2006-1501: DIFFERENCES IN CLIMATE FOR UNDERGRADUATE AND GRADUATE WOMEN IN ENGINEERING: THE EFFECT OF CONTEXT

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Differences in Climate for Undergraduate and Graduate Women in Engineering: The Effect of Context

Abstract

When examining the impact of campus climate on the retention of women in STEM fields, it is clearly assumed that women engineering students experience "chilly climates" primarily in the classroom [1,2]. Thus, as students move from the undergraduate to the graduate level where the number of classes is few, it is not unnatural to assume that the climate for women is warmer at the graduate level. However, there is little research to back up this assumption. Quite simply, the contexts in which undergraduates and graduate students experience their educations are quite different, and these different contexts may have important effects on the climate issues faced by undergraduate and graduate women in engineering. This research study conducted at a Pacific Northwest university sought to understand the extent to which assumptions about climate at the undergraduate and graduate level are true. The study found that while undergraduate and graduate women in engineering deal with some of the same climate issues, the contextual differences relative to faculty interactions and classroom experiences were significant in how climate is perceived. The differences in perceptions about climate speak to the fact that a one-size solution does not fit all, and policy changes must account for the contextual differences in the education of female undergraduate and graduate students.

Introduction

First coined by Hall & Sandler in the early 1980's to describe the classroom experiences of undergraduate women, the construct of a "chilly climate" has been extended to include experiences outside the classroom, graduate student experiences and the academic workplace for female faculty and administrators[1-5]. A chilly climate is defined by the isolation, subtle discrimination and persistent micro-inequities experienced by women and underrepresented groups in academic settings. Hall and Sandler identified behaviors that overlook, ignore, discount or single out women, and reflect preconceived ideas about the ability of women to succeed in academic settings[4].

However, context seems to matter in the experience of climate in engineering departments. Climate in science and engineering disciplines is more problematic than in other disciplines due to the culture of science itself. In addition, what constitutes a gender difference in climate at the undergraduate level is not always a gender difference at the graduate level.

The literature contains research on gender differences in climate for graduate students and gender differences in climate for undergraduate students, but there is no research that compares gender differences in climate experiences at different educational levels. Additionally, very little research has focused exclusively on engineering climate. This study fills these gaps in the literature. This research seeks to answer the following questions: How does the educational climate experienced by women engineers at the graduate and undergraduate level differ? Are gender differences in climate pervasive, or does the context of engineering education affect the experience of climate?

Numerous reports and research studies have shown that the paucity of women in STEM coupled with the culture of science can create a climate that surpasses chilly to be frigid for women in those disciplines[6-11]. Research on the climate in science departments finds that climate continues to be based upon masculine ideals, such as competitiveness and a belief in the objectivity of the scientist [12-15]. In a study of biology and chemistry departments, Ferreira [12] found that men and women differed in their perception of certain aspects of climate, including whether gender was a barrier to a successful career in science, and whether women have to prove themselves more than men. Although the men and women in Ferreira's study also had similar perceptions of the culture of science, most of the data in general pointed to the perception of science as a masculinized and inflexible career.

Department climate in terms of STEM graduate education is characterized by departmental differences in the orientation and support provided to students, faculty expectations of and relationships with graduate students, and the quality of student peer relationships[2,6,16-18]. Graduate education is decentralized and occurs under the auspices of academic disciplines and departments. Graduate students are admitted by and spend most of their time in the context of an academic department. Climate within a department varies in the same manner that informal norms, expectations about student admissions, degree requirements and student performance varies from one academic department to another.

Some of the literature written about undergraduate climate focuses not on the specific problems with climate, but on ways to warm the climate in the classroom and promote gender equity in instruction[19-20]. Competition in school is a negative aspect of the climate for women, and has been said to be a barrier for women interested in science[21-22]. Climate is typically discussed as one factor affecting the departure of women students from STEM fields.

Seymour and Hewitt[23] have written extensively about the reasons women and undergraduates in general leave the sciences. They discuss the culture of competition, the problems with the pace and workload of classes, and the weed-out process in general. These aspects of departmental culture and climate affect women's perceptions of their major. Their ethnographic study has provided deep, rich description of women's experiences in STEM majors in general.

