The Relations of Ethnicity to Female Engineering Students' Educational Experiences and College and Career Plans in an Ethnically Diverse Learning Environment

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ABSTRACT

This paper describes a mixed-methods study employing a social cognitive theoretical framework that emphasizes the interplay of person factors, environment, and behavior to explore the educational experiences of female students in an ethnically diverse learning environment. Specifically, we investigate the relations of ethnicity to female students' perceptions and experiences related to engineering, as well as their selection of and persistence in undergraduate engineering majors. An ethnically diverse sample of female engineering undergraduates at an urban research university completed an online survey and participated in semi-structured interviews. Results revealed that participants of all ethnicities perceived strong institutional and peer supports in this diverse learning environment. Additionally, differences in participants' perceived barriers for achieving engineering educational and career plans were found based on ethnicity and parental level of education.

Keywords: ethnicity, first generation college students, Social Cognitive Career Theory

I. INTRODUCTION

From 1984 to 2004, both the absolute number and proportion of all under-represented minority groups increased while overall U.S. freshman enrollment in engineering declined. During this 20 year period, Hispanic students enjoyed a 72 percent gain in engineering enrollment, the highest of any ethnic group (Women in Engineering ProActive Network (WEPAN), 2006). Despite recent strides, Hispanics and African Americans remain under-represented in engineering majors and careers compared to their representation in the U.S. population, and the gap has been described as "narrowed but persistent" (Huang et al., 2000). The U.S. Census Bureau (2004) predicts shifting demographics over the next two decades, estimating that by 2030, these two groups will together comprise 34 percent of the country's population. Among all ethnic groups, Hispanics are the fastest growing portion of the American population, and are anticipated to experience a 45 percent growth during the years 2000–2015, compared to 1 percent of the White population (Barton, 2003). The implication of this projected growth is that very large increases in the number of Hispanics and African Americans entering engineering will be needed just to keep up with current proportions of the overall population (Barton, 2003). As our nation's potential scientific talent pool continues to expand to include more persons from diverse ethnic backgrounds, so does our need to understand their perceptions of the field, educational experiences, and perceived barriers and supports relating to engineering education and career plans.

Phinney, Dennis, and Osorio (2006) investigated reasons for attending college among minority students and students from immigrant families, with the goal of gaining a better understanding of differences in academic outcomes based on ethnicity. Their research found that students of color have more complicated reasons for seeking higher education than White students, such as helping family and proving self-worth. Their work explored not only ethnic group differences in reasons for attending college, but also other variables associated with ethnicity such as social class, generation of immigration, and cultural factors such as ethnic identity and family interdependence (Phinney, Dennis, and Osorio, 2006). Likewise, Seymour and Hewitt (1997) found that students of color have unique reasons for pursuing undergraduate science, engineering, and mathematics (SEM) degrees, such as long-term contributions to family and community.

African American, Hispanic, and Native American students are retained in engineering majors at lower rates than their White counterparts (Brown, Morning, and Watkins, 2005; Huang et al., 2000; May and Chubin, 2003). In their landmark study of attrition patterns of undergraduate SEM majors, Seymour and Hewitt (1997) discussed factors influencing the persistence of minority students. They interviewed 88 students of color (26 percent of their sample) majoring in science, engineering, or math fields from seven institutions, classifying them as "switchers" (students who left SEM majors) or "non-switchers" (students who persisted in SEM majors). Four factors unique to students of color that contributed to their attrition were identified: 1) differences in ethnic values and socialization, 2) internalization of stereotypes, 3) ethnic isolation and perceptions of racism, and 4) inadequate support systems.

In addition to people of color, women remain another largely untapped resource in meeting the demand for a skilled scientific workforce. In fact, during the same period that minority freshman enrollment experienced gains, freshman female engineering enrollment declined for all ethnic groups. While considerable attention has been paid in the literature to the issue of attracting and retaining more females in the engineering "pipeline," enrollment numbers have remained virtually stagnant for over 20 years (WEPAN, 2006). For the U.S. to remain competitive in today's global economy, it is essential to attract and retain more women—from all backgrounds—in the field of engineering. However, few studies have investigated ethnically diverse female engineering student populations in order to better understand their educational experiences and academic decisions related to engineering. Much of the previous collegiate-level engineering education research has been conducted either at predominantly White institutions (where students of color were in the minority), or at minority-serving institutions, such as historically Black colleges/universities (HBCUs), where one ethnic group (African Americans) makes up the vast majority of the student body.

Recommendations by Pascarella (2006) recently indicated ten directions for future research on the effects that college has on students, including: "acknowledging the increasing diversity of the American postsecondary student population by estimating conditional effects" and "extending and expanding inquiry to previously ignored students and institutions." He stated:

> … we can no longer plan an effective research agenda based on the assumption that our undergraduate student population is made up of White undergraduates from middle or upper-middle class homes, ages 18 to 22, attending four year institutions full time, living on campus, not working, and having few family responsibilities (Pascarella, 2006).

While the current need to attract and retain diverse students to the profession has been recognized, little attention has been paid to the study of institutions that *already* model the ethnic diversity currently being sought by many predominantly White institutions; in many cases the student bodies of urban universities and community colleges represent such diversity. Our work builds on that of engineering educators and social scientists, particularly the works of Seymour and Hewitt (1997), Lent and colleagues (Lent, Brown, and Hackett, 1994, 2000; Lent et al., 2003, 2005), Phinney, Dennis, and Osorio (2006) and Pascarella (2006), by investigating experiences of White students and students of color in a diverse educational environment—a distinguishing feature from nearly all prior research on students majoring in engineering at the undergraduate level.

Our study is unique in that our sample of female engineering undergraduates comes from an extremely ethnically diverse institution (U.S. News and World Report, 2007), where no one ethnic group constitutes the majority. By studying female engineering students in a diverse educational setting, in this case an urban research university, we can begin to explore what factors become salient in student experiences when ethnic diversity is achieved, and how these factors relate to intentions to persist in engineering majors. Investigating engineering student experiences with this diverse student population offers additional insights that have not been thoroughly addressed in previous research, yet may be critical to developing improved recruitment, retention, and pedagogical practices for diverse female students.

A. Theoretical Framework

Our interdisciplinary collaboration aimed to investigate the interplay of person factors, environment, and behavior as they relate to female students' perceptions and intention to major in engineering. We employed a social cognitive theoretical framework rooted in Bandura's (1986) work, first applied to career choice by Betz and Hackett (1981), and further developed by Lent, Brown, and Hackett (1994). Social cognitive theory as it is applied to career choices and development, termed Social Cognitive Career Theory (SCCT), hypothesizes that an individual's career choice processes and development do not occur in a social vacuum. A variety of distal (background) and proximal (contemporary) environmental and person variables directly influence and/or moderate career choice processes and behavior (i.e., how interests turn into goals and goals to actions) (Lent, Brown, and Hackett, 1994, 2000). These processes are intimately and reciprocally connected to contextual (environmental) variables such as socioeconomic status, social support, family influences, and barriers, as well as cognitive person variables (e.g., self-efficacy and outcome expectations) and other personal characteristics such as ethnicity and gender (Lent, Brown, and Hackett, 1994). Seymour and Hewitt (1997) asserted that contextual factors are particularly influential for female students and ethnic minorities. Their aforementioned results related to ethnic isolation and perceptions of racism and inadequate support systems contribute to or derive from the weak sense of belonging perceived by students of color on predominantly White campuses. Goodenow (1993) defined belonging as "a student's sense of being accepted, valued, included, and encouraged by others (teachers and peers) in the academic classroom setting and of feeling oneself to be an important part of the life and activity of the class," and found that a sense of belonging is related to two components of motivation: expectancies and values, which in turn influence academic achievement.

