Changes in Undergraduate Engineering College Climate and Predictors of Major Commitment: Results from Climate Studies in 2008 and 2015

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Abstract

This paper presents results of two cross-sectional investigations of educational and interpersonal climate in a college of engineering at a large mid-western university. In 2008 and in 2015 we deployed a survey ("Project to Assess Climate in Engineering") to undergraduate engineering students. In each survey year, just over 1000 eligible students participated and responded to items contributing to scales rating their professors, teaching assistants, college resources, confidence (self-efficacy) in engineering, student interactions, perceptions of engineering, and commitment to an engineering major. Participants were also asked about experiences of being singled-out based on race or gender, hearing gender or racial stereotypes expressed by faculty or students, sexual harassment and racial harassment. Scale means and some individual items were analyzed for differences by demographic group, and were compared to data collected by the same institution in 2008. Results revealed significant differences in attitudes and experiences from 2008 to 2015 for the entire sample and within demographic groups. For example, experiences of stereotyping and being singled-out due to gender or race were reported at higher rates across all groups in 2015 compared to 2008, while engineering self-efficacy, ratings of professors and student interactions were lower. To investigate the influence of demographic and scale factors on commitment to major, we formed regression equations for each survey year. In 2015, perceptions of engineering, engineering self-efficacy and professor ratings predicted commitment to major. Regression results differed significantly in 2008 and 2015. Among other findings, while underrepresented minority and international status negatively influenced commitment to major in 2008, neither underrepresented minority nor international status had a significant influence on commitment to major in our 2015 sample.

Introduction

The loss of students from engineering often represents lost economic opportunities for individuals, families, and society and can be a loss for post-secondary institutions who have an educational mission but also a mission to graduate students with strong employment prospects[1]. Further, engineering as a field has lagged other fields in representation of women and racial/ethnic minority students, leading to long-standing calls for increased recruitment and retention of women and minorities to increase the number of individuals graduating from and practicing in engineering[2,3].

There is a large literature base over the last 40 years investigating factors associated with retention in undergraduate engineering education. Many studies have focused on identifying pre-college factors (high school GPA, rank, high school course rigor, standardized test scores, personality and psychological variables, etc.) associated with engineering graduation, following a model first introduced by Tinto in 1993[4]. Results of these studies allow better targeting of admissions to particular student achievement characteristics and may maximize educational resources and improve retention rates. However, such research does not provide guidance in why high-achieving students, particularly women and racial/ethnic minorities enroll in but then leave engineering education, or how such influences might be changing over time.

A second category of studies has considered the learning and interpersonal environment of engineering and the interaction with student characteristics that might influence students' decisions to remain in or leave engineering education. Some studies have described the totality of the college environment as the "climate", a term that attempts to capture the classroom, lab, resources and extracurricular contextual factors that may influence students' decisions to remain in the college or transfer to other majors, institutions or out of post-secondary education[6]. The present study falls within this line of inquiry, and aims to demonstrate that repeated measures of college climate are an important mechanism for engineering colleges to monitor the impact of educational environment on students and make adjustments to promote student retention.

College Climate Research

The application of the term "climate" to organizations grew from an industrial and organizational research framework and provides a holistic perspective on how an organization functions, and thus influences how individuals situated within the organization function[7]. Definitions and operational measures vary widely, but generally share the basis that climate is a "common member perception of attitudes towards and feelings about organizational life"[8].

In 1992, Hurtado[9] utilized the climate concept to study the racial dynamics and conflict in higher education. Fifteen years later, Harper and Hurtado[10] surveyed the literature on campus racial climates and categorized over 30 qualitative and quantitative studies. These authors argued that the literature on campus racial climate supports the conclusion that a negative racial climate inhibits learning, and made the specific recommendation for ongoing assessment of campus racial climate. More recently, a study of 1,491 students at a large, predominantly white research institution found that observations of racism and feelings about the campus environment had both direct and indirect influence on the persistence of students of color[11]. In addition to racial dynamics, gender disparities in higher education climate persist. Despite high representation overall of women in higher education[12], researchers have described the classroom environment for women in higher education as "chilly" [13,14], and suggest that women's major choices may be related to differentially chilly climates in schools, colleges and academic departments.