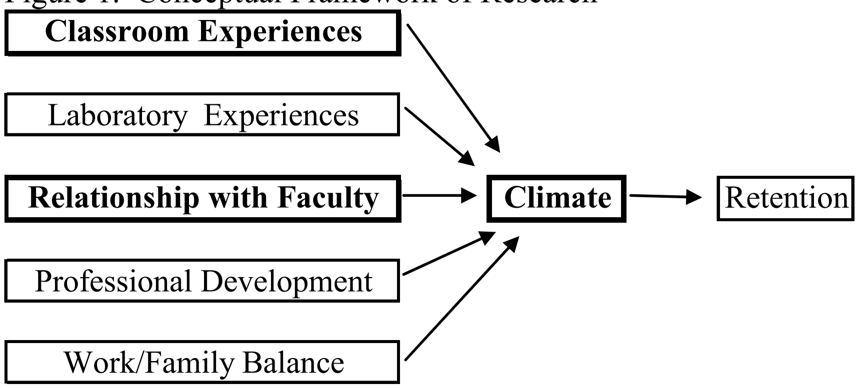
Problem Statement

It has been documented that the climate in engineering for women undergraduates and women graduate students is chilly. In what ways is the climate different depending on the level of education? In other words, how does the educational context affect gender differences in perception of climate. What are the implications of these findings?

Conceptual Framework

The conceptual framework utilized to guide the research is built off previous research. The expectation is that multiple factors affect ones overall perception of climate. Classroom experiences, laboratory experiences, relationships with faculty, degree of professional development, and work/family balance are all factors which impact climate. Climate then has effects on the retention of students, but especially women students. This paper focuses in on classroom experiences and faculty relationships since those are the most obvious way in which the context of education is different for undergraduate and graduate students. The research presented here uses an observation about the context of education to frame the research project; and locates the project within the realm of previous research on educational climate. This project tests the null hypothesis that the context of education does not matter for women's experience of climate. Figure 1 indicates the conceptual framework utilized by this research. The main variables of interest are in a bold font.

Figure 1. Conceptual Framework of Research



The contexts in which students are educated are different at the undergraduate and graduate levels. At the undergraduate level, students spend most of their time in classrooms completing degree requirements as needed for their individual programs. Although undergraduates may develop meaningful relationships with a few key faculty members, those faculty have little influence over student completion of degree requirements.

At the graduate level, contact with faculty is more intense and relevant to degree completion. A faculty member serves as the supervisory chair, helps students develop their own research agendas, and provides critical introductions to the discipline. Much of a student's professional development and career trajectory depend on positive relationships with faculty in their department. While graduate students are required to take some classes, the classes are not viewed as the most important part of their education. In science and engineering fields, time spent in laboratory settings pursuing a self-defined or an advisor's research agenda is weighted greater than time spent in classrooms. In addition, the thesis that results from that research is considered the most important indicator of educational growth for graduate students.

It is expected that there will be more gender differences on classroom experiences for undergraduates, and more gender differences on relationships with faculty for graduate students. This difference in the context of education at the undergraduate and graduate level is the framework around which the research questions evolved. Examining gender differences in climate is not a new research topic, but investigating and comparing gender differences in climate at the undergraduate and graduate level is.

Implications of Climate

Of late, research has focused on both documenting gender differences in departmental climate for female faculty and graduate students, and discerning how those differences influence the recruitment, retention and advancement of women in STEM. Barber hypothesized that the climate for women in STEM at the doctoral level leads them to change their minds about careers in STEM[13]. In other words, something happens during the course of doctoral training that lessens women's commitment to a career in STEM. Lovitts[24] hypothesized that high attrition rates for women and underrepresented groups can be attributed to flaws in departmental climate, which prohibit their social and academic integration into the department's formal and informal community. Nerad & Miller [25] found that a chilly department climate was a salient factor in student decision-making about leaving doctoral programs after advancement to candidacy. In support of the importance of faculty advisors for graduate student outcomes, Ulku-Steiner, Kurtz-Costes and Kinlaw[6] found that mentor support predicted career commitment of students, male or female.

For undergraduate students, one of the most important implications of a chilly climate is high attrition from engineering degree programs. Some students find that they feel isolated and disconnected from their department for numerous reasons, and thus leave their engineering major for a more welcoming major[23]. Bergvall, Sorby and Worthen[18] conclude from their research that most women undergraduate students are not "well served" by the current trends in engineering education. The result is that few women become interested in pursuing engineering and some of those who are interested are soured by the educational climate.

