AC 2008-2764: PERCEPTIONS OF WOMEN'S TREATMENT IN ENGINEERING EDUCATION: FROM THE VOICES OF MALE AND FEMALE STUDENTS

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PERCEPTIONS OF WOMEN'S TREATMENT IN ENGINEERING EDUCATION: FROM THE VOICES OF MALE AND FEMALE STUDENTS

Despite the well-documented under-representation of women in higher education engineering programs, little research has probed the perceptions of gendered treatment of women as compared to men in these programs. Such information may be important in helping young women navigate the complex social and academic requirements of the major, and to illuminate men students and faculty to their contributions to the environment. This study uses a web questionnaire and interviews with sophomore engineering students to address this research question. The themes that emerged regarding perceptions of treatment of females in engineering indicate male and female students view the treatment of females differently both between and within gender groups.

Introduction

The number of women enrolling in higher education exceeds the number of men at 57.4% and 42.6% respectively (NSF, 2004), yet women are still under-represented in certain fields of study. In certain academic majors, women are significantly under-represented. Most notably, women comprise less than 20% of undergraduate students in engineering (NSF, 2004). Perhaps more disturbing, however, is that undergraduate women "drop out of engineering school at a higher rate (54 to 70 percent) than men (39 to 61 percent)" (Brainard, Staffin Metz, & Gillmore, 1991, p. 2).

Despite the well-documented under-representation of women in higher education engineering programs, little research has probed the perceptions of women in engineering as compared to perceptions of their male counterparts. As such, the purpose of this study was to investigate the question, "How do male and female engineering students perceive treatment of women in engineering education?" Of particular importance to this project is the perceptions students have about perceived treatment of women students by peers in the male-dominated major of engineering. Since our behaviors are a result of our perceptions of reality, women's and men's assessment of peers in the engineering major should be an important factor related to women's treatment. The objective of this project is two-fold: 1) to empirically contribute to the bodies of literature on gender and student experiences in engineering education; 2) to provide additional empirical research on the experiences of both women and men engineering students to understand how they perceive gender as a part of their education.

Background

Researchers have identified a number of barriers associated with women's success or lack of success in engineering education. The educational environment is shown to be particularly important to women's success in engineering education. Researchers have examined facets of the educational environment that represent barriers to women, including instructor behavior (Nair & Majetich, 1995; Rosser, 1990), peer culture (Holland & Eisenhart, 1990; Dryburgh, 1999; Hacker, 1981; Wajcman, 1991), and instructional methods used (Gainen, 1995; Goodman, et al., 2002; Hall & Sandler, 1982; Nair & Majetich, 1995; Rosser & Kelly, 1994). While all of these factors contribute to the educational environment, the research described herein examines ways that students experience the engineering education environment. Specifically, this study compares ways that women engineering students and their male peers perceive the treatment of women in engineering education.

Peer Culture

Astin (1993) describes peer culture as exerting the greatest influence on student development during the college years. Moreover, according to Baird (1988) peer culture exerts an important influence on *what* students learn. A primary factor affecting attrition rates among women in the engineering major is peer culture, including patterns of student interactions both in and out of class. Peer acceptance is critical in the development and maintenance of a hospitable learning environment. Conversely, a “chilly” climate (Hall & Sandler, 1982) is created when certain groups of students are treated as less capable, or “outsiders.” It is a climate that is counterproductive to student learning. In-class interactions and those that can occur during lab sessions and in out-of-class study groups all contribute to an enabling or “chilly” learning environment.

Discovering the powerful influence of peer culture was an unexpected, yet integral, finding of Holland and Eisenhart’s study (1990). They sought to understand why so few women entered science, mathematics and engineering majors (SME) in college. The researchers conducted a longitudinal ethnographic study at two southern colleges, a predominantly black university, Bradford, and a predominantly white university, Southern University (both pseudonyms) to examine why women tended to shy away from majors and occupations that are seen as traditionally male. Holland and Eisenhart studied 23 college women as they traversed the complexities of undergraduate life. All the women in the sample were identified as high achievers at the inception of the study. About half the women planned to major in fields such as mathematics and the “hard” sciences.

A picture emerges from this study that speaks to the powerful influence of peers on women’s academic goals. Over the course of the study, the women’s career goals shifted, giving way to what the researchers described as “the cultural model of romance” (Holland & Eisenhart, 1990, p. 93). They found that for three-quarters of their sample, peer relations, especially in the form of romantic ties, became a greater determinant of women’s actions than their academic aspirations. According to the researchers, by the end of their sophomore year, the women's sense of self-esteem and self-worth were derived more from their perceived attractiveness to men than from their academic prowess.

Peer culture also reflects organizational culture. The culture of engineering has been described as a "masculine culture" (Hacker, 1981; Wajcman, 1991) where quantitative, analytic skills are considered more valuable than social skills. Students are socialized into the culture of engineering by their professors and by peers. Women are confronted with an assumption that being women makes them *inherently* less qualified than men to become engineers.