While SCCT has often been applied to the math and science domain (Lent et al., 2001; Lent, Lopez, and Bieschke, 1993), fewer studies have focused on engineering students, particularly with samples of women and students of color (Blaisdell, 1998; Hackett et al., 1992; Nauta and Epperson, 2003; Schaefers, Epperson, and Nauta, 1997). Lent and colleagues (2003, 2005) used SCCT to explore the relationship of contextual supports and

barriers among engineering students. In one study (Lent et al., 2003), the sample consisted of primarily White male students. Another study was conducted with students (75 percent male) at a predominantly White institution and two HBCUs (Lent et al., 2005). African American students at the HBCUs reported strong levels of environmental supports and weak barriers. The authors called for future SCCT research to include samples with more variability in perceptions of barriers and supports, varying academic levels, as well as more participants who are female and from different ethnic backgrounds (Lent et al., 2005). Additionally these researchers advocate conducting SCCT work in other educational settings and developing theory-derived interventions for underrepresented groups in engineering (Lent et al., 2005).

B. Research Questions

In order to better understand the contextual and person variables influencing female students' educational decisions related to engineering, we investigated the following research questions:

1. How is ethnicity related to female students' perceptions and experiences related to engineering?
2. How do these factors influence female students' selection of and intentions to persist in engineering majors?
3. What are the experiences of female engineering students of color in an ethnically diverse learning environment?

C. Research Setting and Subject Pool

This work was conducted at the University of Houston (UH), an urban university located in the fourth-largest city in the United States. The engineering student body at the University of Houston, and specifically the students in this sample, represent the changing face of engineering education. Approximately one-third of engineering students enter as transfer students (mostly from local community colleges). As a primarily commuter campus, the vast majority of the university's student body hails from the Houston-metro area, an area rich in diversity with a large immigrant population. In fact, UH is one of the most ethnically diverse research institutions in the country (U.S. News and World Report, 2007). Approximately 23 percent of undergraduate engineering students enrolled in Fall 2006 were female, and 59 percent of female students reported belonging to an ethnic minority group (28 percent Hispanic, 20 percent Asian, and 11 percent African American students). An additional 13 percent were classified by the university as international students and may also self-identify with one of the ethnic groups mentioned above.

II. Methodology

This paper reports the results of a collaborative study conducted by faculty in three colleges at the University of Houston: Engineering, Education, and Technology. Approval for the study was obtained through the University of Houston Committee for the Protection of Human Subjects. A mixed-methods approach was adopted (Creswell, 2003; Gall, Gall, and Borg, 2007; Leydens, Moskal, and Pavelich, 2004) and included a web-based survey instrument and one-on-one semi-structured interviews. While research questions 1 and 2 were investigated using both approaches, research question 3 was one of a phenomenological nature, and was best explored in the qualitative study.

The first phase of the study consisted of the development and implementation of a survey instrument. The quantitative portion of the study allowed for statistically rigorous analysis to be conducted with a relatively large sample, and for the exploration of possible statistical relationships between ethnicity and a variety of constructs queried in the instrument. The results from these analyses, and in some cases, lack of statistically significant relationships, gave us direction in developing a semi-structured interview guide for the second phase, which consisted of interviews with a subset of the survey participants.

The addition of interview data to the survey dataset allowed us to study participants' perceptions in their own words and encouraged participants to elaborate on constructs explored in the quantitative portion of the study. The use of a semi-structured interview guide allowed comparative data to be collected from all interview participants but was flexible enough to allow the interviewer to ask follow-up questions and pursue relevant lines of inquiry based on students' open-ended responses, and therefore complemented the quantitative approach. The qualitative data help to explain the "why" and "how" of some of the results obtained from the larger survey dataset, revealing insights once data were triangulated. The interview data also revealed additional emergent themes that would have gone otherwise uncaptured in a purely quantitative study.

A. Quantitative Study Design and Methodology

A survey consisting of demographic information and 81 items corresponding to 17 scales was developed by adapting relevant measures from published instruments in the educational psychology, higher education and engineering education literatures. The survey was designed to measure a host of variables, including person variables (ethnicity, generational status in college and country), contextual variables (perceptions about the field of engineering, sense of belonging and experiences in the university engineering community, social support and barriers for achieving college and career plans), and behavior (persistence goals). This paper focuses on seven scales, which are shown in Table 1 along with the corresponding number of items and Cronbach's alpha reliability values. The alphas for two of the scales (sense of belonging and financial influences for studying engineering) were marginally acceptable and low, respectively, indicating low internal consistency and the possibility of multidimensionality. Therefore, caution must be exercised in interpretations based on these scales. Likert-type scales were used; the anchors corresponding to each scale are shown. Additionally, participants were asked to identify sources of information used in their decision to study engineering (parents, teachers, summer camps, college visits, etc.), and reasons for entering the field (liking to solve problems, being good at math or science, wanting to get a well-paying job, etc.). Participants' identities were collected in order to correspond results from Phases I and II, award prizes, and verify participants' eligibility (i.e., gender and current undergraduate engineering enrollment at UH).

All female engineering undergraduates ($N = 350$) enrolled during the Fall 2006 semester were invited to participate in the study via email, announcements, and fliers. The incentive for participation in Phase I was the chance to win one of several $50 cash cards. Data were collected using SurveyMonkey, an online survey website which required participants to access a URL that was provided only in the invitations. Data were then transferred to the Statistical Package for the Social Sciences (SPSS 14.0) for analysis.

Construct	Scale	No. of Items	Sample Item	Cronbach's α	Likert Scale
Social Supports	Social Support in Achieving College and Career Plans (Lent et al., 2005)	9	Feel that your family members support this decision.	0.83	1 = Not At All Likely 5 = Extremely Likely
Barriers	Barriers to Achieving College and Career Plans (Lent et al., 2005)	5	Feel pressure from parents or other important people to change your major to some other field.	0.71	
Sense of Belonging and Experiences	Sense of Belonging (Goodenow, 1993)	4	There is at least one professor or individual that works in the College of Engineering who I feel I can talk to if I have a problem.	0.62	1 = Never 4 = Very Often
	Experiences with Faculty (Gonyea et al., 2003)	8	I have discussed my academic program or course selection with a faculty member in the College of Engineering.	0.73	
Impressions of Engineering	Financial Influences for Studying Engineering (Besterfield-Sacre, Shuman, and Atman, 1997, 1998)	4	An engineering degree will guarantee me a job when I graduate.	0.57	1 = Strongly Disagree 5 = Strongly Agree
	Perception of the Work Engineers Do and The Engineering Profession (Besterfield-Sacre, Shuman, and Atman, 1997, 1998)	7	I expect that engineering will be a rewarding career.	0.82	
Persistence Goals	Major Choice Goals (Lent et al., 2005)	4	I am fully committed to getting my college degree in engineering.	0.85	

Table 1. Scales employed in the survey instrument.

B. Qualitative Study Research Design and Methodology

This exploratory study was based on a phenomenological design. Phenomenological research deals with the essence of human experiences concerning a phenomenon (perceptions and experiences related to engineering), as described by the participants (female students) in the study (Creswell, 2003).

Interview questions were informed by results from Phase I and the research team's own teaching, advising, and administrative experiences. In initially planning the project, an outline of the interview guide was created with the intention of having students elaborate on constructs from the survey; the guide was re-worked following analysis of survey results in order to gather additional information on key findings from the survey. For example, after examining survey results related to perceived barriers for college plans, we believed that the five survey items (which queried the likelihood of receiving discouragement or feeling pressured to change majors by family and friends, not fitting in socially, and worrying that too much schooling is required to be an engineer) did not adequately address potential barriers perceived by this distinctive student population. Therefore, a main purpose of the interviews was to explore participants' perceived barriers to college and career plans in a more in-depth manner than was allowed by the closed-ended survey.

The interview guide contained 40 questions divided into four sections: demographics, barriers to engineering, barriers to career plans, and UH Cullen College of Engineering interventions. The interview guide was pilot tested with seven students for reliability and validity. The results of the pilot led to the revision of five questions. All Phase I participants ($N = 160$) were invited to participate in a one-on-one semi-structured interview conducted by one of the research team members. Interviews lasted approximately 30 minutes to one hour, and students were given a $20 cash card for their participation. With the participants' permission, interviews were recorded. Recorded interviews were transcribed by a graduate assistant and checked for accuracy by the faculty project leader.