Engineering Climate Research

Assessments of climate within engineering schools and colleges were developed to probe the differential retention of women when compared to men in undergraduate engineering programs, and later expanded to include questions about racial dynamics[16,17]. In 1999, Metz, Brainard and Gilmore[18] reported on a pilot 45-item climate survey as a method to assess engineering students' perceptions of the educational climate, and aimed to identify variables related to lower persistence of women. Researchers found differences in responses between men and women in academic confidence in engineering and physics courses, the belief that engineering is the right major, comfort using lab equipment and comfort asking questions in class. In 2008, some of the same researchers were involved in the development and deployment of the national Project to Assess Climate in Engineering ("PACE") survey[19]. The survey at that time was expanded substantially to investigate a wide variety of items and constructs that had been theorized or demonstrated in the literature to be related to differential retention of women and students of color, including engineering self-efficacy[20,21], outcome expectations[22], racial/ethnic stereotyping and harassment[16]. The second deployment of the PACE survey in

2012 was further expanded to include questions about stereotyping and harassment related to sexual orientation.

Litzer and Young [23] utilized the 2008 PACE data from more than 10,000 engineering students at 22 institutions to perform a multinomial logistic regression analysis investigating the risk of attrition in undergraduate programs. These researchers modeled attrition risk as three latent classes of students which they termed "Committed" (52%), "Committed with Ambivalence" (41%) and "At-Risk of Attrition" (7%), and calculated the probability of students from demographic groups of belonging to a class. For example, they found that while females were less likely than males to be in the "Committed" group, the difference in likelihood disappeared after accounting for by student experiences and perceptions. Researchers did not report on variables associated with stereotyping and harassment, perhaps because these variables were non-significant (E. Litzler, personal communication, May 2015). This study is important as the largest investigation of the influence of educational climate in engineering on student retention. However, the relative importance and effect size of demographic variables and climate measures in predicting retention is not readily apparent with this analytic approach.

Significance of Present Study

The aim of this study is to build on and extend the results of the PACE research using two cross-sectional data collections at a single large engineering college, to identify and rank factors that may influence student retention in engineering, and to ascertain any significant changes that occurred between 2008 and 2015. First, we identified group differences in perception of college climate, in order to evaluate if some demographic groups are uniquely vulnerable to, or critical of, particular aspects of climate within engineering education. Second, we determined which demographic and climate factors are significant in predicting commitment to an engineering major, the strength of the prediction, and the relative importance of predictor variables for this student sample. Finally, we investigated whether there are differences in climate factors or how such factors interrelate between data collected in 2008 and 2015. The intent of this last goal is to gather evidence as to the importance of repeating measures of college climate at discrete points over time, to capture changes that may be occurring in the college climate or possibly in the attitudes and perceptions of students.

Methods

The PACE was a multi-site research project intended to identify issues that affect persistence rates among engineering undergraduates. The project was intended to be longitudinal and since project initiation, two waves of multi-site data collection have occurred, in 2008 (22 institutions) and 2012 (16 institutions, not including this institution). Our current project is a single-site study utilizing the initial data collection in Spring 2008, and data from a second survey performed at the same institution in Spring 2015, three years after the second national data collection[1]. Changes between survey instruments in 2008 and 2015 were minimal. Data were collected at both time points using online survey software, and student responses were anonymous. Demographics of total college enrollment were obtained from institutional data sources for comparison of participant representation, however no student identifiers were

[1] Data from the institution of the present study was not included in the analysis of 2008 PACE data from 22 institutions, which was limited to institutions with direct admission to engineering majors.

collected and no link was made between student responses and institutional student data. In 2008, Institutional Review Board approval was received for the study. In 2015, the Institutional Review Board identified the project as program evaluation and declined to review.

Methods for participant recruitment and data collection in 2008 and 2015 were nearly identical. Students enrolled in the College of Engineering were invited to participate by emails from the Dean, multiple reminders were sent to encourage student participation, and participants who participated in the survey were offered an incentive to enter a drawing for a cash prize. Data were retained only from students who had taken at least one course offered by the College of Engineering.

