Running Head: STEM Departmental Climate

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Underrepresented Students in STEM: An Examination of Departmental Climate

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ABSTRACT

This paper seeks to examine underrepresented undergraduate students' experiences within the fields of Science, Technology, Engineering, and Mathematics (STEM). For the purpose of this paper, underrepresented students within STEM include women and traditionally underrepresented minority students. Specifically, this paper focuses on factors of department climate that may contribute to underrepresented students' experiences within STEM majors. Although enrollment for minority and female students in higher education has increased substantially over the years, little progress has been made within the STEM fields. Furthermore, retention rates for underrepresented students continue to be dismal in a time when an increase in STEM degrees is necessary in order to ensure the nation's global economic future. This study seeks to examine non-academic factors—specifically departmental climate—that may influence student retention in the STEM fields. To investigate undergraduate students' experiences, an online student survey was launched at nine large, public, research institutions. The findings suggest that there are subtle but significant differences in regards to departmental climate perceptions by gender and type of STEM field; substantial and significant differences by race/ethnicity and type of STEM field; and significant differences at the intersection of race/ethnicity and gender for minority males.

INTRODUCTION

Recent reports indicate that the United States STEM workforce is ill prepared to compete within the global market (Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline, 2010; Taningco et al., 2008). Specifically, the number of U.S. trained STEM professionals is inadequate to meet the nation's workforce/economic needs given the decreasing number of international students studying engineering and science within the United States and the insufficient numbers of U.S. students' pursuing STEM degrees within higher education and the workforce (U.S. Congress, 2006). Furthermore, changing population demographics within the United States has intensified the need to improve college access and retention rates among traditionally underserved students, particularly within the STEM fields (Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline, 2010). With a growing number of minority and female students comprising the U.S. college-age population, it is imperative to draw from this pool of students in order to ensure a competitive global workforce (Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline, 2010; Milett and Nettles, 2006). While access to higher education for minority and female has improved significantly in recent decades, modest growth has been made in degree attainment within Science and Engineering STEM fields among both women and underrepresented minority students (Science and Engineering Indicators, 2010). Of great concern is the decrease in female representation within mathematics, computer sciences, and engineering fields, and the dismal retention rates within STEM fields for both women and underrepresented minority students (Science and Engineering Indicators, 2010). As a result of recent reports and indicators, the issue of underrepresentation

within the STEM fields for domestic women and racial/ethnic underrepresented minority students has become a national concern in regards to diversity, inclusion, and equity within the nation's colleges and universities (Chapa and De La Rosa, 2006; Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline, 2010; Smyth and McArdle, 2004; Vela, 2003). In light of concerns for equity and the development of human capital, this study seeks to investigate how issues of departmental climate reflect a university's commitment to diversity and access within STEM for underrepresented students.

LITERATURE REVIEW

Over the years, consistent findings indicate that underrepresented minority students and women who enroll in science majors are more likely to leave the sciences than their white male counterparts (George-Jackson, 2010 ; Oakes, 1989; Uma, 2009). Many factors including financial aid, academic preparedness, and student experiences on campus and within their major have been highlighted when examining issues that impact underrepresented students' undergraduate experiences overall, and within the STEM fields. Research suggests that minority, first-generation, and low-income students lack the social resources necessary to adequately navigate the university experience (O'Brien, 1993; Cole, 2008). In addition, these students also tend to experience a "chilly" campus climate due to a lack of diversity amongst the faculty and students (Hurtado, 1992). Not surprisingly, studies indicate that students of color desire a support group; this group usually consists of mentors, alum, and faculty that guide students to persist within STEM fields (Cole, 2008). These support groups often provide resources that significantly

impact student recruitment, retention, sense of belonging, and overall satisfaction for students of color attending predominantly white institutions (Cole, 2008; Uma et. al., 2009).