If climate does have important consequences for recruitment, retention and advancement of women in STEM, it is all the more important to understand the differences in climate for women in engineering at the undergraduate and graduate level. Proposals to ameliorate the climate for women in engineering must recognize that not all climate issues for women are universal, and so proposed solutions must consider the context. This study will assist educators and administrators in understanding the specific climate issues at the graduate and undergraduate level, so that solutions will be appropriate for the context of education, and thus will be more effective at increasing the recruitment, retention and advancement of women in engineering.

Methodology

The Engineering Undergraduate Student Experience Survey and the Science and Engineering Graduate Student Experience Survey were both conducted in 2004 at the University of Washington. As suggested by their titles, they explore the experiences of students, and include questions regarding the quality of teaching, lab experiences, department climate, professional development, relationships with faculty and mentors, degree progress, and others. Both surveys over-sampled for women and underrepresented minority students to yield larger numbers for analysis. These two surveys have a set of questions that are worded the same, and also a set of questions that are highly comparable.

Engineering Undergraduate Student Experience Survey

The Engineering Undergraduate Student Experience Survey explores the academic experiences of undergraduate students in engineering. It has been administered at the University of Washington since 1993[26]. The UW's Undergraduate Student Experience Survey was expanded by the Women in Engineering Program & Advocates Network (WEPAN) and administered to 29 institutions in 1998[27]. The current version of the survey builds off this longstanding experience with undergraduate climate surveys. The survey asks questions about the quality of faculty teaching, quality of teaching assistants, quality of lab work, academic confidence, discrimination, and organizational involvement. Responses can be disaggregated by gender, ethnicity, year in school, and citizenship status. The survey is composed of fifty nine questions, the majority of which use a five point Likert scale ("1" =not at all, "5" =very much) to assess student experiences. Demographic information is collected from nine items in the survey.

The Engineering Undergraduate Student Experience Survey was conducted in April/May of 2004 to a sample of engineering undergraduate students. All women and underrepresented male students in the population of interest were included in the sample. The population of Asian American males were randomly sampled to equal the number of white females. White males were also randomly sampled to equal the number of white females. A total of 447 surveys were completed, resulting in a 31% response rate.

The mean age of the undergraduate respondents was 21.76, and ranged from 17 to 50. Approximately 33% of the respondents were in their freshman or sophomore year, 32% were in their junior year, and 29% were in their senior year. An additional 5% of the respondents were in their fifth year. U.S. citizens and permanent residents comprised about 90% of the respondents while 6.5% were on temporary visas and 2.7% did not respond to that question.

Science and Engineering Graduate Student Experience Survey

The Science and Engineering Graduate Student Experience Survey was developed at the University of Washington (UW) and builds upon an Undergraduate Student Experience Survey which was originally designed at the UW[26-27]. The web-based Science and Engineering Graduate Student Experience Survey explores the extent to which graduate students feel comfortable and supported in their department. It asks questions about classroom experiences, laboratory experiences, department climate, professional development, relationships with faculty and mentors, academic program status and work/family balance. Additionally there is a question about career aspirations, and multiple demographic questions including marital status, children, and financial resources. The survey is composed of sixty-two questions, the majority of which use a five point Likert scale ("1" =not at all, "5" =very much) to assess student experiences.

Graduate students enrolled in 19 UW science and engineering departments in March 2004 were included in the sample. All STEM graduate students who were female or who were members of underrepresented ethnic groups were selected for inclusion in the sample. Additionally, the number of Asian American men and White American men were each made equal to the number of White American women in the sample, using a random sampling technique. The population of international men was randomly sampled to equal the population of international women. This strategy under-represented White and Asian men while over-representing women and under-represented groups compared to the population of graduate students in Science and Engineering programs. There were a total of 1224 participants selected for the survey. Of those, 574 returned usable surveys, resulting in a response rate of 47%. For the purposes of this paper, only the surveys from the engineering graduate students will be used (n=298).

The graduate student respondents had an average age of 27.56; the range varied from age 20 to 51. Approximately 78% of graduate respondents were U.S. citizens or permanent residents, almost 19% were on temporary U.S. visas, and 3.0% did not respond to the citizenship question.