Hacker (1981) spent a year researching the culture of engineering, gathering data through participant observation and interviews at an elite engineering institute. She immersed herself in the environment in order to acquire a deep understanding of "patriarchal elements in the culture of engineering" (Hacker, 1981, p. 341). Hacker discovered that a dichotomy of valued and devalued characteristics form of the basis for constructing a hierarchy within the culture of engineering. Students develop solidarity within their discipline and consider students in majors other than science, mathematics and engineering "out-groups." She describes the environment in engineering education as one that promotes in-group/out-group dynamics, divisions used to facilitate a sense of solidarity within the group.

Engineering faculty contributed to the social construction of "outsiders." "Engineering faculty ranked technical experience more valuable than knowledge of social relations. They described social science in womanly terms: soft, inaccurate, lacking in rigor, unpredictable, amorphous" (Hacker, 1981, p. 345). According to Hacker "the [engineering] institute was a major point of origin and transmission of engineering culture as exhibited in the behavior and attitudes of both students and faculty, and in classroom procedures and general atmosphere" (p.

343). Compared to faculty members in the humanities, engineering faculty embraced a hierarchy valuing abstract, scientific abilities over other capabilities, including social relationship skills.

The culture of engineering was also addressed in McIlwee and Robinson's (1992) *Women in Engineering: Gender, Power, and Workplace Culture.* While the focus of their research was on women in engineering occupations they did, however, explore the path to the labor force for these women as well. As such, McIlwee and Robinson provide a chapter on college experiences of women who majored in engineering. They utilized both qualitative and quantitative methods of data gathering to more comprehensively develop a picture of the process of becoming "an engineer." The researchers surveyed engineering graduates from two public universities in southern California during 1986 (N=545). They also conducted interviews with 82 people who completed the survey and volunteered to speak with the researchers. An over-sampling of women was used to ensure that women's experiences were documented, as the number of women graduating in the years associated with the study (graduated between 1976 and 1985) was fairly low.

McIlwee and Robinson (1992: 50) explain, "the culture of engineering that prevails in many workplaces emphasizes activities identified with the male gender role: a fascination with technology, expertise as a tinkerer, and an aggressive style of self-presentation." However, they note that this description holds true more for the culture of engineering in occupations than in college. They maintain that in the university setting, faculty shape the definition of a "good engineer" and therefore, the culture of engineering promotes academic over technical skills (McIlwee & Robinson, 1992). The results of this research indicate that women fit well with the university defined culture of engineering because it focuses on math and theory over tinkering, however, they note that women doubt their technical abilities. It seems, according to McIlwee and Robinson's findings, women should do well within the university culture of engineering as defined by professors encouraging academic prowess. Yet, many women, with grade point averages higher than their men peers, leave engineering. Though their contribution to the understanding of the culture of engineering differs from Hacker's (1981) in that the aforementioned describes the university culture of engineering in masculine terms also associated with engineering occupations, McIlwee and Robinson argue that the university environment differs from that of engineering workplace culture.

Dryburgh (1999) also explored the culture of engineering. The research focused on socialization processes in the culture of engineering and how female students experience these processes. Through content analysis of interviews and observations, a story unfolded in which faculty and students participate in promoting the masculinist culture of engineering while creating a sense of solidarity among engineering students. According to Dryburgh, women adapt to the masculinist environment of engineering schools by learning collaboration techniques, group solidarity, and to project confidence. In order to succeed, women in engineering must align themselves with their male counterparts. They must not "break rank" by exposing a negative side of the engineering culture. Most women in the study denied that sexism existed or contended that it was an exception rather than a behavioral norm. This manner of adapting to masculinist culture may be a requisite survival technique in both school and industry, especially in the fields traditionally seen as men's work.

Instruction Methods

Attitudes are transmitted to students informally in the classroom. Engineering faculty, holding positive assumptions about the skills hierarchy described above, transmit their values to students, often through the use of humor. Hacker's content analysis of dialogue in classrooms demonstrates the use of humor in this way: “[W]ives, students, and others with relatively little power were frequently the butt of the joke” (Hacker, 1981, p. 347). The two major targets of jokes were the technically inept and women. Jokes serve to socialize students by identifying what they should avoid and what they should emulate. In this manner, students locate themselves in the in-group by virtue of being technologically savvy. Women, however, are confronted with a perception that characteristics associated with femininity undermine the status their technological know-how bestowed upon them.

As part of a larger research study on women in engineering at the University of Washington, Huang and Brainard (2001) surveyed 336 engineering undergraduates to examine the persisting gender gap in self-confidence levels of students in science, technology, engineering, and mathematics (STEM). Drawing on the Undergraduate Retention Study and using the Student Experience Survey, the researchers found that differences between women and men’s experiences as engineering majors have a determining effect on the levels of academic self-confidence among students. In particular, women students’ self-confidence levels correlate positively with how women believe instructors and peers perceive them. These researchers found that peer group influence is greater on women’s than on men’s self- assessments of their capabilities.