Uma (2009) suggests that the implications of having few faculty and students of color may result in students switching out of STEM fields or dropping out altogether due to feelings of disconnection between their values and those of the academic program (Cole, 2008). As a result, many students of color experience culture shock upon first entering the university due to the university's campus climate (Hurtado, 1998). Hurtado (1992) defines the university campus climate as the atmosphere created due to the behaviors within a learning environment that is reflected through the structures, policies, practices, demographics, attitudes, and values of the institution. These feelings are exacerbated for students whose academic program is not reflective of their own ethnicity and/or gender, and especially for students who view the campus climate as hostile, disrespectful, racist, or sexist (Rankin & Reason, as cited in Cole, 2008; Tate, 2005). This is especially true for minorities in science who may be stigmatized within the classroom due to their race, specifically in regards to the conditions of their acceptance to the university and their involvement in minority intervention programs for students in STEM (Hurtado, 2009).

Similarly, women in STEM also experience a "chilly climate," especially women who pursue male-dominant fields within STEM (Rolin, 2008). Given the lack of gender diversity within STEM fields such as physics and engineering, male-dominated professions may be perceived as less welcoming to the opposing gender. As a result, women are often alienated and seen as unable to "do" science, which has long been understood as a masculine activity (Rolin, 2008). Furthermore, Tate (2005) highlights the importance of academic and social support systems that were critical in the undergraduate experiences of women of color as they content with their dual-minority status within STEM. With few women and students of color within the

STEM fields, students' experiences within their majors warrant continued/additional investigation given that these "chilly" experiences have been found to directly affect a student's sense of belonging and their decision to switch to another major due to climate factors. These previous findings inform the current study that seeks to examine how students may perceive campus climate differently based on gender, race/ethnicity, and field of study within STEM majors.

DATA AND METHODOLOGY

This paper uses survey data on undergraduate students gathered online in 2010, which was conducted with the support of a grant from the National Science Foundation (n=1,881). The online survey was launched at nine large, public, research universities in 2010. Respondents include undergraduate students in a variety of STEM and non-STEM majors, as well as underrepresented and well-represented students, so that analytical comparisons can be made by major field of study, sex and race/ethnicity. The survey instrument includes questions regarding students' socio-demographic backgrounds, academic preparation and experiences, social activities, financial aid, and notions of self-efficacy and engagement. For the purposes of this paper, questions pertaining to campus climate are used for analytical purposes.

The following research questions were used to guide the study:

1. *How do women experience their departmental climate within STEM fields?*
2. *How do underrepresented minority students experience their departmental climate within STEM fields?*

3. *Do women and underrepresented minority students within traditionally "hard" or "soft" STEM experience STEM differently?*
4. *To what extent do faculty experiences, academic factors, social support, gender, race/ethnicity, and type of STEM field impact students' sense of belonging?*

For the purpose of this paper, the responses to several survey questions were examined to measure departmental climate including: My major field department is my intellectual home; The faculty in my department make me feel welcome; The students in my department make me feel welcome; I have a sense of belonging in my major; and The faculty in my department want me to succeed (see Appendix A). A total of 21 variables pertaining to campus and department climate used in this study use a Likert Scale with responses ranging from "strongly disagree" to "strongly agree".[1] Basic descriptive statistics and cross-tabulations of gender, underrepresented minority student status, and traditionally "hard" and "soft" STEM were conducted with variables pertaining to department climate, to create a baseline understanding of department climate. Chi square tests were used to determine if the differences observed in the cross-tabulations were statistically significant.

As the specific construct for campus and department climate has not previously been used prior to this study and there may be underlying constructs within the 21 individual variables , Principal Axis Factor (PAF) Analysis was performed to reduce the. PAF was chosen as the appropriate method for its ability to examine shared variance across multiple variables, and to determine the constructs found at the core of a set of questions. The results of the factor analysis identified four specific underlying factors: 1) *Sense of Belonging*; 2) *Faculty Influence*; 3) *Social*

[1] Negatively-scaled items were rescaled prior to analysis.

Support; and 4) *Academic Climate* (see Appendix B). Taken together, these four factors account for 65.4 percent of the variance across the 21 variables.