Measurement Instruments

In 2008, the survey instrument that was deployed was nearly identical to University of Washington national PACE survey, with some minor customization. The final instrument included 130 total items, divided into sections on overall quality of teaching, engineering professors, teaching assistants, labs, college resources, student interpersonal interactions, participation in student organizations, perceptions of engineering, commitment to major, confidence in academic ability in engineering-preparation and engineering courses, stereotyping/harassment, experiences of transfer students, and demographic questions. The instrument is described in depth in Litzler and Young, 2012 [20].

In 2015, researchers for the current study obtained the most recent survey instrument that was used for the 2012 multi-site PACE data collection by the University of Washington. Changes made by the lead PACE team since 2008 were limited to adding several demographic questions and the addition of items intended to more completely measure commitment to major. Researchers for the current study made the following additional minor changes: (1) institutional customization, (2) stereotyping and harassment questions were broadened to include sexual orientation, (3) follow-up questions were added to stereotyping and harassment questions to ask students to identify the source of their experiences (faculty, teaching assistants, other students or other). The complete 2015 survey instrument can be obtained from the lead author.

Response Rates and Characteristics of Samples

In 2008, 3000 students were invited to participate in the study and 1,101 students responded. Of these respondents, 19 students were ineligible since they had not yet taken a course in engineering, representing a usable response rate of 35.6%. In 2015, overall enrollment in the college had grown considerably and 4,552 students were invited to participate in the study. Of the 1,458 students who responded, 1,036 had taken an engineering course and were thus retained in the sample. The overall usable response rate in 2015 was 23%. In both years among respondents, males were slightly underrepresented and females were slightly overrepresented, and respondents had somewhat higher grades than was average for the college. Underrepresented Minority students (includes domestic African American, Hispanic/Latino, Native American/Native Hawaiian, SE Asian or Pacific Islander) in 2008 were underrepresented compared to enrollment, while in 2015 underrepresented minority students responded at levels equal or nearly equal to their college enrollment. Table 1 shows demographic characteristics and missing data for each of the samples. Columns that do not sum to 100% indicate missing data.

Groups that were significantly over- or under-represented compared to their college enrollment are indicated.

TABLE 1: Respondent Demographics in 2008 and 2015

	2008 Survey Respondents		2015 Survey Respondents	
	N	%	N	%
ALL	1082	100	1036	100
Gender				
Male	733	75.6*	714	68.9*
Female	237	24.4**	287	27.7**
Race/Ethnicity				
African American/Black	14	1.3	16	1.5
Hispanic/Latino	17	1.6*	43	4.2
American Indian/Native Alaskan/Hawaiian	11	1.1	~	~
Asian/Asian American (includes East Indian)	67	6.2*	99	9.6
SE Asian/Pacific Islander	16	1.5	13	1.3
White	815	75.3	796	76.8
Other/Unknown	142	11.9**	69	6.8
International Student	52	4.8*	64	6.2
Underrepresented Minority	45	4.8*	70	6.8
Rank				
Freshman	229	22.3	221	21.5
Sophomore	225	22.9	258	25.1
Junior	209	21.3	218	21.2
Senior+	318	32.4	430	32.2
Mean GPA		3.28		3.36
High GPA (> 3.5)	344	31.8**	433	41.8**
Student Works	633	59.5	676	65.3
Financial Need	143	13.2	238	23
First Generation	*	*	179	17.3

* Indicates participants are underrepresented compared to enrollment

** Indicates participants are overrepresented compared to enrollment

~ Low representation risks identification

Variables

The majority of variables were formed using a 5-point Likert scale, with response choices matched to the item content, but typically ranging from “Strongly disagree” to “Strongly agree”, or “Never” to “Always Questions about specific experiences of stereotyping or harassment offered choices of “Yes”, “No”, or “Don’t Know”, and “Don’t know” choices were re-coded as “No”. Demographic questions asked students to report their sex, racial/ethnic category (respondents could choose multiple category), citizenship status, parent/guardian education level (2015 only), age, grade point average in college and high school (2015 only), family status, disability status, year in school, transfer status and financial sources for tuition payment.

Dependent Variable

The primary outcome variable is scale called Commitment to Major. This scale consisted of four items in 2008, and eight items in 2015 and included items such as “I have no desire to choose another major”, “It is my choice to study engineering”, “I intend to complete my engineering degree”, “I enjoy solving engineering problems”, and similar items. The scale was not computed for participants with more than 15% of missing items, e.g. maximum of one missing item in 2008, and two missing items in 2015.