Data from the interviews were content analyzed. Content analysis is a research technique for systematically examining the content of communications (Gall, Gall, and Borg, 2007). Participants' descriptive content responses to the interview questions were read and categorized by sections (barriers, careers, interventions). The analysis included six major steps, which allowed for reliability and validity of the findings. Three researchers read and reviewed ten transcripts independently; upon completing the review of these ten transcripts, each researcher identified themes. The researchers then convened to discuss the themes they had identified and to discuss similarities and differences. Approximately 150 themes were identified among the first ten transcripts. Upon agreeing on the themes, a theme template was created to assist with the analysis of the second batch of interviews. Upon completing the analysis of the second batch of interviews, the researchers reconvened to discuss their findings. The theme template was further revised as additional themes were added while others were collapsed. Upon review of the last batch of 17 transcripts, the researchers once more convened to discuss the new findings and to collapse where necessary. Overall, the analysis concluded with 76 themes for barriers to engineering, 63 themes for barriers to career, and 72 themes for interventions. During each discussion, the researchers provided explanations and evidence for their findings. Overall, the analysis included three inter-rater analyses. Upon completing

the analysis of the original data set, the researchers then proceeded to analyze the data by ethnic group. This analysis was conducted in the same fashion as the overall data set. Using a collapsed set of recurrent themes and their supporting contexts, the researchers wrote descriptions, and included quotes as illustration of major points. The most frequent recurrent themes were triangulated with survey data to develop the five major findings presented in this paper.

C. Survey Participants

The survey response rate for Phase I was 46 percent, with 160 female undergraduate engineering students completing the online survey. Students' self-reported ethnicity is shown in Table 2 along with other demographic data. The sample was divided into four major ethnicity groups: 1) African American or Black 2) Asian 3) Hispanic and 4) White. An additional category was created for students whose ethnicity was reported as "other" or more than one group, although they were not included in the main ethnicity data analyses due to the small number (n = 9). The ethnic demographics of the survey sample closely followed the ethnic breakdown of enrolled female undergraduates during the semester the survey was conducted.

A distinctive aspect of the UH student population is the fact that many students come from families where one or both parents were born outside the U.S. (64 percent in our sample, n = 102). Additionally, many students either immigrated to this country as children or are attending school in the U.S. on international student visas. The survey did not distinguish between immigrant and international student status, but it is known that 83 percent (n = 133) of the sample graduated from high school in the U.S. We utilized a modified version of Fuligni's (1997) definitions of generational status in the country, where first generation indicated that neither students nor their parents were born in the U.S. (i.e., the participant is an immigrant or international student; 37 percent, n = 59), second-generation designated an individual who was born in the U.S. but whose parents were born outside the U.S.

	Percent of sample	Parent in science/ engineering field*	Non-native English speaker*	First generation college*	No family financial support*	≥1 parent born outside U.S. *	Family income < $40k /yr*
Survey *N* = 160							
African American or Black	11% (17)	35%* (6)	12% (2)	6%* (1)	41%* (7)	65%* (11)	31%* (5)
Asian	20% (32)	47%* (15)	72% (23)	28%* (9)	47%* (15)	100%* (32)	52%* (15)
Hispanic	30% (48)	26%* (12)	65% (31)	47%* (22)	36%* (17)	85%* (40)	46%* (21)
White	34% (54)	65%* (35)	17% (9)	7%* (4)	52%* (28)	21%* (11)	25%* (13)
Other/>1 ethnicity	6% (9)	33%* (3)	22% (2)	0%* (0)	33%* (3)	100%* (8)	0%* (0)
Percent of Survey Respondents	100% (160)	44% (71)	42% (67)	22% (36)	44% (70)	64% (102)	34% (54)
Interviews *N* = 37							
African American or Black	24% (9)	11%* (1)	0%* (0)	0%* (0)	56%* (5)	44%* (4)	33%* (3)
Asian	22% (8)	38%* (3)	75%* (6)	50%* (4)	75%* (6)	100%* (8)	75%* (6)
Hispanic	22% (8)	13%* (1)	50%* (4)	38%* (3)	38%* (3)	88%* (7)	38%* (3)
White	27% (10)	40%* (4)	10%* (1)	10%* (1)	50%* (5)	30%* (3)	20%* (2)
Other/>1 ethnicity	5% (2)	50%* (1)	0%* (0)	0%* (0)	0%* (0)	100%* (2)	0%* (0)
Percent of Interview Respondents	100% (37)	27% (10)	30% (11)	22% (8)	51% (19)	65% (24)	38% (14)

*Percentages reported are relative to individual ethnic group.

Table 2. Participant demographic information by ethnic group.

(21 percent, $n = 34$), and third-generation indicated that the student and at least one parent were born in the U.S. (42 percent of the sample was third generation or higher, $n = 67$).

The survey sample included undergraduate students from all university classifications: 24 percent freshman, 19 percent sophomore, 22 percent junior, 33 percent senior. During the Fall 2006 semester, undergraduate female enrollment consisted of students from the following classifications: 23 percent freshman, 15 percent sophomore, 19 percent junior, and 43 percent senior. Thirty-three percent of survey participants were in their first year at the university, 26 percent were second year, 13 percent were third year, 13 percent were fourth year, and 14 percent were fifth year and above. Due to the fact that many UH students (about one-third) transfer from community or junior colleges, class standing demographics in the general enrollment and survey sample were weighted more heavily toward upper-division university classifications, i.e., there are many first year students who are considered juniors or seniors by the university due to transfer credits. Survey participants were majoring in all seven engineering disciplines offered, with the highest number being Chemical and Biomolecular Engineering majors (24 percent); this is not surprising given that this department has the highest percentage of female students in the College of Engineering (38 percent in Fall 2006).

We classified participants as "first generation college" or "continuing generation college" based on the highest level of education attained by either parent. Participants were classified as "first generation college" only if the highest level of education attained by either parent was a high school diploma (or equivalent) or less. Students who had a parent who attended some college but did not receive a degree or who attained a college or graduate degree were classified as "continuing generation college" using this definition. Twenty-three percent ($n = 36$) of participants were first generation college (FGC) students.

The mean age of the participants was 22.79 years ($sd = 5.74$). The mean age of the accessible population was 23.5 years ($sd = 4.71$). More than half (59 percent) of the students in the sample were employed; 22 percent of the sample reported working more than 20 hours per week. In many cases, students were working to finance their education. Forty-four percent of the participants indicated that none of their expenses were being paid by parents or family. The average self-reported annual household income level was 5.90 ($sd = 3.06$) on an 11-point scale, where 5 represented \$40,000–\$49,999 and 6 represented \$50,000–\$59,999. An ANOVA comparing the four ethnic groups indicated that there was a group difference in household income, $F(3, 139) = 3.84$, $p < 0.05$. Specifically, Bonferroni post hoc tests indicated that the income of Hispanic students was significantly lower than that of White students, $p < 0.05$. However, not all students chose to report income information, so income was not included in subsequent analyses due to the lower n that would result. Hispanic students' mean household income was 5.15 (corresponding to \$40,000–\$49,999) while White students' was 7.00 (\$60,000–\$69,999).

D. Interview Participants

Thirty seven (23 percent) of the 160 participants from the quantitative study responded to the invitation to participate in an interview. University classifications ranged from freshman ($n = 16$) to one student who was an undergraduate during the survey phase of the project, but was enrolled in a masters program during the interview phase. All seven engineering disciplines offered at UH were represented among the interview participants. Like the survey sample, the largest percentage of interview participants came from the Department of Chemical and Biomolecular Engineering ($n = 12$). The mean age of interview participants was 22.52 ($sd = 8.10$), and included four participants over the age of 30. The oldest participant was 63 years old.

The survey and interview samples represented diversity in parental educational attainment, generational status in country, and socioeconomic status. A comparison of sample demographics is presented in Table 2. Similar proportions of interview and survey participants were first generation college students, had no family financial support for college, had at least one parent born outside the U.S., and reported an annual family income of less than \$40,000 per year. Higher percentages of survey respondents were non-native English speakers and had a parent who worked in a science or engineering field.

Eight (22 percent) of the interview participants were first generation college students. The educational attainment of interview participants' parents varied from parents who did not finish high school ($n = 3$) to one parent who had a doctorate. Ten (27 percent) interview participants had a parent who worked in a science or engineering field.