Next, the reliability of each newly identified factor was examined. Cronbach's Alpha ranged from 0.629 to 0.901. The specific survey items for each factor are provided in Appendix B. A composite score for the first factor, *Sense of Belonging*, based on the means of the responses across the 8 variables included in the construct, was created for the purpose of further analysis. This composite variable served as the dependent variable in regression analysis which investigated the relationship between a students' sense of belonging with the other identified factors related to climate, as well as other variables, including gender, underrepresented minority status, and the type of STEM field the student is majoring in. The remaining three factors were saved for the purpose of the regression analysis, and were included in some models.

RESULTS

Table 1 summarizes the socio-demographic backgrounds of the survey respondents (see Appendix C). Of the 1,881respondents, 38.1 percent are male and 61.2 percent are female. Nearly 72.4 percent are white, 11.6 percent are Asian or Pacific Islander, 4.3 percent are Black, 4.7 percent are Hispanic, 0.6 percent are Native American or Alaskan Native, and 3.7 percent indicated they are other. In terms of the respondents' current majors: 4.7 percent are majoring in Agricultural Sciences,12.3 percent are majoring in the Biological and Biomedical Sciences, 3.7 percent are majoring in Computer and Information Sciences, 38.2 percent are majoring in Engineering, 9.8 percent are majoring in Health Professions and Related Clinical Sciences, 2.4 percent are majoring in Mathematics/Statistics, 2.8 percent in Natural Resources and

Conservation, 10.4 percent in Physical Sciences, and 3.7 percent are majoring in Psychology (see Table 2).

Analysis of the survey items revealed subtle differences among gender and substantial departmental climate experiences among racial/ethnic minorities. Differences found by gender will be discussed first, followed by differences by underrepresented minority status, and finally the intersection of gender and minority status.

Campus Climate by Gender

Contrary to previous findings, preliminary cross-tabulations indicated that female and male students experienced their department climate similarly. Findings indicate that there are dismal differences in regards to gendered departmental climate perceptions. Women (33.8%, strongly agree) within traditionally "hard" STEM were slightly more likely to indicate that they enjoyed working with other students in department than their male counterparts (27.9%, strongly agree). Within traditionally "soft" STEM however, females (6.3%) were more likely to indicate they disagreed that they were confident they would succeed within their major in comparison to males (3.4%). Of importance, among those who reported that they agreed or strongly agreed that they had more social support within their majors, female students were more likely to indicate that this was the case (see Figure 1). Findings for women in STEM are inconsistent with previous findings on differences in climate between Gender. It is important to note the large sample of women in traditionally "hard" STEM fields within our overall online student survey sample. STEM intervention programs that serviced underrepresented students were one of the avenues by which students were recruited to participate in the survey. As a result, it is

hypothesized that women who participate in these STEM interventions are more likely to have a sense of belonging within their department or college.

Campus Climate by Race/Ethnicity

The analysis of racial and ethnic differences among students in regards to departmental climate factors, specifically sense of belonging, indicated that minority students were more likely to indicate that they negatively experienced their overall departmental climate. In both traditionally "hard" and "soft" STEM majors, underrepresented minorities are more likely to feel that students (see Figure 2) and faculty (see Figure 3) are unwelcoming in comparison to their peers, this is especially true for those who indicated that they disagreed and strongly disagreed that peers and faculty within their major were welcoming. Furthermore, underrepresented minority students (7.1%) within "soft" STEM were more likely to indicate that they strongly disagreed that they had a sense of belonging in their major in comparison to their non-minority counterparts (1.1%). In the classroom, of the student who indicated having negative experiences working with their peers, underrepresented minorities were more likely to indicate that they were not included in group assignments within their majors (8.2% point difference among those who disagreed and strongly disagreed) and were also more likely to indicate that they felt their input was not valued in in group assignments (5.5% point difference among those who strongly disagreed).