Independent Variables

Binary demographic groups were created for the following variables: Sex, Underrepresented Minority, International Student, High GPA (> 3.5), financial need, work status, first generation status (neither parent graduated from 4-year post-secondary institution; 2015 only). Although there are likely important differences between racial/ethnic minority groups, underrepresented minority students were grouped into a single category because representation was too low to allow for meaningful analysis between groups.

Predictor scales were formed for the following factors. (1) Professors: 21 items (20 in 2008) such as “My engineering professors care whether or not I learn the material”, “My engineering professors hold regular office hours”, “Professors move through material too quickly”. (2) Teaching Assistants: nine items such as “My teaching assistants are knowledgeable about material”, “My teaching assistants are good communicators”. (3) Student Interaction: originally eight items such as “Group projects are valuable”, “I feel a part of an engineering community”, “Students help each other succeed in class”. Two of these items did not correlate well with other items on the scale. An item asking students to self-rate their engineering ability compared to peers was most closely associated with items on Engineering Self-Efficacy, and logically seemed better associated with that scale. When analyzed with other self-efficacy items, this item increased the overall reliability of the Engineering Self-Efficacy scale. A second item (“Students compete with each other in class”) designed to be included in the Student Interaction factor did not correlate well with any items or scales, so was treated individually. Six remaining items made up the Student Interaction scale. (4) Engineering self-efficacy: six items such as “I am confident I can do well in my engineering courses”, “Compared to other engineering students, my academic ability is….”, (5) Perceptions of Engineering: twelve items such as “Engineers are respected by society”, “Engineers can set their own schedules”. The Perceptions of Engineering scale was originally designed to be two subscales, one related to perceptions of work-life balance within engineering and the other related to perceptions of general engineering workplace and professional characteristics. In this sample, the complete scale offered more predictive value, however sub-scales were computed to examine group differences by sex. In this sample, scales showed excellent to acceptable internal consistency, with an average α = .749 in the 2008 sample, and α = .782 in the 2015 sample. All scale reliabilities are shown in Table 2.

TABLE 2: Scale Reliabilities and Descriptive Statistics

	2008 PACE Sample					**2015 PACE Sample**				
	Items	**N**	**α**	**Mean**	**SD**	**Items**	**N**	**α**	**Mean**	**SD**
Professors	20	910	0.849	3.6	0.413	21	897	0.877	3.54	0.442
Teaching Assistants	8	877	0.755	3.58	0.545	9	935	0.814	3.63	0.559
Student Interaction	6	991	0.794	3.51	0.666	6	1020	0.719	3.41	0.602
Engineering Academic Self Efficacy	6	985	0.833	4.16	0.585	6	1013	0.875	3.96	0.636
Perceptions of Engineering	12	973	0.736	3.86	0.464	12	973	0.756	3.85	0.404
Work-Life Balance	4	984	0.639	3.18	0.594	4	1022	0.617	3.18	0.586
Workplace/Field	8	981	0.731	4.2	0.557	8	975	0.743	4.2	0.439
Commitment to Major	4	987	0.657	4.09	0.768	8	1011	0.859	4.12	0.6
Average Cronbach's α			**0.74925**					**0.7825**		

In 2015, there were 15 items intended to measure students' experiences and observations regarding stereotyping and harassment. The 15 items measured five types of stereotyping/harassment (singling out, faculty expressing stereotypes, students expressing stereotypes (2015 only), faculty harassment, and student harassment) associated with three demographic groups (racial/ethnicity, sex, and sexual orientation-2015 only). While these items were not designed to form a scale, in this sample items were internally correlated and demonstrated Cronbach's α = .730. In the 2008 survey, six items measured racial and sex stereotyping/harassment. Items asking participants about stereotyping/harassment related to sexual orientation and hearing gender/racial stereotypes from other students were added by between the first and second wave of data collection.

Data Analysis

Data from both survey years was initially exported from survey software into an Excel spreadsheet, which was then imported to SPSS software (IBM, Inc.) for statistical analysis. Data were examined for demographic characteristics, missing data, univariate and multivariate outliers, and variable normalcy. Items designed to contribute to a factor scale were investigated for internal consistency, and scale means were computed for those cases that had internal consistency (Cronbach's Alpha) > .6, and no more than 15% missing data on contributing items.