Income levels and financial support for college also varied; 19 participants (51 percent) indicated that none of their college expenses were being paid by their parents or family, while eight (22 percent) had full or nearly full family financial support. Self-reported annual household income levels ranged from less than \$10,000 per year to over \$100,000 per year. Fourteen participants (38 percent) were employed outside of school. Sixteen (43 percent) interview participants were living at home with their parents or other relatives. Two lived with a spouse.

III. Results

A. Survey Data

Survey participants indicated the sources of information used in selecting engineering as a college major by choosing each of the sources that they utilized from among a list; several sources were reported: parents, high school personnel, college visits and college classes, which are shown in Table 3. Percentages reported are relative to individual ethnic groups.

In the first set of analyses, the four ethnic groups were compared on the main variables utilizing ANOVAs with Bonferroni post hoc tests. Results indicated that the four ethnic groups did not differ on perceived social supports, barriers, sense of belonging, experiences in the College of Engineering, or financial influences for studying engineering, all ps > 0.05. There were also no ethnic group differences in the reported persistence toward major choice goals, $p > 0.05$.

However, there was a significant difference in the way participants from different ethnic groups perceived the field of engineering, $F(3, 147) = 4.25$, $p < 0.01$, with Asian students reporting less positive perceptions of engineering than did Hispanic students ($p = 0.01$). Examination of responses to additional questions on the survey indicated that approximately half of the sample knew someone employed as an engineer before enrolling in college, but being a minority student was significantly related to not knowing an engineer, $\chi^2(1, N = 159) = 5.23$, $p < 0.05$.

Further examination of the ethnic groups revealed that they differed in generational status in country, $F(3, 147) = 26.37$, $p < 0.001$. Post hoc tests showed that more generations of White students' families were born in this country than each of the other ethnic groups. More generations of African American/Black students' families were born in the U.S. than those of Asian students, ps < 0.05 (Figure 1).

An ANOVA indicated that the ethnic groups also differed in number of generations in the family to enroll in college, $F(3, 143) = 10.24$, $p < 0.001$. Post hoc tests showed that Hispanic students had significantly fewer generations of their families enrolled in college compared to African American/Black ($p < 0.05$) and White students ($p < 0.001$) (Figure 1). Further analyses indicated that there were ethnic group differences in the highest level of education attained by one or more of the students' parents, $F(3, 146) = 9.64$, $p < 0.001$, with parents of Hispanic students having significantly lower levels of educational attainment than both African American/Black and White parents, ps < 0.05.

Given that we found ethnic group differences in generational status in country, we next utilized generational status in country as the grouping variable in a set of similar ANOVAs with Bonferroni post hoc tests. An ANOVA showed differences between the generational statuses in country on perceived social supports, $F(2, 157) = 3.56$, $p < 0.05$, with post hoc tests indicating that first generation students perceived less social supports for their engineering college and career plans than did second generation students.

As shown in Table 4, perceived social supports were related to a number of other variables, including a negative correlation to perceived barriers, $r(160) = -0.36$ $p < 0.001$. Perceived social supports were also positively correlated with sense of belonging, $r(158) = 0.57$, $p < 0.001$, experiences with faculty, $r(158) = 0.23$, $p < 0.01$, and intentions to persist in engineering, $r(160) = 0.30$, $p < 0.001$.

Likewise, experiences with faculty members were positively correlated with both persistence goals, $r(158) = 0.22$, $p < 0.01$, and sense of belonging in the College of Engineering, $r(158) = 0.37$, $p < 0.001$. Experiences with faculty were negatively correlated with perceived barriers to college and career plans, $r(158) = -0.22$, $p < 0.05$.

	Parents*	High school counselor*	High school teacher*	College visit*	College classes*
African American/ Black	47%	24%	41%	12%	24%
Asian	38%	19%	31%	6%	16%
Hispanic	23%	25%	50%	21%	35%
White	43%	11%	33%	17%	19%

*Percentages reported are relative to individual ethnic group. Participants identified all sources of information used in their selection process.

Table 3. Information sources for selecting engineering major by ethnic group.

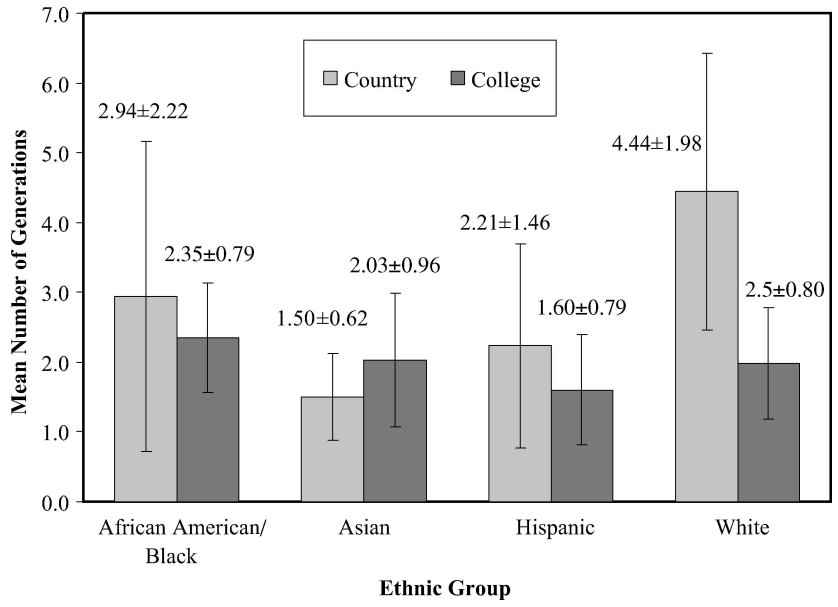

Figure 1. Generational status in country and college by ethnic group.

Survey Variables	Survey Variables 1.	2.	3.	4.	5.	6.	7.	8.
1. Social Supports								
2. Barriers	–.36**							
3. Sense of Belonging	.57**	–.44**						
4. Experiences with Faculty	.23**	–.22**	.37**					
5. Financial Influences for Studying Engineering	.27**	–.11	.16*	.19*				
6. Perceptions of the Work Engineers Do and the Engineering Profession	.31**	–.13	.27**	.16	.27**			
7. Major Choice Goals	.30**	–.35**	.39**	.22**	.09	.48**		
8. Generational Status in Country	.14	–.06	.13	–.14	.09	.09	.01	
9. Generational Status in College	–.15	.07	.01	–.20*	–.05	.04	.06	–.05

* $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

Table 4. Correlations among main survey variables.

Additionally, experiences with faculty members were negatively correlated with generational status in college, $r(157) = -0.20$, $p < 0.05$ (i.e., the more generations of a student's family had enrolled in college, the more negative experiences with faculty were reported). Therefore, we conducted some additional analyses to further examine the impact of generational status in college.

Three generational status in college groups were compared utilizing ANOVAs with Bonferroni post hoc tests: first generation in college, second generation (i.e. students and their parents had enrolled in college), and third generation or more. An ANOVA showed that the generational status in college groups were significantly different in perceived social supports, $F(2, 153) = 4.15$, $p < 0.05$, with first generation students reporting lower levels of support than did third generation students, $p < 0.05$. No significant differences based on generational status in college were found on the other variables.

B. Interview Results

Five major themes emerged from the interviews: 1) family and school personnel influences differed by ethnicity, 2) purpose for pursuing an engineering degree differed by ethnicity, 3) sense of belonging and social supports existed for participants of all ethnicities, 4) academic preparation acted as a barrier for some students of color, and 5) conflicting role struggles existed for some students of color. Each of the five emergent themes from the interviews is described in detail in this section.

Finding #1: Family influences major and career choice in different ways for students of different ethnicities; specific roles varied with parental education level and occupation. While school personnel encouraged participants of all ethnicities to pursue engineering, their influence proved more instrumental for Hispanic students.

Four of the ten White students had parents and/or other family members who were engineers. Only one of the White students interviewed was a first generation college student. For continuing generation college (CGC) students, family members served as role models and sources of information to help students make decisions about a college major. One participant (CGC, engineer parent) said,

> "My parents are both engineers and a bunch of my other relatives, too. So I got to see what they were doing in their jobs and that seemed interesting to me."