Gender/Race/Ethnicity Campus Climate

When examining the experiences of minority males and females within STEM, underrepresented minority males consistently indicated having substantially more negative experiences in regards to sense of belonging than their majority counterparts (see Figure 4). Minority males were also more likely than non-Minority peers to indicate that students in

department made them feel unwelcome (8.6% point difference among those who strongly disagreed), that they were not included within group assignments (6.6% point difference among those who strongly disagreed), and did not have a sense of belonging within their major (6.7% point difference among those who strongly disagreed). Not surprisingly, minority males were also less likely to indicate that they had a social support system within their major in comparison to their non-Minority peers. These findings highlight the importance of investigating the intersection of gender and race/ethnicity, as underrepresented minority males and females perceive and react to their department climates differently. Differences between minority females and non-Minority females were not found.

Regression Results

The fourth research question investigates what factors impact students' sense of belonging. As a reminder, a composite score for sense of belonging was created for the purpose of the regression analysis. All independent variables were recoded to binary variables, to express the extent to which students Agreed/Strongly Agreed versus Disagreed/Strongly Disagreed with a particular statement.[2] Table 3 provides a summary of the seven models used in the analysis. As additional variables were added to the model, R^2 increased from 0.1 to 0.3, with the final model explaining 30 percent of the variance in students' sense of belonging.

Several variables in the final model were statistically significant at the $p<0.05$ level, *ceteris paribus*. Three of the variables that had a positive impact on students' sense of belonging were the factors saved from the PAF analysis which represented *Faculty Influence, Social Support* and *Academic Climate*. Being an underrepresented minority student had a statistically

[2] Items that were negatively-oriented were recoded to compare Disagree and Strongly Disagree with all other responses.

significant and negative impact on students' sense of belonging, reaffirming the findings from the descriptive analysis. It is important to note that being female, majoring in the "hard" STEM fields, and majoring in the "soft" STEM fields did not have a statistically significant impact on students' sense of belonging.

IMPLICATIONS

The results of the study offer a number of programmatic and research-oriented implications. First, the findings highlight the need for departments in the STEM fields to foster a sense of belonging for underrepresented minority students. While the specific program design may differ by type of STEM field (i.e., "hard" or "soft" STEM) and by population of student, an increased sense of belonging could be achieved through the establishment of new or revision of existing recruitment and retention programs designed to serve underrepresented minority students in the sciences. An example would be research opportunities with faculty members, such as those funded by the National Science Foundation's *Research Experiences for Undergraduates* (REU) program. In addition to providing students with hands-on research experiences, participating in such programs may increase students' sense of belonging within their department. Participating in department and college-sponsored engagement activities, as well as student-based organizations, may also provide opportunities to foster students' sense of belonging and inclusion. Departments and colleges are also encouraged to provide cultural competency training for their faculty and staff as a simultaneous effort to the programmatic offerings mentioned above.

The findings also offer two implications related to research. The first is the opportunity for departments, colleges, and universities to examine the many climates that exist on campus,

and how students perceive and interact with each climate. While a number of past studies have focused on campus-climate, this study highlights the importance of department climates which are imbedded within the overall campus climate. Institutional researchers have the opportunity to collect and analyze data according to multiple and nested climates. The second implication pertaining to research is for additional research conducted on students in STEM fields to disaggregate by type of major, race/ethnicity, and gender when possible. Such detailed analysis allows for specific differences between students to be identified and understood, rather than aggregating students by various characteristics or majors. Disaggregated analyses also allows for targeted interventions to be designed for specific groups and/or specific types of majors, as indicated above.

LIMITATIONS

Several limitations must be considered when generalizing findings to underrepresented students within STEM. Among participants it is important to note that generalizability is limited due to the geographical location of participants and institution type. Furthermore, underrepresented minority students are underrepresented within the sample. In regards to responses, variations were found among institution participation rates among colleges, with some institutions comprising the majority of the sample. Also, responses within campuses varied by college major, engineering students were substantially overrepresented. Within the college majors, a lack of non-STEM majors does not allow for a comparison group. The survey instrument did not consider a students' overall perception of the campus climate, thus the chilly factor found within their department or major may be the institutions' overall climate, which is equally as problematic. In addition, the survey instrument was quite long, thus approximately

800 addition students who attempted the survey did not persist to completion, thus not included within the findings.