Data analysis proceeded as follows. First, multiple ANOVAs were used to investigate differences and interactions on scales and on several key individual item variables. Scale items between groups generally exhibited homogeneity of variance, however items intended to measure experiences of stereotyping and harassment generally had significantly different variances. This was not surprising since these items had a restricted response set (Yes/No/Don't Know). The Welsh statistic was used to evaluate significant differences when items did not meet the standard of homogeneity of variance. Further, on stereotyping/harassment items that were found to be significant, we also reported "% Yes" to simplify interpretation. Second, 2008 and 2015 data were combined into a single dataset to investigate main effects of demographic variables and interactions with survey year. Multivariate ANOVA was not used because group size became too small with multiple demographic and survey year groupings. Third, stepped hierarchical linear regression analysis was performed to predict Commitment to Major. Predictors included demographic characteristics and survey year (first block), scale means (second block), and stereotype/harassment items (third block). Survey year was found to be a significant predictor in the regression equation, thus in our final analysis, individual regressions were performed on 2008 and 2015 data separately to evaluate the differences in significance and weight of predictor variables.

Results

Descriptive Statistics and Between Group Differences

We were interested in investigating differences in group means on survey factors, and for items associated with stereotyping/harassment. We formed groups for gender, underrepresented minority students, international students, students with high-GPA (> 3.5), low income students, working students and first generation students (2015 only).

In the 2008 sample, we found males rated Professors significantly higher than females (p=.03), and had higher Engineering Self-Efficacy (p=002). Females reported higher rates of three gender stereotyping/harassment items (singled out in class, faculty expressing stereotypes, and sexually harassed by other students). Comparing group means between underrepresented and majority students, we found underrepresented students rated Teaching Assistants higher (p=.04, had more favorable Perceptions of Engineering (p=.028), lower Commitment to Major (p=.04) and reported higher rates of three racial stereotyping/harassment items (singled out in class due to race, harassed by faculty because of race, and harassed by other students due to race). Comparing international to domestic students, international students had lower ratings for Teaching Assistants (p=.014), lower Perceptions of Engineering (p=.000), lower Engineering Self Efficacy (p=002), lower Commitment to Major (p=.000) and reported higher levels of two racial stereotyping/harassment variables (singled out in class due to race, harassed by other students due to race).

In the 2015 sample, we found women reported very small but still significantly lower levels of Engineering Self-Efficacy (p=.045), and higher rates of three gender stereotyping/harassment (singled out in class, faculty expressing stereotypes, and sexually harassed by other students). Underrepresented minority students reported higher levels to stereotyping variables (singled out in class due to race, harassed by other students due to race) than majority students. International students differed from domestic students on their more positive perceptions of Professors ($p=.039$), and higher reports in all four racial stereotyping/harassment variables (singled out in class due to race, faculty expressing racial stereotypes, and harassed by faculty due to race). In both survey years, High GPA students rated professors significantly higher (Mean Δ 2008 = .13; Mean Δ 2015=.19, $p<.001$) and had higher Engineering Self-Efficacy (Mean Δ 2008 = .46, Mean Δ 2015=.44,$p<.001$). In 2015, High GPA students had a higher level of Commitment to Major (Mean Δ 2015=.11 ,$p<.002$). Finally, as noted in Methods, in 2015 several questions about stereotyping and harassment were added. Three additional questions asked students about hearing or experiencing stereotypical comments about sexual orientation. Two additional questions asked students if they had heard other students express gender or racial stereotypes. More than 38% of students reported hearing other students express gender stereotypes, and 37% of students reported hearing other student express racial stereotypes. Among women who participated in the study, 58% reported hearing other students' express gender stereotypes. Among underrepresented students who participated in the study, 55% reported hearing other students express racial stereotypes.

