hartman, Hartman and Kadlowec [34].

Currently, our study is examining only students who are admitted to an engineering major. We hypothesize that we may find more gender differences for students in the first two years of engineering where retention between men and women differs more substantively and students are also taking fewer courses actually in engineering. We are in the process of collecting and analyzing data to explore this hypothesis.

At the halfway point of the AWISE study, we realize we have raised many questions that have yet to be answered, but feel that the results that show the *lack* of gender differences are significant to engineering educators both to understand that statements often made about gender-based educational preferences may not in fact be accurate, and also potentially to focus retention efforts on points in the curriculum where more gender differences may be found. Specifically during the first two years of an engineering curriculum where many engineering students are not as of yet admitted to an engineering major.

Bibliography

1. National Academy of Science. 2005. *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future.*
2. U. S. Chamber of Commerce. 2005. Tapping America's Potential: The Education for Innovation Initiative. Retrieved October 25, 2007, from http://www.uschamber.com/NR/rdonlyres/epivg5lni4pxype7by6h3gl5kpkbr3hyief6oxhbv4dgodcj4kmizkva2oe542sdaq2cx33sxce36i3jgwmflzf2q6b/050727_tapstatement.pdf.
3. Cunningham, C. M., et al. 2000. *Women's Experiences in College Engineering and Support Programs: Findings from the WECE project. Paper presented at WEPAN2000.*
4. Goodman, I. F., et al. 2002. Final Report of Women's Experiences in College Engineering (WECE) Project. *Goodman Research Group Inc.* Available from the Goodman Research Group Web site www.grginc.com.
5. Bransford, J. 2000. *How People Learn: Brain, Mind, Experience, and School.* Committee on Developments in the Science of Learning and Committee on Learning Research and Educational Practice, Commission on Behavioral and Social Sciences and Education. National Research Council. Washington, D.C.: National