Burack and Franks (2004) used a group psychodynamics approach to explain group social identity and the establishment and maintenance of in-group solidarity. These researchers assert that forming intra-group alliances is central to the engineering enculturation process. The process, they argue, begins with engineering students being taught that “hard sciences,” requiring analytic and mathematical skills, are valued above “soft sciences.” Thus, engineering students come to view themselves as smarter and better than those outside the realm of SME disciplines.

While this builds in-group solidarity it is a solidarity that is contingent for women engineering students. Burack and Franks provide examples in which women students articulate the discomfort of feeling superior to non-engineering majors and, simultaneously, inferior to their male engineering peers. "From a group-psychodynamics perspective, the mixed messages presented by the call for diversity in a culture that holds the superiority myth *reinforces* [emphasis added] durable unconscious convictions about the unfitness of…[inferior] group members rather than challenging [the myths]" (Burack & Franks, 2004, p. 89).

These studies affirm that gender role expectations and gender stereotypes are integral to college peer culture. Guimond and Roussel (2001) surveyed perceptions of undergraduate engineering majors regarding gender differences in mathematical and language capabilities. Despite the fact that in their sample female engineering students had higher grades than their male counterparts, both sexes attributed males with greater analytical and mathematical abilities. Ironically, stereotyped assumptions that males have innate mathematical abilities which females lack permits both women and men who can be justifiably proud of their analytical abilities to sustain belief, even in the face of contradictory evidence.

Gender stereotypes also figure in the work of Steele, James, and Barnett (2002). The researchers explored student perceptions of sex discrimination and "stereotype threat" (p. 797) in a sample of 801 undergraduates. Steele and Aronson (1995, p. 797) defined " stereotype threat" as "being at risk for confirming as self-characteristic a negative stereotype about one's group." Steele, et al. (2002) reported that in the perceptions of women in engineering when compared with other groups of students (including men in engineering and students in other majors), sex discrimination is more apparent. Women in engineering were also more likely to perceive threats that arise from gender stereotypes that depict women as inherently less capable engineers than their male counterparts. Steele, et al. explained that their findings are consistent with other research on the culture of engineering and the significance of group solidarity.

Heyman, Martyna, and Bhatia (2002) compared perceptions of male and female engineering students regarding the treatment of women in engineering. The researchers argue that the perceptions of peers are particularly important to women in engineering since women face “stereotype threat” (Steele & Aronson, 1995). Two hundred thirty eight undergraduates from SME and social science majors completed a survey assessing their perceptions of the treatment of women in engineering education. Survey results indicated that female engineering students do perceive gender differences in the treatment of engineering students more often than their male peers. The researchers reported that in open-ended interviews, female participants commented on being treated "negatively" by male peers, including condescending behavior toward them and being treated like “little girls.” Additionally, females in engineering reported more often than male students that the climate for women in engineering was different from the climate for men. Open-ended questions about treatment yielded additional evidence of the differential treatment experienced by women in engineering.

Theoretical Perspective

A theoretical approach to understanding perceptions about the abilities of women in engineering can be found using standpoint feminist theory (Harding, 1991; Hartsock, 1987), also referred to as the standpoint of women (Smith, 1987), which advocates the exploration into women’s experiences by reframing research questions from the position of women and challenging scientific universals. In particular, this theory argues that women’s experiences must be central to any research agenda and that research on women is best conducted by women investigators. Due to its focus on the lived experiences of women and its concern with the production of science and knowledge, standpoint feminist theory is a particularly appropriate theoretical frame to guide this research.

The use of Feminist Standpoint theory calls for the researcher to position herself within the project and explain how her life experiences contribute to the understanding of the research. Briefly, my interest in pedagogy began when I was a Master's student. I became intrigued with the literature on how to teach to facilitate learning, an interest that led me to feminist pedagogical literature. Feminist pedagogy guided my master's project and subsequently my doctoral project as well. I was particularly drawn to literature on the position of women within education that led me to Feminist Standpoint theory and literature on women in engineering education. Being at an engineering institution, I developed my own research agenda around my interests in women, pedagogy, and engineering.

In addition to academic influences, there are many personal factors that I bring to this project. As a 30-something married, liberal, and strong woman committed to gender equality, my personal experiences allow me to come to this work from a position of experience and commitment to gender equity. While my personal position biases me in certain ways (liberal perspective, focus on position of women), all researchers and research projects have biases. I believe that my position helps me to understand the students and faculty who I studied and to more clearly describe their experiences.

Feminist Standpoint Theory

Hartsock (1987), when developing the feminist standpoint, drew upon the materialist aspects of women's lives by calling attention to commonalities in women's experience. She asserts that men, because of their dominant position in patriarchy, are able to ignore the limits on the society's subordinated people while women are in a position to see how certain people benefit from capitalism and patriarchy to the detriment of others.