Comparing 2008 and 2015 student samples, we found students in 2015 evaluated Professors, Student Interactions, Engineering Self-Efficacy significantly lower than did students in 2008. Because items assessing stereotyping and harassment associated with sexual orientation were added after 2008, we could not compare these items. On the six stereotyping/harassment items that were included in both years, students in 2015 endorsed four items at higher levels than in 2008 (singled out because of race, faculty express race stereotypes, singled out because of gender, faculty express gender stereotypes), and two items (sexually harassed by faculty, sexually harassed by other students) at lower levels.

Tables 3-6 show group means and standard deviations (sex, underrepresented minority, international students, survey year) on variables for which significant differences were found.

TABLE 3: Group Mean Differences by Gender and Survey Year

Group Mean Differences by Gender									
		2008				**2015**			
Scales or Items		N	Mean	Std. Deviation	p or W	N	Mean	Std. Deviation	p or W
Professors Scale	Male	726	3.621	0.411	0.030	713	3.541	0.445	N/S
	Female	236	3.556	0.377		286	3.547	0.435	
Engineering Self-Efficacy Scale	Male	729	4.197	0.572	0.002	713	3.987	0.636	0.045
	Female	237	4.060	0.598		286	3.899	0.613	
In class, singled out because of gender.	Male	729	0.019	0.113	0.000	712	0.022	0.115	0.000
	Female	237	0.249	0.421		287	0.364	0.461	
In class, faculty express gender stereotypes	Male	730	0.075	0.249	0.000	708	0.114	0.305	0.000
	Female	237	0.247	0.421		286	0.295	0.440	
Sexually harassed by student	Male	727	0.014	0.097	0.000	711	0.006	0.065	0.000
	Female	236	0.072	0.251		287	0.035	0.174	

TABLE 4: Group Mean Differences by Underrepresented Minority Status and Survey Year

Group Mean Differences by URM Status									
		2008				**2015**			
Scales or Items		N	Mean	Std. Deviation	p or W	N	Mean	Std. Deviation	p or W
Teaching Assistants Scale	Non URM	878	3.575	0.547	0.040	885	3.625	0.555	N/S
	URM	41	3.754	0.489		63	3.747	0.614	
Perceptions of Engineering Scale	Non URM	945	3.856	0.467	0.028	950	3.857	0.400	N/S
	URM	45	4.011	0.386		70	3.894	0.457	
In class, singled out due to race/ethnicity	Non URM	939	0.027	0.135	0.021	950	0.042	0.171	0.000
	URM	45	0.122	0.264		70	0.236	0.406	

In class, faculty express racial stereotypes	Non URM	938	0.054	0.208	N/S	939	0.087	0.269	N/S
	URM	45	0.056	0.159		69	0.116	0.299	
Harassed by faculty due to race	Non URM	937	0.009	0.078	N/S	941	0.008	0.081	N/S
	URM	45	0.044	0.144		69	0.014	0.084	
Harassed by students due to race	Non URM	938	0.017	0.113	N/S	944	0.012	0.101	0.010
	URM	45	0.056	0.191		70	0.100	0.277	

TABLE 5: Group Mean Differences by International Status

Group Mean Differences by International Status									
		2008				**2015**			
		N	Mean	Std. Deviation	p or W	N	Mean	Std. Deviation	p or W
Teaching Assistants	Domestic	877	3.574	0.546	0.014	865	3.626	0.554	N/S
	Intl	42	3.778	0.508		58	3.768	0.606	
Perceptions of Engineering	Domestic	938	3.880	0.450	0.000	937	3.871	0.396	N/S
	Intl	52	3.559	0.609		64	3.788	0.457	
Engineering Self-Efficacy Scale Mean	Domestic	937	4.172	0.577	0.002	941	3.957	0.629	N/S
	Intl	52	3.869	0.669		64	4.049	0.691	
Commitment to Major	Domestic	940	4.116	0.758	0.000	941	4.131	0.595	N/S
	Intl	51	3.652	0.834		64	4.063	0.664	
In class, singled out due to race/ethnicity	Domestic	932	0.025	0.129	0.002	941	0.044	0.183	0.000
	Intl	52	0.154	0.289		64	0.211	0.354	
In class, faculty express racial stereotypes	Domestic	931	0.053	0.206	N/S	932	0.079	0.258	0.003
	Intl	52	0.077	0.207		63	0.230	0.390	

TABLE 6: Significant Group Mean Differences by Survey Year, % Yes to Stereotype/Harassment Items