FUTURE RESEARCH

While the study offers important implications, the findings presented here may serve as the basis for additional investigations on underrepresented students in STEM and issues of departmental climate. Future research can study students' sense of belonging in relation to their academic engagement within their home department, as well as across campus. While this study disaggregates students in the "hard" and "soft" STEM fields, further disaggregation—to specific disciplines—can determine differences that exist within the categories of STEM majors used in this study. This type of inquiry may be limited in certain fields, as it will be dependent on having an appropriate number of underrepresented students within a specific discipline or major.

The data used in this study will be expanded upon through a follow-up survey that will be administered in Fall 2011. Approximately 65 percent of the students who participated in the first survey agreed to be contacted again, and will be invited to take the follow-up survey later this year. For students who take both surveys, the researchers will have the opportunity to examine how students' sense of belonging within their home department changes over time, as well as if students who expressed feelings of isolation and perceived an unwelcoming environment in their current major at the baseline survey changed majors, either to a different STEM major or to a non-STEM major.

CONCLUSION

This paper sought to enhance our understanding of underrepresented student's experiences within the STEM fields by examining how students may perceive and interpret an

institution's values and practices in regards to serving underrepresented students in STEM. This can potentially lead to students seeing an institution or department as promoting a "chilly" climate for minority and female students that may potentially contribute to pushing students out of STEM and/or the university altogether. Furthermore, these practices directly reflect the university's commitment to diversity via the implementation of STEM intervention programs that may minimize or mitigate the effects of an unwelcoming campus climate. In light of calls for diversifying the STEM fields and strengthening the STEM workforce within the United States, research regarding student experiences within STEM continues to be needed in order to better understand a student's reason for entering and deciding to leave the STEM fields.

Furthermore, understanding student's reasons for leaving the STEM fields will also highlight survival strategies used by those students who do persist to graduation. These strategies may include social and cultural networks in order to confront issues of racism, isolation, and sexism. This insight will allow administrators, faculty, and STEM intervention coordinators to better serve women, minorities, and low-income students who aspire to major in STEM fields.

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Appendix A: Departmental Climate Matrix

Indicate the extent to which you agree or disagree with the following statements (strongly disagree, disagree, agree, or strongly agree):

My major field department is my intellectual home
I enjoy working with other students in my department
The faculty in my department make me feel welcome
The students in my department make me feel welcome
The support staff in my department make me feel welcome
The faculty in my department respect and value my input in the classroom
In courses for my major my input is valued in the classroom
In courses for my major, my input is valued in group assignments
I feel included in group assignments for my major
I feel comfortable in classes for my major
I have a sense of belonging in my major
There are other students like myself in my major
There are faculty who look like me teaching courses in my major
I receive good advising from my department
I receive good mentoring from my department
The faculty in my department want me to succeed
There is a lot of competition among students in my major
Faculty members in my department take my academic work seriously
Faculty members in my department accept me for who I am
I am confident that I will succeed in my major
My department provides me with academic support
I have a social support system within my department
Most of my social support is within my major

Appendix B: Factors Identified by Principal Axis Factor Analysis

Sense of Belonging (Cronbach's Alpha = 0.901)

My major field department is my intellectual home
I enjoy working with other students in my department
The students in my department make me feel welcome
In courses for my major, my input is valued in group assignments
I feel included in group assignments for my major
I feel comfortable in classes for my major
I have a sense of belonging in my major
There are other students like myself in my major

Faculty Influence (Cronbach's Alpha =0.829)

The faculty in my department make me feel welcome
The faculty in my department respect and value my input in the classroom
There are faculty who look like me teaching courses in my major
The faculty in my department want me to succeed
Faculty members in my department take my academic work seriously
Faculty members of my department accept me for who I am

Social Support (Cronbach's Alpha = 0.770)

I have a social support system within my department
Most of my social support is within my major

Academic Climate (Cronbach's Alpha = 0.629)

There is a lot of competition among students in my major
My department provides me with academic support

Appendix C: Result Tables and Figures

Table 1
Demographic and Background Information of Survey Respondents
(n=1,881)