According to Hartsock (1987), the "add women" method of integrating women into scientific fields and research is not a sufficient means by which to gain knowledge from the perspective of women nor to integrate women into positions of power. Rather, she maintains that women and their experiences must be at the forefront of investigation both as investigators and research subjects. Hartsock proposed five criteria for standpoint feminist theory:

> 1) Material life (class position in Marxist theory) not only structures but sets limits on the understanding of social relations.
> 2) If material life is structured in fundamentally opposing ways for two different groups, one can expect that the vision of each will represent an inversion of the other, and in systems of domination the vision available to the rulers will be both partial and perverse.
> 3) The vision of the ruling class (or gender) structures the material relations in which all parties are forced to participate, and therefore cannot be dismissed as simply false.
> 4) In consequence, the vision available to the oppressed group must be struggled for and represents an achievement that requires both science to see beneath the surface of the social relations in which all are forced to participate, and the education which can only grow from struggle to change those relations.
> 5) As an engaged vision, the understanding of the oppressed, the adoption of a standpoint exposes the real relations among human beings as inhuman, points beyond the present, and carries an historically libratory role. (Hartsock, 1987:159)

From the feminist standpoint approach, a significant problem associated with gender inequality stems from neglecting women's perspectives and experiences in the production of culture and knowledge (Lorber, 2001) as well as their exclusion from science fields in general. As a means of remedying the inequality caused by said neglect and exclusion, feminist standpoint theorists advocate "making women central to research as researchers and subjects" and by "asking research questions from a woman's point of view" (Lorber, 2001, p. 129). Opposing positivist inquiry, standpoint feminist epistemology purports investigation from the situated position of women which emphasizes interest in and connection with the women being researched. Feminist standpoint is both a theory and a methodology guided by the concern for elucidating experiences of women as a counter and compliment to current research and science which tend to be based on men's experience. To wit, we cannot address gender inequality without refocusing efforts on discovering and valuing women's experiences and contributions to the sciences.

Previous research has focused on the influence of peer culture on learning (Astin, 1993; Baird, 1988), why women opt for majors other than science, math, and engineering (SME) or change their initial goals of majoring in SME to fit more cultural expectations of femininity (Holland & Eisenhart, 1990). Additionally, the culture of engineering as a particularly masculine arena has been found to play a role in discouraging women from completion of SME programs (Hacker, 1981). Furthermore, the situation of women in engineering education exemplifies Hartsock's concern with the material life of women. What is missing in the literature is an investigation into how men and women students in engineering perceive the treatment of women in engineering education. This project was developed to fill the gap in the literature by exploring student perceptions of women's abilities in engineering via an anonymous survey and personal interviews with sophomore engineering students at a Research I university in the Midwest.

Purpose and Method

The primary research question was: How do male and female engineering students perceive treatment of women in engineering education?" To answer this question I employed within-method triangulation and used two data gathering approaches. Triangulation is a method for ascertaining the accuracy of data through the use of multiple data sources and/or multiple methods of data collection (Reinharz, 1992). First, sophomore engineering students were solicited to complete an online survey of their perceptions of the treatment of women in engineering education. Second, students were interviewed in order to further illuminate the perceptions identified in the web survey. The unit of analysis for this project is the group.

Web Survey Participants

Participants for the web survey were recruited via email solicitation sent to all (N=1130) sophomore engineering students enrolled at Midwest University. Three hundred forty one students responded to the web survey (30% of the population). Demographic statistics of the sample are provided in Table 1. Eighty eight percent of the respondents indicated a sex category (N=300) and 22% did not provide an answer to the question (N=41). Of the students who indicated their sex (N=300), males accounted for 96%, females accounted for 4% of the sample population. This distribution is not representative of the sophomore engineering student population at Midwest University where they account for approximately 81% and 19% respectively. The mean age of the participants was 21.8 years with a standard deviation of 3.45 years. These characteristics did not differ significantly by sex (data

Table 1. Description of Sample

Variable	(N)	Percent
Sex Category	(300)	
Male	288	96
Female	12	4
Race/Ethnicity	(413)	
African American/Black	12	2.7
Asian American/Pacific Islander	34	7.8
Caucasian/White	292	66.7
Native American	1	0.2
Other	36	8.2
Class Position - Self Rank	(408)	
Top 1%	69	15.8
Top 10%	95	21.7
Top 25%	92	21
Top 50%	102	23.3
Lower 50%	29	6.6
Don't Know	8	1.8

not shown). Distribution of enrollment by field of engineering of sophomores is presented in Table 2.