Sample Characteristics

The response rates for both the surveys are low, and thus make it hard to generalize to a larger population. Additionally, the researchers recognize that because the research compares results from two different surveys, there are differing levels of reliability and validity for the data. While a comparison between the means for undergraduate women and graduate level women on certain questions would be ideal, it is not methodologically sound because of the differences in the surveys in general. The analysis used here is appropriate because it examines statistical significance within undergraduate and graduate student populations, and only compares the differences in statistical significance and does not compare the magnitude of effects.

Reported in Table 1 are some descriptive statistics for the respondents. This is an unduplicated count of the respondents, students who chose multiple ethnicities were assigned one race based on the method used by Hirschman and Lee[28]. For the Undergraduate Student Experience Survey, 37 students chose more than one race/ethnicity. For the Graduate Student Experience Survey, 10 students chose multiple race/ethnicity identities. Missing values are included since not all respondents answered all questions. Understandably, using this method to simplify race ignores the complexity of student identities, but response rates must use unduplicated counts.

Table 1. Frequency distribution by gender and ethnicity

Ethnicity	**Undergraduate Students**			**Graduate Students**		
	Male	**Female**	**Missing**	**Male**	**Female**	**Missing**
African American	9	3		3	1	
Asian Indian	6	8		12	6	1
Asian	63	96		31	23	2
Pacific Islander	3	1		0	1	
Hispanic	18	10		3	4	
Native American	3	1		1	0	
Caucasian	98	107	1	89	91	4
Missing / Other	9 / 2	3 / 2	4	8 / 5	4 / 0	9
Total	211	231	5	152	130	16

Table 2 provides the response rates for the Undergraduate Student Experience Survey by gender and race. In the undergraduate sample, there were large discrepancies in response rates by gender. Only 25% of the men in the original sample responded to the survey, while 40% of women responded.

Table 2. Response Rates by Gender and Race for the Undergraduate Student Experience Survey

	Response Rate	Sample %	Respondent %
Male	25.0%	59.4	47.2
Female*	40.0%	40.6	51.7
African American	19.0%	4.4	2.7
Asian American	39.9%	30.5	38.7
Pacific Islander	28.6%	1.0	0.9
Hispanic/Latino**	29.2%	6.8	6.3
Native American	15.4%	1.8	0.9
Caucasian	46.2%	31.4	46.1
Unknown/Other	5.8%	24.1	4.5

Note: Some students did not designate a gender. Also, students who designated Asian or Asian Indian ethnicity were combined into Asian American for the response rate comparison.

Table 3 provides the response rates for the graduate student survey by gender and race. Among graduate students, males and females responded at approximately the same rate. The one Pacific Islander in the sample pool responded to the survey, which means that Pacific Islanders have a 100% response rate for this survey.

Table 3. Response Rates by Gender and Race for the Graduate Student Experience Survey

	Response Rate	Sample %	Respondent %
Male	22.0%	56.4	51.0
Female*	24.3%	43.6	43.6
African American	30.8%	1.1	1.3
Asian American	51.4%	11.9	25.2
Pacific Islander	100%	0.1	0.3
Hispanic/Latino**	22.6%	2.5	2.3
Native American	14.3%	0.6	0.3
Caucasian	32.6%	46.1	61.7
Unknown/Other	5.6%	37.7	8.7

Note: Some students did not designate a gender. Also, students who designated Asian or Asian Indian ethnicity were combined into Asian American for the response rate comparison.

Variables

This research project focuses only on undergraduate and graduate students in engineering departments. The following climate factors were analyzed in this research study: perception of gender discrimination, feeling judged on the basis of gender, being singled out to speak for your gender, intensity of the pace/workload, sense of isolation, degree of competition, and relationship with faculty/graduate advisor. Table 4 reports the means and standard deviations for the variables used in the analyses.