Academy Press.
6 Pascarella, E.T.; Trenzini, P.T. 2005 *How college affects students*. Jossey-Bass San Francisco, CA.
7 ABET**.** *ABET Engineering Criteria 2000.* Accreditation Board for Engineering Technology, Inc., 2000.
8 ABET**.** *ABET Engineering Criteria 2005.* Accreditation Board for Engineering Technology, Inc., 2005.
9 Pederson-Gallegos. 2004.
10 Wankat, P. C. et al. 2002.The Scholarship of Teaching and Learning in Engineering. In M. T. Huber and S. P. Morreale. *Disciplinary Styles in the Scholarship of Teaching and Learning: Exploring Common Ground.*. Stylus Publishing, LLC, 2002.
11 ABET**.** *ABET Engineering Criteria 1998.* Accreditation Board for Engineering Technology, Inc., 1998.
12 Prados, J. W., Peterson, G. D. & Lattuca, L. R. 2005. *Quality Assurance of Engineering Education through Accreditation: The Impact of Engineering Criteria 2000 and its Global Influence.* Journal of Engineering Education, 94(1), 165-184.
13 Olds, B., Moskal, B. & Miller, R. 2005. *Assessment in Engineering Education: Evolution Approaches and Future Collaborations.* Journal of Engineering Education, Vol. 94(1), 13-25.
14 Johnson, D., Johnson, R. & Smith, K. (1991). *Cooperative Learning: Increasing College Faculty Instructional Productivity.* ASHE ERIC Higher Education Report No.4.
15 Sandler, B., Silverberg, L. & Hall, R. 1996. *The Chilly Classroom Climate: A Guide to Improve the Education of Women.* Washington, DC.: The National Association for Women in Education.
16 Colby, A. & Damon, W. 1987. Listening to a Different Voice: A Review of Gilligan's in a Different Voice. In M. Walsh (ed.) *The Psychology of Women: Ongoing Debates* (pp. 321-329). New Haven : Yale University Press.
17 Barnett, R. & Rivers, C. 2004. *Same Difference: How Gender Myths are Hurting Our Relationships, Our Children, and Our Jobs.* New York: Basic Books.
18 Nails, D. 1983. *Social Scientific Sexism: Gilligan's Measure of Man.* Social Research, 50. 662-64.
19 Crosby, F. J. 1991. *Juggling: The Unexpected Advantages of Balancing Career and Home for Women and Their Families.* NY: The Free Press.
20 Kaufman, D. B., Felder, R. & Fuller, H. 2000. *Accounting for Individual Effort in Cooperative Learning Teams.* Journal of Engineering Education, 89(2). 133-40.
21 Seymour, E. & Hewitt, N. 1997. *Talking About Leaving: Why Undergraduates Leave the Sciences.* Boulder : Westview Press.
22 Kahle, J. B. 1988. *Recruitment and Retention of Women in College Science Majors.* Journal of College Science Teaching. 17(5). 382-84.
23 Koehler, M. S. 1990. Classroom, teachers and gender differences in mathematics. In E. Fennema and .G. C. Leder (eds.). *Mathematics and Gender.* NY: Teachers College Press.
24 Johnson, D. W. & Johnson, R. T. 1987. Cooperative learning and the achievement and socialization crisis in science and math classroom. In A. B. Champagne and L. E. Hornig (eds). *Students and Science Learning.* Washington: AAAS.
25 Okudan, G. E., Horner, D. & Russell, M. (2001). Achieving High Performing Engineering Design Teams: A Curriculum Intervention Study. August 6-10, 2001. Retrieved October 25, 2005, from http://nich.dgtu.donetsk.ua/konf/konf1/529.pdf.
26 Terenzini, P. T., et al. 2001. *Collaborative Learning vs. Lecture/Discussion: Students' Reported Learning Gains.* Journal of Engineering Education. 90. 123-30.
27 Byrd, J. S. & Hudgins, J. L. 1995. *Teaming in the Design Laboratory.* Journal of Engineering Education, 84(4). 335-341.
28 Felder, R. M. 1995. *A Longitudinal Study of Engineering Student Performance and Retention. IV. Instructional Methods and Student Responses to Them.* Journal of Engineering Education. 84(4). 361-67.
29 Matyas, M. L. & Malcom, S. M. 1991. *Investing in Human Potential: Science and Engineering at the Crossroads.* Washington : AAAS Publishing. 37-96.
30 ASEE Deans Council and Corporate Roundtable. 1994. The Green Report: Engineering Education for a Changing World. 1994. Retrieved October 28, 2005, from www.asee.org/resources/green.cfm.
31 Wild, W. G. & Ryan, M. E. 2002. *Retention and Success of Engineering Undergraduates: A Discussion of Retention-related Initiatives at the University at Buffalo.* Proceedings of the Annual Meeting of the American Society for Engineering Education (ASEE), Montreal.
32 Brainard, S. G., Metz, S. S. & Gillmore, G. 1999. National WEPAN Pilot Climate Survey: Exploring the Environment for Undergraduate Engineering Students. *Women in Engineering Programs & Advocates Network (WEPAN).* June 5-8, 1999. Retrieved January 10, 2008, from www.wepan.org.

[33] Hartman, H. & Hartman, M. 2002. *Best practices in engineering: Is the impact gendered?* Proceedings of American Society of Engineering Education (ASEE), Montreal.

[34] Hartman, M., Hartman, H. & Kadlowec, J. 2007. *Gender Differences Across Engineering Majors.* Proceedings of American Society of Engineering Education, Honolulu.

[35] Barnett, R. & Rivers, C. 2005. Biology, Destiny, and Bad Science. Retrieved October 25, 2005, from www.dissentmagazine.org/menutest/articles/su05/barnett.htm.

[36] Felder, R. M., Felder, G. N. & Dietz, E. J. 1998. *A Longitudinal Study of Engineering Student Performance and Retention. Comparisons with Traditionally-Taught Students.* Journal of Engineeriing Education. 87(4). 469-80.

Acknowledgement

The authors would like to acknowledge the National Science Foundation Grant #HRD 0607081 that provided funding for this project.