Several of the White students identified with carrying on a family tradition, naming grandparents, parents, cousins, and/or siblings who were engineers. Others mentioned that parents took an active role in helping them gain information about the field, whether by giving them access to engineering-related employment or workplaces, or by encouraging their pursuit via engineering camp experiences. Other parents supported their interest by helping them identify characteristics pertinent to the field:

> "My dad had a lot to do with that. He told me I have a very mechanical mind" (CGC, engineer parent).

Seven of the nine African American/Black participants indicated that parents and family were supportive of their goals in a general sense, but did not specifically cite family as role models in the field of engineering. While all African American/Black students interviewed had college-educated parents, only one of the eight had an engineer parent. One participant (CGC, non-engineer parent) described her parents' support,

> "They weren't really specific on what I had to do. They just said 'go for your goals' and do whatever you think, but make sure you do something that you like."

Three participants mentioned that their family influenced their career decisions by serving as an inspiration to overcome obstacles. One participant indicated that her mother went back to college at the age of 52 and that she was motivated by that fact. She also expressed that she saw herself as a positive role model for her own teenage daughter.

Asian students perceived a strong cultural expectation to pursue one of several professional fields, including engineering. All eight Asian participants stated that their parents were supportive of their studies and their choice of major. Although all of the Asian participants reported that they were aware of cultural or family expectations to go into engineering or medicine when choosing their majors, they also stated that it was their independent decision when their final choice of majors was made.

Some differences did emerge within the Asian subcultures. One participant (CGC) stated that it is expected for Indian children to become doctors and engineers. However the student also said that she loved math and science, so engineering was both a cultural expectation and her own choice. Another participant mentioned having relatives who were doctors, and that the goal of attaining higher education was something she grew up with. Respondents whose parents were from other Asian countries, on the other hand (all FGC), indicated that their parents did not attain high levels of education, but as one student stated,

> "They really don't know anything about engineering but they're just happy that I'm going to college…" (Asian, FGC).

Other participants described the influence of family values,

> "In general, hard work is valued in my family and also a good education is expected. Even though they work in a restaurant, they work really hard to earn what they really want" (Asian, FGC).

Six of the eight Hispanic participants indicated that their parents influenced their career choices. The influence, however, was focused on the importance of completing a degree rather than on a specific job or career. Four of the five participants indicated that although their parents were supportive of their major, their parents did not know much about what the major meant from a content and job perspective. What was most important for these parents was that their children were attending a university. Only one of the eight Hispanic participants, a student who had an uncle who was employed as an engineer, perceived her family as playing a direct role in her choice of major.

One participant (Hispanic, FGC) stated that her older sister experienced resistance from her father initially with respect to attending college. She stated that in the Hispanic culture daughters are expected to get married and have children and are not encouraged to "be with people [the parents] don't know." However, her father was more supportive by the time the participant reached college age because he had changed his attitude about education in the intervening years due to training classes he took at work. Another participant (Hispanic, FGC) interpreted her family's lack of discouragement as support,

> "Well they really haven't told me not to go to school or anything like that. It's pretty much they support what I do so they just help me by not prohibiting me from, you know, doing what I want to do."

Many participants not only had an awareness of the work engineers do and characteristics of engineers through personal role models, they also self-identified with these traits. This was particularly expressed by White, African American/Black, and Asian students. Five White participants cited the applied focus of engineering (e.g., problem solving, use of math and science principles), as a motivation for selecting an engineering major. Likewise, six of the nine African American/Black participants and seven of the eight Asian participants indicated that they chose engineering either because they loved math, computers, fixing things, science, or a specific aspect of engineering such as robotics.

Students of all ethnicities cited educational personnel at the middle school, high school, or collegiate level as influencing their decision to major in (or in one case, remain in) engineering. In the absence of familial knowledge about the field, educational personnel filled the void for five out of eight of the Hispanic participants by providing information, inspiration, and access to engineering role models. Nearly all were previously unaware that engineering was an option. The participants' routes to engineering were marked by a teacher or counselor highlighting the participants' science and math skills and suggesting that they pursue engineering.

Finding #2: The purpose for selecting engineering as a career was expressed in very general ways by White, African American/Black, and Asian students. Hispanic students were more likely to express their choice of engineering specifically as a means of helping their immediate family or home community.

In discussing their future engineering careers, many participants expressed an interest in developing, inventing, or improving something in a very general sense. The following statements represent the responses participants offered when asked about their purpose for pursuing an engineering career:

> "I'd like to help with the aerospace industry in some way. Just building space ships that will get us one step closer to exploring the universe is kinda cool…" (White).

> "[I want to] invent or improve a product that we're working on. Maybe even get a patent…" (Asian).

> "I want to be someone who makes a contribution" (White).

Several White, African American/Black, and Asian participants mentioned doing research,

> "Well, I want to do like research. I want to come up with … like, curing cancer is a little far-fetched, but, you know, do something that makes a difference" (Asian).

Two of the nine African American/Black participants mentioned that they would like to give back to girls who are pursuing engineering. One participant (African American/Black) said that she wanted to help "other girls who are struggling" and that "at some point I would like to be a mentor." One Asian participant expressed her desire to be a mentor and help other women in the

workplace. Three others shared a desire to "give back" through their engineering work. None of the White participants mentioned giving back to family or a specific community, or to other women.

Specific employment plans varied in degree of detail with the academic level of the interview participant (first-year students, for example, were far more vague than upper division students). Many White, African American/Black, and Asian participants expressed interest in the possibility of pursuing a graduate degree or certification, and several wanted to combine working with pursuing graduate level work at some point in the future. The advanced degrees mentioned by participants included master's in engineering, business and other fields, and doctorates in engineering, and medicine. Seven of the eight Asian students reported intentions of additional degree(s) and/or Professional Engineer certifications, and seven reported a desire to combine these goals with employment after graduation.

All Hispanic participants indicated that they were planning to get a job directly after completing their engineering degree. Only one participant indicated that she was considering a master's degree in engineering in the future, while two participants indicated possibilities of getting a master's degree in another field at some future point in time. All participants saw a job as being critical to help improve their lives and those of their families. Three participants in particular shared that their families needed financial support and that they looked forward to giving their families a new way of life. One student (Hispanic, FGC) explained,

> "My mom always said that education is what's going to get me ahead. My mom went to third grade. My dad passed away when I was six months old. So it's just been me and my mom… I put myself through college, you know. I want to get a job and I want to work and try to save some money together to get a down payment on a house. I want to help my mom… right now my main focus is to graduate, start paying my loans and my bills off, and try to get that house. I mean my mom and I… 22 years that we've been living in a house that's not even our own. I mean, like, it took us 12 years to put a nail in one of the walls cause the day we move out we don't want them to tell us something. And so that's my thing. I need to have that financial stability where I can get the house for my mom. At least something I can say 'This is yours…You want to put a nail in the wall, put a nail in the wall!'"

Another participant (Hispanic, FGC) said,

> "…once I get my degree and once I get a good amount of money I could pay off [my parents'] bills, their mortgage… so that they don't have to struggle anymore…that's what I want to do…get my degree, get a good job… and still support my parents."

Finding #3: Participants' sense of belonging contributes to positive learning experiences and eases the transition to college for students of all ethnicities.

No major differences were noted across ethnicities in the sense of belonging felt by students in the College of Engineering. Overall, students had a high rate of participation in engineering support programs and other engineering-related associations and resources. Participants cited these programs as being instrumental in easing the social transition to college. Participants discussed support systems such as the Women in Engineering Learning Community for Maximizing Excellence (WELCOME) women-in-engineering program (Trenor, Madubike, and Claydon, 2006), learning communities such as the Program for the Mastery of Engineering Studies (PROMES) program and the University of Houston Honors College, as well as student organizations, collaborative learning experiences, and positive relationships with faculty and other students. One student (White) compared her experience in the College of Engineering to those of her friends in non-engineering majors, and observed that her friends "don't know as many people and they don't feel as connected as a freshman." She noted that "engineering is more … of a community."