Students who have achieved sophomore status due to number of credit hours completed, but who are still considered first year engineering students because of the courses they are taking, were not considered for analysis because they were not enrolled in sophomore level engineering courses. Distribution of majors represented by study participants, by sex category, is presented in Table 2. Percentages of females and males in each major, by those enrolled in the University program and by those participating in the study are also presented in Table 2. T-tests were conducted to analyze any differences in proportions of gender representation in the enrolled population to proportions of gender representation in the study participants. Among males, no significant differences were found in major distribution between the enrolled population and the study participants; among females, significant proportion differences were found in Biomedical and Chemical engineering majors (data not shown). However, given the small sample size of females in the present study, and thus the general lack of statistical power in major analysis, these differences were not deemed detrimental to the study.

Table 2. Percentages of females and males in each major, by those enrolled in the University program and by those participating in the study.

	FEMALE		MALE			
Major	Enrolled	Participants	Enrolled	Participants	Total (By Major)	
	N (%)	N (%)	N (%)	N (%)	Enrolled	Participants
Aerospace/ Astrospace	16 (8%)	2 (13%)	98 (11%)	41 (13%)	114	43
Agriculture/ Biology & Food Processing	10 (5%)	1 (6%)	19 (2%)	6 (2%)	29	7
Biomedical	14 (7%)	0 (0%)	25 (3%)	8 (2%)	39	8

Chemical	37 (18%)	1 (6%)	79 (9%)	26 (8%)	116	27
Civil	16 (8%)	2 (13%)	85 (9%)	33 (10%)	101	35
Construction	8 (4%)	0 (0%)	26 (3%)	7 (2%)	34	7
Electric & Computer	15 (7%)	3 (19%)	211 (23%)	82 (25%)	226	85
Industrial	44 (21%)	4 (25%)	77 (8%)	25 (8%)	121	29
Interdisciplinary	0 (0%)	0 (0%)	7 (1%)	0 (0%)	7	0
Materials	7 (3%)	0 (0%)	21 (2%)	3 (1%)	28	3
Mechanical	35 (17%)	3 (19%)	240 (26%)	79 (24%)	275	82
Nuclear	4 (2%)	0 (0%)	35 (4%)	15 (5%)	39	15
Total (By Sex)	206	16	923	325		

Interview Participants

In order to gain deeper knowledge about perceptions of the treatment of women in engineering, interviews were conducted with students. Interviewees for this project came from a self-selected sub-sample of questionnaire respondents from the web survey and from direct email solicitation. Students who indicated that they were interested in being interviewed provided contact information at the end of the web survey (which was not associated with their survey answers) and were contacted and scheduled for an interview. Five women and 35 men were interviewed. Given that the percent of females in engineering at Midwest University is 19%, this sample is fairly representative of the population of engineering students. However, in order to be able to gain access to the voices of the women, an additional recruitment strategy needed to be employed to increase the number of female participants.

In order to recruit additional women, personal emails were sent to each female sophomore engineering student (except for the 5 who had been interviewed) (N=292) asking them to respond to the interview questions as a written survey. Thirty-one women responded that they would be willing to answer the questions via email. Eighteen of the 31 women returned the interview questions with their answers. Those responses proved to be as telling, yet not as detailed as the actual interviews with the five women and 35 men who were interviewed in person. Interview data, both from face to face interviews and from email responses to the interview questions were treated as the same for the purposes of data analysis.

Student interviews took place during May 2005. Face to face student interviews lasted between 15 minutes and 90 minutes, were tape-recorded, and subsequently transcribed. Email interviews were printed as they were presented to the researcher.

Measures

Several variables, drawn from the web questionnaire, were used to examine perceptions of possible differential treatment of females in engineering classrooms and work groups. Two Likert-type items (variables engcrs8 and engcrs9) asked subjects to rate their levels of agreement with the following two statements: 1) "In the classroom, male students treat female students the same as they treat other male students;" and 2) "When working in teams or groups, male students treat female students the same as they treat other male students." Response categories ranged from 1 (strongly agree) to 5 (strongly disagree).

Statistical Procedure

Several statistics were used to assess association between gender and treatment attitudes and included difference in means t-tests, chi-square tests and logistic regression. Difference of means t-test and chi-square tests, respectively, were used to determine significant differences in mean perception attitudes between males and females and if relationships were present between gender and perception attitudes. Logistic regression was used to not only predict perception attitudes on the basis of sex, but also to determine the percent of variance in the perception attitudes explained by gender and other covariates. For this latter procedure, dependent variables were dichotomized: 0 (strongly or disagreed) and 1 (strongly agreed or agreed). Other covariates in the logistic models included self-ranking of academic position and race; these variables were entered into the model to adjust the odds ratios for additional potential confounding influences.