Table 4. Descriptive Statistics for Variables in Analysis. UW Student Experience Surveys 2004

	Undergraduate Students					Graduate Students				
Survey Question	**N**	**Min**	**Max**	**Mean**	**Std. Dev.**	**N**	**Min**	**Max**	**Mean**	**Std. Dev.**
Since entering the department, have you experienced discrimination on the basis of gender?	413	1	5	1.53	1.003	296	1	4	1.25	.648
Since entering the department, have you experienced sexual harassment?	410	1	5	1.18	5.92	294	1	5	1.09	.423
Since entering the department, have you experienced isolation?	412	1	5	1.72	1.100	295	1	5	1.94	1.279
To what extent do you feel you have been judged on the basis of your gender?	439	1	5	2.05	1.259	298	1	5	1.51	.904
To what extent do you feel singled out in class to speak on behalf of your gender?	433	1	5	1.54	.949	292	1	5	1.29	.720
Do you feel overwhelmed by the pace and workload (in your degree program)?	437	1	5	3.36	1.055	296	1	5	2.67	.939
To what extent do you feel that you are treated with respect by your advisor (your professors)?	443	1	5	3.88	.772	292	1	5	4.22	.970
To what extent do you feel your suggestions or comments in the classroom are taken seriously by faculty?	418	1	5	3.47	.916	296	1	5	3.93	.873
To what extent is your advisor available to you? #						288	1	5	3.81	1.003
To what extent do professors set office hours and not keep them? #	427	1	5	1.82	.960					
To what extent do you feel that grades are given solely on the basis of your performance in the classroom? #						290	1	5	3.65	1.052
To what degree do you feel your grades reflect your knowledge of course material? #	444	1	5	3.07	.980					
To what extent does competition within your departmental classes negatively impact you? #	408	1	5	3.04	1.247					
To what extent do engineering students compete against each other in class? #	430	1	5	3.63	1.091					

To what extent do graduate students in your department compete against each other for funding? #						281	1	5	2.63	1.212
To what extent do graduate students in your department compete against each other for grades? #						288	1	5	2.65	1.159

Note: Questions with the # sign were only asked on one of the surveys. Comparable questions are included from the other survey.

Both surveys contained eight questions that were exactly the same. For the constructs of availability of faculty, grade assignment bias and competition, there were not exact duplicates on each survey. Instead, questions were chosen that seemed to have face validity for the construct and which matched well with questions from the other survey. These comparable questions are indicated with a number (#) sign in Table 4. For example, graduate students were asked, “To what extent is your advisor available to you?”, while undergraduate students were asked, “To what extent do professors set office hours and not keep them?”. Both of these questions measure the construct of ‘availability of faculty’, and perhaps, they each more appropriately measure the construct because they account for the context of education.

Analysis and Results

In order to assess gender differences among undergraduate students and gender differences among graduate students, a t-test analysis was performed on survey questions of interest. A t-test measures whether there are statistically significant differences in the means for two groups. Often a t-test may indicate statistical significance of difference of means, but because the differences between the group means are so small, the difference is not really substantively significant. In cases where the variances of the variables was not assumed to be equal, and thus violated an assumption of t-test analysis, the Levene test as used to determine the proper statistical significance of the relationship.

The reader must be cautioned that the findings for the t-test analysis are correlational, not causal. It is impossible to determine causation in cross-sectional data, and so future research should examine longitudinal data. In discussion of the results, we take care to refer to relationships between variables but not to suggest that one variable is the cause of another.

Table 5 shows the results of the t-test analysis of gender differences among undergraduate and graduate students. The shaded areas indicate questions with statistically significant gender differences, and act as a visual aid in understanding the similarities and differences in climate for undergraduates and graduate students. The gender differences in undergraduate engineering and the gender differences in graduate engineering programs converge and diverge on certain climate indicators. Both female undergraduate and graduate students in engineering report more negative responses than their same level males on the following issues: discrimination on the basis of gender, being judged on the basis of gender, singled out to speak on behalf of gender, and feeling overwhelmed by the pace and workload. These issues seem to follow women in engineering to all levels of the educational structure.

Similarities in Climate

The similarities in climate for undergraduate and graduate women are enlightening. Feeling discriminated against on the basis of gender, being judged on gender, and singled out to speak on behalf of ones gender all highlight the visibility of gender in engineering departments. Women in engineering continue to feel singled out because of their gender, and gender biases continue to exist. Feeling overwhelmed by the pace and workload is another climate issue that crosses educational level lines. While it remains unclear why women feel more overwhelmed than men by the pace and workload in engineering, this finding, which had supporting evidence in the early 1990’s[23], continues to be true today.