This closeness among students was cited by students of all ethnicities. Another participant, for example, thought that the people within College of Engineering were very friendly and welcoming (African American/Black). Several students specifically mentioned the diversity of the student body as enhancing their experience. A representative comment was:

> "When I first came to here I was very amazed at the diversity of the University. I felt like it was more fun; it's different to see a lot of different people with their different perspectives" (Asian).

Another respondent (Asian) expressed her enthusiasm about the diverse community at UH and her surprise at the number of other Asian people on campus. She remarked,

> "… you walk around and you see every different culture here and it's amazing and I've meet a lot of people from different backgrounds and that's interesting. I mean, you don't even have to travel to learn about their cultures."

Collaborative learning experiences were cited by students of all levels as major factors in enhancing their sense of belonging. ENGI 1100, a project-based first semester course recently added to the curriculum, was cited by all interviewees who had taken the class as being helpful not only academically but socially as well. Team-based design projects were credited with allowing students to network and make friends quickly while also teaching students how to think and collaboratively generate ideas and solutions.

Other students who had not taken the ENGI 1100 course cited team-based experiences in other courses, as well as study groups as positive contributions to their engineering experience. One participant (Hispanic) highlighted the sharing of ideas through collaborative learning by saying,

> "To me it's all about the social [aspect]. Someone can help you because they may know how to do something better or a different way. They can help you have a better understanding … if you all have the same homework assignment and we're all working together and I get to a certain spot and I can't move past it, someone in the group can look at it in a different way and help you."

The women-in-engineering organizations (WELCOME women-in-engineering program, Phi Sigma Rho engineering

sorority, and UH Society of Women Engineers student section) were mentioned frequently by participants of all ethnicities, particularly as helping to deal with being in a degree program where women are in the minority. In particular, 25 of the 37 students mentioned WELCOME, which was perceived to be instrumental in creating opportunities for the women to create support networks with other students, working professionals, and faculty. One student (White) said,

> "I think the first time I really felt part of the engineering college is when I went to the WELCOME retreat."

Student organizations and learning communities were also cited as key contributors to building camaraderie among students of all ethnicities. One participant (White) remarked that "being part of different programs helped me to meet people and I started to make friends relatively quickly… They have a lot of programs, things that you can be involved in." Most participants shared that the support networks were major positive influences in their engineering experience. However, six of the 37 students said that they were not involved in student organizations, citing lack of time as the reason.

Early access of support systems was noted as being critical to enhancing a sense of belonging for students. Several respondents recalled that activities held very early in their first semester on campus or even prior to classes starting helped to cement their feelings of inclusion and community.

While cases of both positive and negative experiences with faculty were cited by participants, it was clear that positive relationships with faculty contributed to a sense of belonging and perceptions of support by students of all ethnicities. One student (White) explained,

> "I think that's one of the most important things [getting to know the faculty] because they can help you do things that you can't do on your own… For me it makes a difference because it's nice to know professionals that have succeeded in the field… It's like you have a support system… When you take those classes… then you become kinda friends with them."

Finding #4: Lack of academic preparation/study skills contributes to a difficult adjustment for some students of color.

Some students of color expressed difficulty adjusting to college courses due to lack of academic preparation and/or study skills. A number of students talked about the fact that they did not need to study in high school or community college and were not prepared for the rigor of the engineering curriculum. Seven of the nine African American/Black participants indicated that they had to adjust their study habits since coming to College of Engineering. While they could procrastinate and under-prepare in high school without penalty, they had to put in extra effort with their studying to get good grades in college. Even though four African American/Black participants indicated that their previous school had provided a strong engineering background, four other respondents indicated that their former school had not prepared them and that their engineering foundation was weak.

Six of eight Hispanic participants said that difficult adjustments to course work negatively affected their engineering experience. Unfamiliar teaching styles, lack of time management, poor networking skills and poor engineering foundation from former schools were cited as reasons. One student shared that it took her a semester to understand fully the teaching styles and the roles that students played in their own learning.

Two of the eight Hispanic participants indicated that their former school did not teach them about forming study groups or how to network. Studying in groups was initially uncomfortable and unfamiliar, and as one student noted, "I was more an individual." One Asian student stated, "I would just study by myself when I was in community college."

Finding #5: Conflicting role struggles exist for many students of color. Time management issues result due to financial obligations, commuting to campus, or both.

While none of the White students cited role conflicts as a barrier to achieving their academic plans, this theme frequently emerged for students of color. Just one of the six White students who worked outside of school mentioned a time management challenge resulting from working and going to school at the same time. While half the White students had no family financial support for college, none of the other White interview participants mentioned struggling with conflicting roles creating by being employed and going to school.

Three African American/Black participants discussed time management as a major issue, particularly as it pertained to finding time to both work and study, as well as commute. When asked about her biggest challenge in completing her degree, one participant said, "Time. It's always time. Not enough time to study as completely as I would like to. Time is my enemy."

Six of the eight Asian students lived at home with their parents and commuted to campus, which created additional time management challenges. One Asian student cited a commute of an hour that makes her schedule challenging and her days long. Commutes of this length are not unusual for students at UH, due to the size of the Houston metropolitan area. Seven Asian students had no family financial support, and six reported family annual incomes of less than $40,000. However, six were not employed, one was employed less than 10 hours a week (one did not answer), and none reported conflicts related to financing their education.

Four of the eight Hispanic students felt that balancing school, work, and family responsibilities was their greatest challenge in pursuing an engineering degree. While five Hispanic students reported some family support for college, their responses indicated that paying for their education and, in some cases, contributing to their family income, weighed heavily on their minds. One Hispanic participant stated that paying for school was her greatest challenge; therefore, she could not avoid work and school struggles. Another participant recounted the struggles in managing family time, school, and work, noting that she does not see her family during the week even though she lives at home, which caused her parents to complain. Yet another Hispanic student related her struggle to balance long hours at work with attending classes:

> "It's hard. You can't go and tell them [the professor] I'm sorry I didn't go to class because I got off of work at two o'clock in the morning and I slept through my alarm clock. And then, I still try my best…and still try to do what I can. It's just hard, you know…"

IV. Discussion

A. Summary of Quantitative and Qualitative Results

Quantitative analysis of survey data revealed that the ethnic groups did not differ on perceived supports, sense of belonging, barriers, financial influence for studying engineering, or major choice goals. The survey results were initially surprising, and differ from other Social Cognitive Career Theory research (Lent, Brown, and Hackett, 1994; McWhirter, Torres, and Rasheed, 1998; Seymour and Hewitt, 1997; Swanson and Woitke, 1997) that reports, for example, that minority students perceive increased barriers to educational plans compared to White students. Therefore, the qualitative portion of the study was designed to provide additional insight into the quantitative results, by focusing interview questions on these constructs. A major goal of the qualitative study was to further investigate the non-significant results related to barriers and sense of belonging. For instance, further examination led us to believe that the five survey items related to perceived barriers perhaps did not address the most pertinent barriers faced by the participants. Interviews allowed for the perceived barriers of participants to be explored in an open-ended format, and subsequently revealed that more pertinent barriers for this sample were related to financial worries, commuting, attempting to balance school with working, and lack of college-educated or engineering role models. Students of color reported conflicting role struggles and (for some) lack of academic preparation, while White students, who were more likely to have college educated parents and higher family income levels, did not. Hispanic students especially reported lack of college educated family role models, but utilized others (academic personnel, mentors) in their absence. Future work will incorporate revised survey items related to the aforementioned barriers which emerged in the interviews.

Survey results indicated no significant differences in perceived social supports or sense of belonging based on ethnicity. These constructs were further explored in the interviews, where participants often spoke at length on the topic. Qualitative data supported the quantitative findings, indicating that students of all ethnic backgrounds generally perceived strong social supports and sense of belonging (Finding 3). This result is notable in light of the apparent difference in parental educational attainment and socioeconomic status between White students and students of color.

No significant differences based on ethnicity were found in the survey data related to student experiences in engineering. Interview questions also addressed students' experiences and prompted participants to discuss their relationships with faculty, with other students, as well as positive and negative experiences in the College of Engineering. Interview participants of all ethnicities reported similar classroom and relational experiences with faculty and peers (Finding 3). African American/Black and Hispanic students in particular reported difficult academic transitions to rigor of college courses (Finding 4).