Qualitative Procedure

Similar to the constant comparative method described by Glaser and Strauss (1967), analysis for this project consisted of combining concrete instances of data into more general categories used for theory building. The voices of the students in engineering were explored to gain greater insight into the classroom climate as depicted through perceptions of peer treatment. Content analysis of the interview transcripts was carried out in order to systematically identify important themes emerging from the data regarding the treatment of females in engineering. During the course of analysis, concrete instances in the data were linked together into more general conceptual themes of categories. By utilizing this approach, evidence for themes or correction of previously developed themes was developed. From the printed transcripts of the interviews, I was able to highlight units of text and code them into two broad, preliminary topics: equal treatment of females, and unequal treatment of females. From these broad topics, transcripts were then cut and sorted by theme.

Results

A goal of the present study was to determine the extent to which women might perceive differences in how male and female engineering students are treated in the classroom and within study groups or work teams. An overview of major findings is provided in Figure 1.

- Males are nearly 7 times more likely than females to perceive that their male peers in engineering treat females as equals.
- Half of the females perceived equal treatment of females by their male counterparts and half perceived unequal treatment.

Figure 1. Major Findings of Survey and Interviews

Pertaining to the classroom, 70.3% of the sophomore engineering students agreed to some extent that males treat females as they treat other males in the classroom; only13.2% disagreed to some extent with this statement. By sex category, fewer females (50.0%) than males (71.0%) agreed to some extent that males and females are treated equally in the classroom (X^2=10.885, df=5, p=. 054), with females (mean = 2.75, SD =1.125) having significantly different mean levels of disagreement than males (mean = 2.15, SD = 1.03) (t = 2.88, df = 387, p=. 02). Controlling for other demographic and academic characteristics (year in school, age, self ranking of academic position, and race) male students were about five times more likely than female students (OR = 4.954, p<. 05) to agree to some extent that males treat females as they treat other males in the classroom (Table 3).

Table 3. Multivariate Odds Ratio[1] (OR) of Perception of Gender Equality of Treatment in Classrooms (N=341) Among Sophomore Engineering Students

	ß	SE	P	Odds Ratio
Sex (Male)	1.600	0.582	0.006	4.954
Self Rank	-0.040	0.100	0.691	1.041
Race	-0.335	0.366	0.361	0.715
Constant	-0.521	2.222	0.814	0.594

Pertaining to group work, 77.2% of respondents agreed to some extent that males treat females as they treat other males in work groups and teams, whereas 8.99% disagreed to some extent with this statement. By sex category, similar to their perception of classroom treatment fewer females (50.0%) than males (78.9%) agreed to some extent that males and females were

[1] ß (beta), SE (standard error), P (p-value) and OR (odds ratio) are calculated and reported to indicate the ratio of the odds of an event occurring in one group to the odds of it occurring in another group.

treated equally in groups (X^2=18.149, df=5, p=. 003). Further, males (mean = 2.02, SD = 1.00) and females (mean = 2.75, SD = 0.91) differed significantly in their perceptions of treatment of females by males in groups or teams (t=3.008, df=388, p=. 003). Controlling for other variables (academic self rank, and race), males were about seven times more likely to agree to some extent (OR= 6.769, p<. 05) that in groups or teams, males treat females the same as they treat other males (Table 4).

Table 4. Multivariate Odds Ratio (OR) of Perception of Gender Equality in Work Groups (N=341) Among Sophomore Engineering Students.

	ß	SE	P	Odds Ratio
Sex	1.912	0.629	0.002	6.769
Self Rank	0.017	0.119	0.887	1.017
Race	0.514	0.387	0.184	1.673
Constant	0.133	2.263	0.953	1.142

In conjunction with the survey results, the interview responses provide powerful insight into the treatment of women in engineering education. An initial look at the responses from all students appears to indicate they perceive the treatment of females as being the same as that of males. However, when the data are disaggregated by sex, we see a more complex picture. While over 70% of males report that males treat females as they treat other males, only half of the females in this study agreed. Half of the females in the project sample did, on the other hand, perceive differential treatment of males and females.

Seventy percent of males in the sample reported that the treatment of females was no different from the treatment of males. Consider the following comments:

> "I don't think it really makes a difference. I know all I really care about is just getting the assignment done, as long as they [female students] come prepared to group meetings, and communicate about what they have done or what they need help with, then I'm a lot more open…It doesn't matter whether it's male or female." (Will)

> "I've noticed that they [male students] try to treat them [women students] about the same." (Cameron)

> "Generally, my experience has been that it's been pretty equal." (Frank)
>
> "I know I treat them equal and I'm pretty sure like all my friends do." (Ubaldo)
>
> "I don't see it any differently, I just sort of see them as another student, I mean it doesn't really make a difference to me if they're male or female, like in my group, I'll still give them the same work load, and still treat them the same, so, I guess it's not all that different it's just sort of they kinda stand out a little bit, I guess is what I'm trying to say, but I mean, I don't really pay attention or treat them differently." (Yuri)

While many men explained that they treated women students equally, deeper analysis of their comments reveals that they appear to say they do one thing (treat women equally), yet their descriptions of treatment reveal that they perceive a dominant position over women. For example, using the excerpts from above, when Yuri says "…I'll still give them the same work load…" he has taken a position of authority over his women peers as exemplified by his ability to *give them* work to do. Another way to understand this power relationship lays in the fact that no male respondent indicated that he "gave work" to other male students; this was only used when describing treatment of female peers.