Scale or Item		N	Mean	SD	p or W	% Yes
Professors	2008	1017	3.601	0.413	0.001	
	2015	1034	3.539	0.442		
Student Interaction	2008	1007	3.511	0.666	0.000	
	2015	1030	3.410	0.602		
Engineering Self-Efficacy	2008	989	4.156	0.585	0.000	
	2015	1021	3.959	0.636		
In class, singled out due to race/ethnicity	2008	984	0.032	0.144	0.002	1.2
	2015	1020	0.055	0.202		3.2
In class, faculty express racial stereotypes	2008	983	0.054	0.206	0.001	3.7
	2015	1008	0.089	0.271		7.3
In class, singled out due to gender	2008	984	0.076	0.251	0.001	6.1
	2015	1019	0.118	0.305		9.4
In class, faculty express gender stereotypes	2008	985	0.116	0.307	0.001	10.1
	2015	1013	0.165	0.358		14.0
Sexually harassed by faculty	2008	982	0.015	0.104	0.048	0.7
	2015	1013	0.007	0.070		0.3
Sexually harassed by student	2008	981	0.028	0.151	0.025	2.0
	2015	1017	0.015	0.110	.	1.0
In class, students express racial stereotypes	2008	Not Asked				
	2015	998	0.40	0.48		37.0
In class, students express gender stereotypes	2008	Not Asked				
	2015	1008	0.41	0.48		38.5
In class, students express stereotypes about LGBT people	2008	Not Asked				
	2015	1012	0.08	0.27		6.8

After investigating differences by group and by survey year, we investigated how independent variables predicted Commitment to Major, and whether this prediction changed from 2008 to 2015 samples. An initial regression model using data combined from both years and survey year as a predictor found significant differences between survey years, and thus regression equations were computed separately for the two survey years. In 2008, the regression model predicted 17% of the variance found in Commitment to Major. Demographic factors that were significant in predicting Commitment to Major included International status (β = -.102), Underrepresented minority (β = -.076), and scale factors included Perceptions of Engineering (β = .293) and Professors (β = .090). Note that Underrepresented minority students and International Student status negatively predicted commitment to major. By contrast, the regression model in 2015 accounted for a total variance of 28.7%. No demographic variables were significant in predicting Commitment to Major in 2015, but Perceptions of Engineering (β = .305), Engineering Self-Efficacy (β = .251), Professors (β = .095), and Student Interaction (β = .068) were significant. No stereotyping or harassment items were significant in predicting Commitment to Engineering in either model.

Discussion

The aim of this study was to extend the Project to Assess Climate in Engineering (PACE) research results by reporting on group differences and retention prediction for two cross-sectional survey deployments at a large, Midwestern engineering college. We found items measuring students' reports of stereotyping and harassment within the College yielded statistically significant differences between groups, with women more likely to report being singled out based on their gender, gender stereotyping, and sexual harassment, and racial/ethnic minorities more likely to report similar experiences associated with race. Our 2008 finding of substantial differences in engineering self-efficacy between women and men are consistent with a large literature base on gender differences in self-efficacy in this field. It is notable that there was no significant difference in Perceptions of Engineering or Commitment to Major between genders in either 2008 or 2015. Indeed, while 6-year retention of women at this institution did lag men in 2008, in the most recent measure (2010), 6-year retention of women and men was different only by a few percentage points.

One of the most interesting findings of this study is how these measures and our prediction of predict Commitment to Major changed over time. As a cross-sectional study, the study design does not allow for any inference of causality for changes over time. There may be cohort differences in students between 2008 and 2015, the college climate itself may have changed, or both. Students in 2015 overall rated professors, student interaction and their own engineering self-efficacy lower than did students in 2008, and there were fairly large increases in reported gender/racial stereotyping and feeling singled-out due to gender and race. Several contextual changes have occurred during this time period. First, enrollment in the college of engineering has grown from 3000 to 4500 students. Second, tuition has increased somewhat, and financial pressures due a difficult economy began in late 2008 and had not completely recovered by 2015. These factors may be related to students' more critical assessment of their educational experiences. Regarding stereotyping and harassment, it is possible that students have become more sensitized to recognizing such experiences. Disturbingly it is equally possible that such experiences have increased. Although we did not find an impact of stereotyping and harassment experiences to Commitment to Major, our finding of substantial reports of stereotyping and harassment experiences is significant for the college, and should be addressed through targeted interventions in order to provide a more welcoming climate to students. Overall, our study reinforces the importance of repeated administration of college climate surveys, because without trend or comparison information such data can be difficult to interpret. Regardless of whether students have increased in sensitivity or there has been an objective decline in racial/gender climate, the fact that in 2015 more than 38% of students report hearing gender stereotypical comments from peers, and more than 37% of students report hearing racial stereotypes from peers is an important and troubling outcome.