Quantitative data showing that differences existed between Hispanic and Asian students' perceptions of the field of engineering were elucidated in the interviews as participants discussed their reasons for selecting engineering as a major and career; in many cases, Asian students felt a cultural expectation to go into medicine or engineering, whereas Hispanic students' families, many of whom were not college educated, viewed engineering as a means to improving their socioeconomic status (Findings 1 and 2).

While quantitative results indicated that there were no differences based on ethnic group regarding financial influence for studying engineering, interviews revealed that the long-term financial implications of a career in engineering was critical to many Hispanic students. However, their interest was not in simply making a high salary to support a comfortable lifestyle for their own sake, but in having a steady, well-paying job for the purpose of helping their family of origin. This discrepancy between quantitative and qualitative results can be explained by differences in the nature of the questions asked in the two methods of inquiry; interview questions allowed researchers to gain a more in-depth understanding of financial influences than was possible with the quantitative results alone. Some of the interview results related to educational barriers created by role conflicts, namely, working and concentrating on studies, were initially puzzling. While seven of the nine Asian students reported no family financial support for college and 52 percent reported household incomes of less than $40,000 per year, only one participant reported being employed (less than ten hours per week). None described concerns about paying for their education. Similarly, half the White students reported no family financial support. Even though six of the ten White students were employed, only one indicated concerns about her financial situation and said that the time spent on her employment was a barrier to her educational plans. Hispanic students, on the other hand, were very vocal about their financial struggles and the challenges their employment created for their educational plans. One possible explanation is that White and Asian students had secured scholarships or loans to help pay for their education, and perhaps Hispanic students had not. This could indicate that the Hispanic students were not as familiar with the financial aid process and/or that they did not receive help in applying for scholarships and loans from their families or high school personnel. We cannot confirm this hypothesis with data collected in the study; however, future surveys will include items about scholarships and sources of information used to obtain them.

Survey data indicated that significant differences existed in the generational status in country and college for students from different ethnic groups, as well as access to engineering role models. Ethnic group differences were also observed in the information sources survey participants used to make their decision to study engineering. Access to role models and sources of information about engineering became salient points in the interviews, as students described their decision making processes in choosing a major. White students who had engineer family members used them as a direct source of information, whereas Hispanic students did not have engineer family role models and therefore relied more heavily on academic personnel (Findings 1–3). Despite similar numbers of first generation college Asian and Hispanic students, many Asian students cited parental expectations to go into professional fields such as engineering or medicine.

B. Study Limitations

Like all research, limitations to this work exist. First of all, the construct of ethnicity is multi-dimensional and complex, and ethnic categories must be used with caution. We recognize each of these categories is insufficient to encompass the multiple dimensionalities of ethnicity stemming from within-group sub-cultures, and that categorical ethnic groupings are not ideal for describing the rich diversity of our student population. However, these provide a starting point for discussion. Categorizing people into various ethnic

groups can be problematic for many reasons, and has been criticized as arbitrary, imprecise, and inadequate (Betancourt and Lopez, 1993; Phinney, 1996). For example, in our sample, within-group ethnic variations were present in terms of generational status in country. Additionally, other potentially important unexplored within-group variations are anticipated to be present; participants included in the Asian ethnic group, for example, listed five familial countries of origin, each potentially corresponding to an associated sub-culture. It is generally felt that using ethnicity categorically is insufficient for describing psychological outcomes, and that a more sophisticated way of dealing with ethnicity is to identify and study contextual variables (cultural and social) associated with ethnicity. Phinney suggests three ethnicity aspects that are important in psychological work that must be investigated to fully treat the complex construct of ethnicity: culture, ethnic identity, and minority status (Betancourt and Lopez, 1993). A complete treatment was not within the scope of this exploratory study; however, future work will include more attention to all three factors. Furthermore, the small sample size of interview participants belonging to each ethnic group ($n = 8$ to $n = 10$) did not allow for statistical comparison of survey results between the survey and interview samples; this is an inherent limitation for any study that relies on volunteers. However, the strong similarities between the demographics of the survey and interview samples give us confidence that the attitudinal results are comparable.

One limitation of the current dataset is the fact that the survey did not distinguish between students attending school in the U.S. on a student visa and students who immigrated to this country prior to college enrollment. However, the results based on generational status born in the U.S. are still potentially important given the fact that the foreign-born population in the United States is at an all-time high of 33.5 million people (Larsen, 2004). In particular, the fastest growing demographic of the country's population is Hispanics aged 18–24 years—a significant portion of our sample—are estimated to account for 61 percent of our country's total population growth from the years 2000 to 2015.

This work applies only to this sample of female students at one university. No Native American students were included in the sample, as none were enrolled in engineering at the time of the study. Further research exploring gender differences and students from other ethnically diverse institutions is warranted, as is the investigation of these research questions with students who have not persisted in engineering majors ("switchers", according to Seymour and Hewitt, 1997), as their educational experiences are likely to be different from those who have intentions to persist.

C. Comparison to Prior Research

Perhaps the most notable aspect of our study is the ethnic diversity of the sample and the learning environment in which the participants experienced their engineering education. Much of the previous collegiate-level engineering education research has been conducted either at predominantly White institutions (where students of color were in the minority) or at minority-serving institutions, such as HBCUs, where one ethnic group (African Americans) makes up the vast majority of the student body. In the current work, 73 percent of interview participants and 66 percent of survey participants reported belonging to an ethnic minority group.

While the scope and focus of this work differed from Seymour and Hewitt's study (1997), several important similarities and differences in sample size and results can be noted. The portion and absolute number of minority participants interviewed was higher in this study (73 percent, $n = 25$ vs. 26 percent, $n = 16$). Our findings support some of those by Seymour and Hewitt, particularly, the conflicts arising from differences in values and socialization of the Hispanic culture with pursuing an engineering degree and the presence of family economic obligations for Hispanic, but not for Asian, students. Our findings differ in other respects, namely:

1. No negative stereotypes were reported by students of color. However, data from Asian students did reinforce "positive" stereotypes associated with expectations to pursue degrees in professional fields. (Current study Findings 1 and 2, Seymour and Hewitt's Finding 2.)
2. Students of color were part of diverse peer groups on campus and no perceptions of racism were reported. (Current study Finding 3, Seymour and Hewitt's Finding 3.)
3. The presence of ample support systems for all students, not based on ethnicity, contributed to students' sense of belonging and positive educational experiences. (Current study Finding 4, Seymour and Hewitt's Finding 4.)

Furthermore, while the Asian participants in the Seymour and Hewitt study reported feeling pressure from families to study engineering, some of our Asian participants cited cultural expectations to enter a field such as engineering or medicine, but clearly indicated that the choice to major in engineering was their independent decision and not a result of these expectations. However, we interviewed only "non-switchers", and anticipate that our results may be more in agreement with the Seymour and Hewitt study if our population was extended to include students who had left engineering majors ("switchers").

Our findings related to the motivation of students of color to pursue an engineering degree, and their influences for doing so echo results by Phinney, Dennis, and Osorio (2006), who identified three distinct reasons minority students pursue higher education: encouragement, helping family, and proving worth. Their work identified differences in reasons for pursuing higher education among students from cultures that emphasize individualism (e.g., self-focused, individual standards of excellence) and collectivism (e.g., motivated by the needs or demands of others). Fuligni, Tseng, and Lam (1999) found that young adults from Asian and Latin American backgrounds reported a stronger sense of duty to respect the wishes of their family, as well as to support them. This family obligation was higher for participants from immigrant families. Likewise, Seymour and Hewitt (1997) found that students of color cited long-term contributions to family and community as an influence for majoring in engineering. In our sample, Hispanic students routinely described helping family as a reason for entering engineering, African American/Black students mentioned giving back to society in a more general sense, while Asian and White students talked about individual accomplishments/goals and contributions in very general sense such as "improving something." Our data on Asian participants are somewhat surprising considering Fuligni and coworker's finding regarding high levels of family obligation among Asian American adolescents (Fuligni and Pedersen, 2002; Fuligni, Tseng, and Lam, 1999; Fuligni, Yip, and Tseng, 2002).