The culture of engineering privileges "masculine" characteristics including analytic and quantitative skills over "feminine" attributes such as communication and organizational skills (Burack & Franks, 2004; Dryburgh, 1999; Hacker, 1981). Masculinist values embedded in the culture of engineering hold women as "naturally" less able or in need of rescue and protection (Heyman, et al. 2002; Miller, 2002). Male respondents in this study openly stated that they relegated female group members to typing reports rather than allowing them to fully participate in the engineering tasks. Women were expected to keep the group organized by, doing clerical tasks such as recording project activities or preparing reports, and setting up group meetings. Such tasks were in addition to contributing to technical aspects of the projects. Information about the power relationship conveyed in Ari's comments about working with a female group member is telling: "I doled out the work, she did more of the word processing," which he justified by saying, "It was slightly easier to stick her with just the word processing because she was a woman."

Additionally, some male respondents expressed the view that they expected to exert more control than women in mixed groups. For example, when speaking about a group comprised of three women engineering students and him, Joshua said, "I had a little bit more control over the group." More explicitly, Yuri held that he and his male partner would "give them [female group members] valid assignments to do" when it came time to divide up the workload for the project. This clearly indicates that the men understood that they were in the positions of power and that the women in the group were expected to both defer to the men and contribute gender-"appropriate" work--as defined by males-- to the project. The concept of *giving valid work* to females also brings into question the definition of "valid work." In the culture of engineering, technical work is considered most valued therefore those who engage in the more technical aspects of project production gain experience and skills necessary to succeed in the workforce. If "valid work" is defined as work that takes approximately the same amount of time, as it appears to mean for many of the men who were interviewed, the work of women continues to be "women's work" in terms of word processing and organization rather than technical contributions. This puts women at a disadvantage in terms of preparation for technical careers where they will be expected to have a knowledge base that includes technical skills.

For most of the males and half of the females in this sample, it was difficult to be able to *see* differences in the treatment accorded to males and females in engineering education. The fact that 50% of female respondents *did* perceive differences in the treatment of males and females is significant, though. From women who were able to articulate the perception of differential treatment, conflicting interpretations were offered. In other words, those women who perceived that males in engineering were treated differently from females experienced this difference positively (e.g.: extra attention from males) or negatively (e.g.: abilities are assumed to be less than those of male peers). In terms of finding a more positive view, those who were able to see the differential treatment of females by males provide a view of the oppressed that is the result of struggle. Specifically, their view is something that is not easily perceived by most of the males and half of the females in this sample. However, those who view this as positive in terms of attaining attention from possible male suitors are still struggling to see the whole picture.

About half the women who perceived that women are treated differently viewed it positively. For instance, Faith, who stated that males do not treat females the same as they treat male students, added:

> "But I don't think that is a bad thing. I like being the only girl in a group because I am treated differently, not in a negative way, rather in a good way. I think that when I give my opinions or ideas for how to go about solving a problem, that I am listened to more because I am the minority."

Further, when asked if males treat females the same as they treat males, Georgia responded,

> "HELL NO! Most of the time it's completely fine with me. I usually get a lot of love from very smart boys. They will refuse to help a boy but if I ask, all of a sudden, they have a lot of free time on their hands."

Or Emily's comment,

> "I love working with men! It always seems to work out that my organizational skills and creativity, molded with his methodical train of thought, produce beautiful results."

Females who indicated that they view unequal treatment as positive are likely to be unaware of how this differential treatment will disadvantage them academically and professionally. For instance, differential treatment in terms of receiving extra assistance may disadvantage them in the long run when males perceive that they are less capable of producing. This can lead to females being relegated to secretarial "contributions" to group projects where they are unable to cultivate technical or applied skills. This disadvantages females in the workplace, then, when they have less hands-on experience compared to their male counterparts who have honed their skills.

About half of the women in the study explained that the differential treatment they receive from their male peers is neither warranted nor appreciated. Consider, for example, the following statements:

> "Some of the male students treat us female students as if we are below them. They treat us like we aren't as smart as them." (Opal)
>
> "I have encountered males who will want to do most of the work themselves, or will take over the hands-on part." (Katie)
>
> "I was very frustrated most of the time because they [male students in lab] ignored my opinion most of the time." (Patsy)
>
> "In group settings, males will believe themselves to be more dominant and try to talk over the female group members." (Brenda)

Those who perceive being treated differently in negative terms are aware that the differential treatment can damage their reputations for being competent engineers. Women are treated as "less than" male students and are aware of the problems associated with having to prove their abilities time after time only to continue to be considered under-skilled (Miller 2002).