Table 5. T-test Analysis of Gender Differences. UW Student Experience Surveys 2004

		Undergraduate Students				Graduate Students			
Survey Question	**Sex**	**N**	**Mean**	**s.d.**	**p-value**	**N**	**Mean**	**s.d.**	**p-value**
Since entering the department, have you experienced discrimination on the basis of gender?	Male Female	201 209	1.24 1.82	.70 1.16	.000***	152 130	1.12 1.41	.445 .804	.000***
Since entering the department, have you experienced sexual harassment?	Male Female	200 207	1.15 1.22	.544 .638	.189	152 128	1.04 1.13	.279 .441	.040*
Since entering the department, have you experienced isolation?	Male Female	199 210	1.58 1.85	.98 1.20	.011*	152 129	1.82 2.09	1.21 1.33	.069
To what extent do you feel you have been judged on the basis of your gender?	Male Female	209 226	1.49 2.59	.88 1.33	.000***	152 129	1.34 1.37	.745 .697	.000***
To what extent do you feel singled out in class to speak on behalf of your gender?	Male Female	206 224	1.25 1.82	.64 1.10	.000***	150 127	1.11 1.50	.442 .899	.000***
Do you feel overwhelmed by the pace and workload (in your degree program)?	Male Female	207 227	3.18 3.53	1.06 1.03	.001**	152 129	2.53 2.81	.941 .944	.016*
To what extent do you feel that you are treated with respect by your advisor (your professors)?	Male Female	210 228	3.87 3.89	.799 .755	.754	151 128	4.34 4.09	.880 1.06	.027*
To what extent do you feel your suggestions or comments in the classroom are taken seriously by faculty?	Male Female	204 211	3.38 3.56	.93 .90	.039*	152 129	3.93 3.92	.896 .853	.911
To what extent is your advisor available to you? #	Male Female					149 126	3.97 3.66	1.01 .997	.010**
To what extent do professors set office hours and not keep them? #	Male Female	205 217	1.86 1.78	1.03 .900	.424				
To what extent do you feel that grades are given solely on the basis of your performance in the classroom? #	Male Female					151 125	3.79 3.49	.928 1.15	.019*
To what degree do you feel your grades reflect your knowledge of course material? #	Male Female	210 229	3.02 3.10	.980 .986	.389				
To what extent does competition within your departmental classes negatively impact you? #	Male Female	196 209	2.88 3.19	1.20 1.29	.014*				
To what extent do engineering students compete against each other in class? #	Male Female	205 222	3.53 3.73	1.13 1.06	.068				

To what extent do graduate students in your department compete against each other for funding? #	Male Female					147 122	2.71 2.56	1.25 1.17	.291
To what extent do graduate students in your department compete against each other for grades? #	Male Female					149 126	2.70 2.61	1.13 1.20	.507

Note. 1. Questions with the # sign were only asked on one of the surveys. Comparable questions are included from the other survey.

2. The question: "To what extent do you feel you have been judged on the basis of your gender", is statistically significant for gender differences for both undergraduates and graduate students, but the difference between men and women graduate students is so small as to not be substantively significant.

Gender Differences in Climate Unique to Undergraduate Students
For undergraduate students, the unique gender differences are primarily related to classroom experiences, which support the hypothesis that the context of education has effects on gender differences in the experience of climate. Surprisingly, women report being taken seriously by faculty in the classroom more than men report; however, women report feeling isolated, and feeling negatively affected by competition more than men report.

It is interesting that women undergraduates feel that their comments or suggestions in the classroom are taken more seriously, on average, than men undergraduates feel. This may suggest that professors have become more aware of gender discrimination in the classroom, and thus it is not because of the professor's actions that they feel the climate is chilly. Given the data from this survey, it is not possible to understand the underpinnings of this finding. Future research should assess whether this finding is an anomaly or is indicative of a larger trend.

Women's isolation and negative experiences with competition may be derived primarily from their relationships (or lack thereof) with their classmates. Women in engineering are a minority, and it is normal to feel alone in a department with only a handful of women. Based on anecdotal evidence, some male peers ostracize and exclude women from their study groups and lab teams; this only increases women's sense of isolation.

Women's greater sense of competition within department classes also suggests that women students may have a lower tolerance for competition, or they may engage in peer comparisons more often than men do. Theories of gender socialization help to explain this difference in tolerance for competition and research on these theories affirms their conclusions[29]. The finding that women are sometimes uncomfortable with competition is a factor cited in the literature on reasons why women undergraduates leave engineering and the sciences[21,23].