Variables	N	%
Gender		
Male	716	38.1%
Female	1151	61.2%
Prefer not to Answer	14	0.7%
Race and Ethnicity		
White not Hispanic	1361	72.4%
Asian or Pacific Islander	218	11.6%
Hispanic or Latino/a	89	4.7%
Black, not Hispanic	81	4.3%
Other Race/Ethnicity	69	3.7%
Prefer not to Answer	52	2.8%
Native American or Alaskan Native	11	0.6%
First-Generation Status		
Yes	231	12.3%
No	1639	87.1%
Prefer not to Answer	11	0.6%
Class Status		
Freshman	288	15.3%
Sophomore	393	20.9%
Junior	538	28.6%
Senior	633	33.7%
Prefer not to Answer	29	1.5%
Transfer Status		
Transferred from a Community College	149	7.9%
Transfer From another Four Year Institution	152	8.1%
Did not Transfer	1575	83.7%
Prefer not to Answer	5	0.3%

Source: Project STEP-UP Survey, 2011; Authors' Calculations.

Table 2

Respondents' Current Major

	Gender			
	Male	Female	Prefer not to Answer	Total
Agricultural Sciences	17	72	0	89
	2.4%	6.3%	0.0%	4.7%
Biological Sciences	87	143	2	232
	12.2%	12.4%	14.3%	12.3%
Computer Information Sciences &	38	30	1	69
Technologies	5.3%	2.6%	7.1%	3.7%
Engineering & Engineering	279	433	7	719
Technologies	39.0%	37.6%	50.0%	38.2%
Health & Clinical Sciences	24	160	0	184
	3.4%	13.9%	0.0%	9.8%
Mathematics & Statistics	20	25	0	45
	2.8%	2.2%	0.0%	2.4%
Natural Resources & Conservation	19	34	0	53
	2.7%	3.0%	0.0%	2.8%
Physical Sciences & Science	91	100	4	195
Technologies	12.7%	8.7%	28.6%	10.4%
Psychology	7	22	0	29
	1.0%	1.9%	0.0%	1.5%
Non-STEM	134	132	0	266
	18.7%	11.5%	0.0%	14.1%
Total	716	1151	14	1881
	100.0%	100.0%	100.0%	100.0%

Source: Project STEP-UP Survey, 2011; Authors' Calculations.

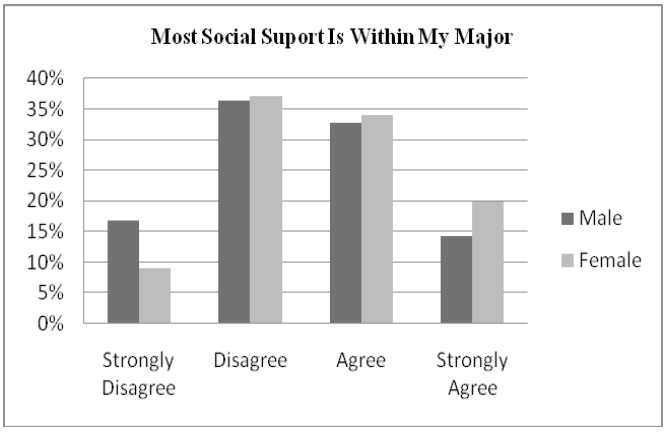
Table 3. Regression Results of Departmental Climate

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Constant	3.216	3.216	3.216	3.225	3.194	3.214	3.257
(Std Dev)	(.015)	(.014)	(.013)	(.014)	(.022)	(.027)	(.042)
Factor 1: Faculty	0.175**	0.162**	0.150**	0.149**	0.151**	0.150**	0.150**
	(.016)	(.015)	(.015)	(.015)	(.015)	(.015)	(.015)
Factor 2: Social Support		0.219**	0.219*	0.219**	0.216**	0.218**	0.218**
		(.017)	(.016)	(.016)	(.016)	(.016)	(.016)
Factor 3: Academic			0.155**	0.157**	0.157**	0.158**	0.159**
			(.016)	(.016)	(.016)	(.016)	(.016)
URM				-.104**	-.100**	-.101**	-.105**
				(.047)	(.047)	(.047)	(.047)
Female					.049	.047	.052
					(.027)	(.027)	(.028)
"hard" STEM						-.033	-.077
						(.027)	(.043)
"soft" STEM							-.061
							(.046)
R-squared	.100	.231	.292	.296	.298	.298	.300
Adjusted R-squared	.099	.230	.290	.293	.295	.295	.295
No. observations	1,881						

Source: Project STEPUP, 2011; Author's calculations.