Discussion

The engineering education climate, as illuminated by peer relations in this instance, can be partially understood in terms of Hartsock's (1987) feminist standpoint theory (FST). According to Marxist theory and to Hartsock's principle that material life structures and sets limits on perceptions of social relationships, so it might be expected that the majority of the participants would see differential treatment of females by their male peers. Because male gender privilege is "naturalized" and deeply imbedded in our culture, it may be predicted that neither females nor males would readily perceive or articulate differential treatment of females. Consistent with findings of Steele, et al. (2002) and Heyman, et al. (2002), the preponderance of males and females report that they receive the same treatment in the classroom and in work groups or teams. This is a predictable artifact of the male-dominated social structure. Accepted views of social relationships are those prescribed by the dominant group and are skewed in ways that perpetuate the group's dominance. Men, who are not subject to the disadvantages of being dominated, experience reality from a position of relative power and privilege *vis a vis* women. A finding might be expected showing that most students would not see differences in the treatment of women and men even if that occurred. Additionally, in the interest of maintaining in-group solidarity (Dryburgh, 1999; Burack & Franks, 2004), women students may be socialized to adapt to sexist behavior from their male peers as a means of insuring their acceptance in the masculinist engineering environment.

Hartsock's criterion that the vision of the oppressed and the view of reality from the standpoint of the privileged will be an inversion of each other was only partially supported by the findings of this study. Counter to the claim of FST, there was no apparent inverse vision held by half of the women in the sample. Data from the women did not present a simple inversion of men's perceptions. Even though females were statistically less likely to perceive equality in the treatment women and men, half of the women in the sample did perceive that women are treated the same as men. The other half of women participants did perceive unequal treatment of women in engineering education.

Hartsock argues that the vision of the oppressed must be *struggled for*. From this criterion, it should be expected that the view of the oppressed might not yet be fully realized by the oppressed group. In fact, it may still be in the process of being struggled for. Not unexpectedly then, data from this study support this assertion in that half of the women articulated that women were treated as equals in engineering. Additionally, of the women who did articulate differential treatment, half viewed it in positive terms of gaining attention and help. Viewing differential treatment in positive terms can perpetuate stereotypes about women's abilities and belonging in engineering. Furthermore, data from the survey and the interviews substantiate the claim that the vision of the oppressed must be struggled for in that many of the victims are still unaware of or unable to articulate the differential treatment and thus are still in the position of struggling for the informed view.

Hartsock's fifth criterion involves an engaged vision, which exposes the real relations of power in the situation and carries a liberation aspiration. At the point at which the oppressed group is able to see its oppression and identify it as negative, Hartsock's final criterion has been realized. Of the women who participated in this study, half of them were able to articulate the differential treatment received by their male peers in engineering that can be understood by the fifth criterion of FST. Unfortunately, most of the males and still half of the females remain unaware of or unable to articulate the differential treatment of females by their male peers. By becoming familiar with the position of women in relation to men in engineering education, students can avail themselves of a view from the "other" and perhaps be able to understand better the oppressive actions that disadvantage women in engineering.

Based on their comments, it seems that the women in this sample who perceive that women are treated differently from their male peers and view this in negative terms have opened the door to the "engaged vision" described by Hartsock. Insomuch as women are able to perceive and articulate their different treatment, they present the voice of a group conscious of its oppression. When the experiences of women, who constitute a subordinate group, are given voice, they contribute to a more complete understanding of the reality of women in engineering education, the engineering profession, and the greater society. The situation of women in engineering education exemplifies Hartsock's concern with the material life of women.

Conclusion

The goal of the present research was to better understand how women and men perceive the treatment of women engineering students and to give a voice to the students. Responses from the survey and from the interviews indicated that males and females maintain very different views of how females are treated in engineering education. Nevertheless, the educational environment in engineering at Midwest University, as determined by peer treatment in this instance, appears to be on par with that reported at other comparable schools (Heyman, et al. 2002; Steele, et al. 2002). Being on par with other schools, however, means that some female engineering students perceive negative, differential treatment by their male peers.

A primary obstacle that continues to block women's equal treatment in engineering education is the social and educational climate. This lingering barrier appears to be related to stereotyped expectations of women engineering students including women being social and/or creative and rather than logical and mathematical (skills which are necessary to survive and prosper in engineering).

Limitations

The limitations of the present study should be kept in mind when interpreting its results. A study that includes a greater number of female engineering students in the quantitative and qualitative methods would help establish the findings more definitively. This study focused only on the perceptions of students at one university. Including respondents from a variety of engineering programs would also be useful to broaden the scope and generalizability of the findings. Additionally, deeper probing into interview answers provided by students could have been used to gain further insights into student perceptions and is recommended for future endeavors. Despite these limitations, the findings of this project contribute theoretically meaningful and statistically significant findings on gendered experiences in engineering education.

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