Gender Differences in Climate Unique to Graduate Students
As expected, the gender differences unique to graduate students revolve around relationships with faculty. Because one of the most important factors related to a graduate students' matriculation is their relationship with their advisor [24,30-32], it is alarming that on questions related to faculty relationships, women consistently report lower satisfaction than men do. Graduate women in engineering report: being treated with less respect by their advisor, feeling their advisor is less available to them, that grades were not based solely on performance in the classroom, and greater experiences of sexual harassment than graduate men reported.

The finding that women feel they are treated with less respect by their advisor and that their advisor is not as available to them as men feel, has serious implications for women's outcomes during and after graduate school. A graduate student's relationship with an advisor can be an important factor in their choice of a faculty career, the choice to persist in graduate school to the degree, or in obtaining a position at a well-regarded university. The support of faculty in general, but especially the support of ones advisor or committee chair is of importance for a graduate student's retention and advancement in engineering. Thus, women may be at a disadvantage with respect to their future careers in engineering.

The fact that female graduate students' experiences with sexual harassment are greater than male graduate students is not unexpected. Females have historically been the subject of harassment by male colleagues and professors on college campuses. What is concerning here is not that women experience sexual harassment more than men, although it is a phenomenon that should continue to be worked on, but that the harassers are likely to be the women's advisors, faculty members, and colleagues. If sexual harassment happens often enough, a woman may begin to feel that this type of behavior is common in engineering in general and decide to leave the field.

Understanding the finding that women were more likely to believe that grades were not based solely on performance in the classroom is more difficult. Perhaps this is due to the phenomenon of attribution bias; women attribute their successes to luck while men attribute their successes to skill and natural ability. In the same vein, women are more likely to attribute their failures to a lack of their own innate ability, while men attribute their failures to things such as lack of sleep or a momentary lapse. Ultimately, the survey did not allow respondents to report why they felt this way about grade assignment, nor did it provide an opportunity for them to suggest what factors they perceived influenced grades.

Discussion

The climate issues for undergraduate women and graduate women in engineering diverge in ways that coincide with educational contexts, and have implications for institutional and departmental climate change. The chilly climate for undergraduate women is felt mainly in the classroom, and so reforms that take place should focus on this arena. Graduate women, on the other hand, find that their experiences with faculty and advisors are much more discouraging than graduate men find. This is a more difficult area to reform because of the autonomous nature of faculty positions. However, this is not to suggest that positive changes are impossible. This study finds that the different contexts experienced by women at different degree levels in engineering are related to the divergent climate issues experienced by students.

Part of the value of this study comes from breaking the assumptions about climate as a monolithic phenomenon. Women experience different climate issues depending on the context of their work. Chilly climates do not occur in the same ways at all educational levels. While this might be obvious to some, it has not been previously documented in the manner of this research. The implication of the findings relate to the efforts of administrators, educators, researchers to recruit and retain women in engineering. Faculty aware of the research can modify their leadership styles to conform to the needs of women, and in doing so, can warm the climate for women in engineering. Administrators can institute policies, practices and procedures to minimize the effect of climate on women. For example, many institutions have policies against sexual harassment and discrimination on the basis of sex; but this study indicates that those policies may not have the impact required to improve the climate in engineering, and either more punitive consequences are needed or perhaps the policies need to be publicized to a greater degree.

One of the biggest implications of a finding of a chilly climate for women in engineering is that climate has been shown to be related to attrition from engineering. In a time where diversity in the workforce is lacking, it is important not to become complacent about the problems women still face in engineering. While things may have improved from 30 years ago, there are still problems, and women still indicate they are affected to a greater degree by climate issues than men indicate.

While the findings here contribute to what is known about climate in engineering departments, the study has a few limitations. The generalizability to other settings is limited due to sampling from one institution, and the small sample size. The small number of underrepresented students in the sample is also problematic. Administration of the survey at other institutions, especially those with more underrepresented students in the population, would increase the generalizability of findings and expand what is known about how department climate differs for undergraduates and graduate students in engineering.

Recommendations for Further Research

Using this survey on an annual basis would provide rich, longitudinal information which could be used to track changes in climate over time. Qualitative research might also be helpful in understanding the climate for graduate students in science and engineering programs. Using the same survey in a single administration to both undergraduate and graduate students would allow for comparison of group means using an accurate methodology.

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