While the data analysis did not focus on multivariate group differences or interaction effects, it is clear that the gap in engineering self-efficacy between men and women decreased from 2008 to 2015. The items used to form the engineering self-efficacy factor in both years were identical, and by 2015 the difference between the two groups was small. The difference decreased largely because while females engineering self-efficacy decreased only slightly, males' engineering self-efficacy decreased more markedly. While it is a hopeful outcome that indicates that women's confidence in their engineering abilities is only slightly lower than males, it is disappointing that this self-assessment of ability in engineering academic pursuits has declined for both males and females. Similarly, students rated Professors and student interactions lower.

The ability of predictor variables to account for variance in Commitment to Major was low in both 2008 and 2015, although it was substantially higher in 2015. In between the two surveys, researchers added 4 additional items to measure Commitment to Major, and the internal reliability of this scale increased substantially. It is possible that the 4 items used in 2008 did not adequately capture the domain of Commitment to Major, and thus the relationship of prediction variables and outcome was poor. However, it is also possible that the changes in group differences on variables has influenced the overall model. We note that while gender was not a significant predictor of Commitment to Major in either year, underrepresented minority and international student status were significant and negative predictors in 2008, even after accounting for variance from scales. By 2015, no demographic variable remained in the model after accounting for other predictor variables. Finally, we note that individual items on stereotyping and harassment did not significantly predict Commitment to Major in either 2008 or in 2015. This result is inconsistent with recent studies linking such experiences to decreased retention[11]. It is possible that the still low representation of students who would be targets of such experiences in engineering limits the ability of these variables to significantly influence Commitment to Major. Alternatively, it is possible that students who are targets of stereotyping or harassment and may have responded negatively to such experiences have never entered or already left the college.

Limitations

The study described here is limited in several important ways. First, as alluded to in the Discussion section, the population sample is of students currently enrolled in the college of engineering. Thus, by design we are unable to capture the attitudes and experiences of the engineering college climate of students who never entered or who have already left. Second, our outcome variable ("Commitment to Major") is a measure of attitudes and intentions, and may not reflect actual decisions to remain in or to leave engineering education. Third, the two samples were separated by more than seven years. This has the advantage of being almost entirely different samples since students who were first-year in 2008 are very unlikely to remain in the sample in 2015, and thus allows us to have fully independent samples. However, changes between 2008 and 2015 were fairly large. More incremental survey deployment, perhaps every 2 years, would allow for better modeling of trends. Finally, we were limited by not having valid pre-college data. A more complete picture of Commitment to Major may be obtained were we able to match institutional data to student responses. While this would not allow the survey to be completely anonymous, it would likely allow more accurate predictions.

Conclusions

The present study demonstrated substantial changes over time in important measures of engineering college climate at this institution. Significant changes include: (1) students in 2015 rated professors, student interaction and engineering self-efficacy lower than student ratings in 2008, (2) substantial increases were reported in 2015 in gender and racial stereotyping, and feeling singled out due to gender and race, (3) improved ability to predict Commitment to Major, and demographic group differences in this variable may be fully accounted for by other factors.

Ongoing and regular national as well as local measures of engineering college climate would have many benefits. First, it would allow institutions to identify gaps between their own climate and peer institutions. Second, educational researchers would be able to track national changes in important variables such as engineering self-efficacy, allowing inferences to be made as to whether interventions targeting such variables were having an impact. Finally, a clearer picture may emerge of the influence of gender and racial stereotyping and harassment in engineering education on the underrepresentation of women and some minority groups. This last item may provide institutions with a clear signal on the need for interventions at the student, faculty and staff level.

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