Parental influence is cited by Goodman and Cunningham (2002) as a salient factor in female engineering students' career choice. The issue of parental influence (Finding 1) is critical to understanding the academic and career choice process of female

engineering students. While Goodman and Cunningham's study was conducted with samples of primarily White (73 percent) students with college educated parents (80 percent), we are particularly interested in understanding the career paths students of color and of those students who do not have college-educated parents. Therefore, our study directly addressed an additional contextual factor: generational status in college (22 percent of both interview and survey participants were FGC students). In analyses of data from three nationally representative longitudinal studies, the National Center for Education Statistics (NCES) reported that 47 percent of beginning postsecondary students in 1995–1996 were among the first generation in their family to go to college. Approximately one-third of incoming engineering students at UH are first generation college students. While there is a dearth of information in the literature regarding first generation college students majoring in engineering, research on students studying other fields has shown that they perceive less support from families (York-Anderson and Bowman, 1991), have lower retention rates, are at particular risk for attrition during the first year of college (Choy, 2001; Pascarella, Pierson, Wolniak et al., 2004; Riehl, 1994) and take longer to graduate. In fact, Ishitani (2006) states that these students face "profound challenges at each level of educational system" due to lack of parental experience with the educational process (Choy, 2001; Gibbons and Shoffner, 2004), including more difficult transitions to college. Our quantitative results echo previous findings that first generation college students perceive fewer social supports for their academic and career plans (Riehl, 1994). Qualitative results revealed different influences and purposes for pursuing an engineering degree based on generational status in college. While "first generation college" has been defined in different ways by various researchers, we felt that our definition (a participant whose parents attained only a high school diploma or below) was most appropriate for this work. In discussing barriers and supports to college and career plans, a participant whose parent(s) has undergone the college application process and some higher education, with or without actually achieving a degree, is likely to experience some lowered barriers and/or higher supports than a participant whose parent(s) is completely unfamiliar with the higher educational system. However, the participants whose parent(s) completed only some college are likely to perceive increased barriers and lowered supports in other regards compared to participants who parent(s) finished college, since their parent(s) may have limited knowledge of the higher education environment. In future work, we suggest utilizing three categories for generational status in college, to better account for the complexities associated with various levels of parental familiarity with the higher educational process.

Brown, Morning and Watkins (2005) studied African American engineering students at predominantly White institutions and HBCUs, finding that students at HBCUs perceived more positive educational experiences and had higher graduation rates than participants at predominantly White institutions. They also found that perceptions of racism by students attending predominantly White institutions strongly correlated with weaker academic performance. Lent and colleagues (Lent et al., 2005) report that engineering students at HBCUs perceived weak barriers, strong supports, and easy access to role models. A similar effect relating to supports and to some extent, barriers, may be at work at our university, where no one group is singled out as the "minority." Our qualitative results (Finding 3) indicated strong perceptions of institutionalized and peer supports for students of all ethnicities. Students of color perceived a strong sense of belonging and exhibited high levels of engagement in this diverse educational setting. While minority engineering programs can be effective for many campuses, Seymour and Hewitt (1997) warn that such programs may not address the needs of all minority students. Because no one group is singled out as a minority at UH; however, non-ethnically based interventions such as the WELCOME women-in-engineering program, Program for the Mastery of Engineering Studies learning community, student organizations and a team-based first year course have successfully created a strong support network for students of all ethnicities. In fact, being in the gender minority, rather than ethnic minority, was often cited as a barrier, and the women-in-engineering support systems were viewed as a significant means of support.

These data reporting high levels of campus support systems are especially significant given the fact that the University of Houston is primarily a commuter campus, a characteristic that has been shown (Astin, 1993, 1999) to create increased barriers and decreased supports for students. Following Astin's model of student involvement (Astin, 1993, 1999), the students in this study devoted large amounts of energy to studying, had high participation rates in student organizations, and interacted frequently with faculty and other students. Astin also uses the amount of time spent on campus as a measure of student involvement. While time spent on campus was not directly addressed in the quantitative or qualitative protocol, challenges related to time management conflicts emerged as students' described balancing their academic life with family and/or employment obligations. Further investigation of students' time spent on campus is an interesting line of inquiry for future work.

In considering educational barriers, other researchers (Lent, Brown, and Hackett, 1994; Phinney, Dennis, and Osorio, 2006; Pascarella et al., 2004) warn against attributing differences in socioeconomic status (which may be related in part to generation of immigration and/or parental educational level) to ethnicity. Our results show that when ethnic isolation and perceptions of racism are removed from a learning environment, some of the salient factors impacting students' educational experiences are related to socioeconomic status. While generational status in college and in country related to ethnicity in this study, they are not a result of ethnicity *per se*. Some of our results point to cultural differences for students from Hispanic and Asian backgrounds, such as their purposes for pursuing an engineering degree. Other results are a combination of cultural values (e.g. family interdependence/obligation) as well as economic factors.

Our qualitative finding relating to lack of academic preparation (Finding 4) is likely related to socioeconomic status via the quality of pre-college educational experiences. May and Chubin (2003) attribute gaps in pre-college preparation of minority students to a number of factors, including a "grievous lack of resources" in inner-city schools (where minorities tend to be concentrated) and less demanding science and engineering curricula. Findings regarding the influence of family in major and career choice (Findings 1 and 2) are believed to be a combination of socioeconomic status (e.g., accessibility of college educated family role models, family income) and culture (i.e., collectivist vs. individualist). Likewise, the barrier of conflicting role struggles is believed to be a combination of both factors, as the family obligation of

some students of color contributes to the desire to help their families of origin meet financial needs. Quantitative and qualitative findings relating to the perceptions of engineering seem to be related to cultural views of the profession, at least for Asian students, whose reported income levels and parental educational attainment does not greatly differ from that of Hispanic students.

V. Conclusions

The current study fills a unique gap in understanding experiences of female students of color studying engineering in a diverse learning environment. Previous studies investigating student experiences, barriers and supports perceived by students of color included participants who were either ethnically isolated at a predominantly White institution (Brown, Morning, and Watkins, 2005; Seymour and Hewitt, 1997) or a member of the majority ethnic group at a minority serving institution (Brown, Morning, and Watkins, 2005; Lent et al., 2005). By studying engineering students in a learning environment that can be considered "model" from an ethnic diversity perspective, we elucidate factors that emerge when ethnic isolation and perceptions of racism are removed from the student experience.

A major finding from this work suggests that within an ethnically diverse learning environment, students of all ethnicities experience strong social supports and weakened barriers, as has been reported for African American students at historically Black colleges and universities. Additionally, we hypothesize that in the presence of an ethnically diverse learning environment, other factors, such as generational status in college and related socioeconomic conditions emerge as salient in students' educational experiences and college and career choices. While these factors relate to ethnicity groupings in this sample, they should not be confused with cultural differences. In this study, differences in culture did contribute to perceptions of the engineering field and findings related to conflicting role struggles for students of color.

Based on these results, successful engineering recruitment and retention programs should emphasize the important roles that parents and role models play in the selection and persistence of female students. When first generation college students are represented in an institution's student body, efforts should be made to include parents and family members in the educational process. Our data also reinforce previous findings summarized by May and Chubin (2003) that financial aid can significantly decrease the educational barriers experienced by low-income students.

Our work has also added to existing literature (namely, that of Seymour and Hewitt) by further exploring the people and experiences that are influential in attracting and retaining diverse students in engineering. The diversity of this sample represents the changing face of engineering education. Currently, many community colleges and other urban universities are comprised of similar student bodies, while many predominantly White institutions seek to achieve similar diversity. As U. S. population demographics shift and our nation continues to recognize and promote the value of diversity in its scientific workforce, engineering programs across the country will continue to seek ways to achieve increased participation of minority students and women. Our research has offered insights into student experiences in a diverse learning environment, where no group is singled out as the "minority." Such an environment indeed holds promise for achieving a highly supportive educational environment for students of all ethnicities.

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