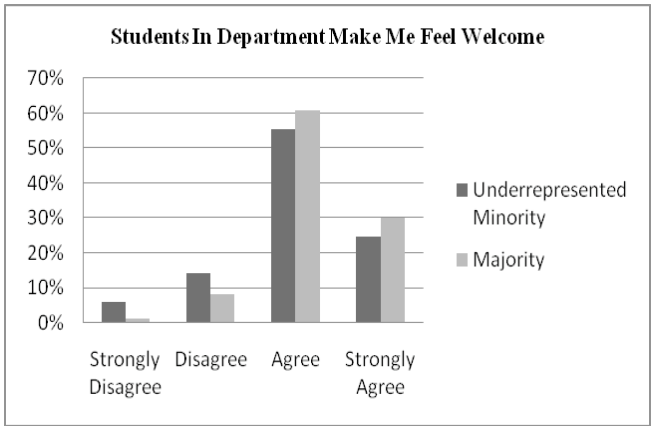
** indicates significance at the p<0.05 level

Figure 1. Social support within major, by gender



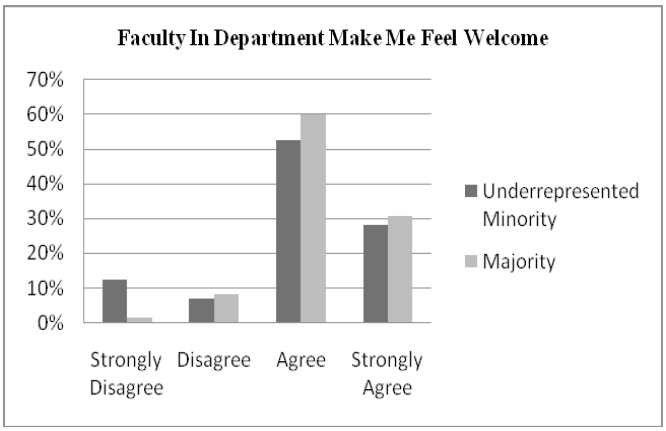
Source: Project STEP-UP Survey, 2011; Authors' Calculations.

Figure 2. Students in department make me feel welcome, by minority status



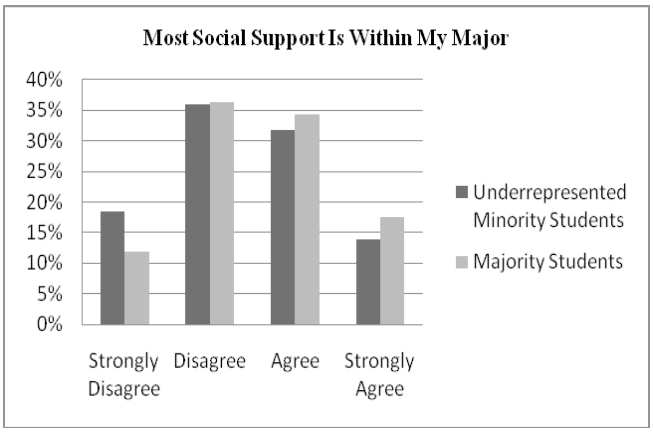
Source: Project STEP-UP Survey, 2011; Authors' Calculations.

Figure 3. Faculty in department make me feel welcome, by minority status



Source: Project STEP-UP Survey, 2011; Authors' Calculations

Figure 4. Social support within major, by minority status



Source: Project STEP-UP Survey, 2011; Authors' Calculations.