WOMEN OF COLOR IN THE ENGINEERING PIPELINE

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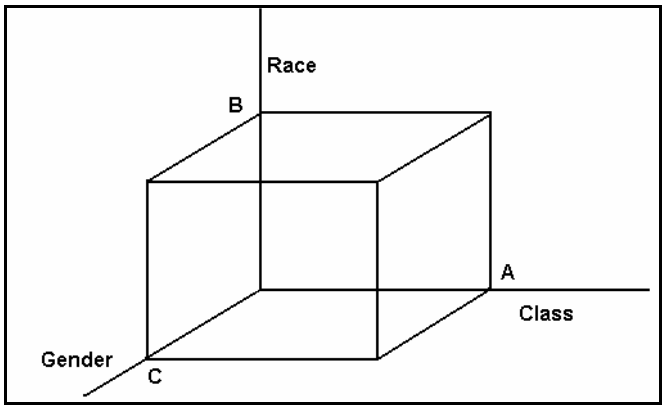
Abstract –- *This paper presents national data to show that ethnicity and gender must be examined simultaneously to understand the U.S. engineering "pipeline." Using the "concentric circles" analytical approach, differences in the rates at which young women are represented within the different stages of the engineering pipeline are documented. While within every racial/ethnic group women are less likely than men to pursue engineering, the within ethnicity sex ratios vary across groups and across the pipeline stages.*

Index Terms – engineering, ethnicity, gender, concentric circles.

THE INTERSECTION OF RACE, CLASS AND GENDER

Over the past decade or so, social scientists who study U.S. social stratification have moved away from models that specify class as the primary mechanism of stratification with race/ethnicity and sex/gender (among other bases) as secondary mechanisms of stratification. Instead, social scientists have increasingly embraced Patricia Hill Collins' approach that views stratification along these three dimensions as forming a matrix of domination and oppression (Figure 1). Individuals' experiences depend not on occupying a specific position based on only one of their characteristics (e.g., say, the individual's sex) but are based on how gender is socially constructed within ethnic and class groups simultaneously.

FIGURE 1
RACE, CLASS, GENDER CONCEPTUAL SCHEME



To illustrate the complexity of this approach, consider the case of the three hypothetical people, A (a wealthy black female), B (a poor, white female), and C (a poor, white male). Imagine the lives of these three people at the turn of the twentieth century. Both of the women (A and B) were denied full citizenship rights (e.g., voting) even though A had a higher class status than C. Yet we cannot assume that racial segregation meant the black woman (A) was in more dire straights than her white sister (B). The class position of each woman shaped her daily experiences. As a member of a wealthy family, B would have been likely to be highly involved in community affairs, to have at least a secondary education (and possibly a 4-year degree from a historically black college), to have been married to a man of similar standing who might have afforded the luxury of having a spouse who does not work for pay. The poor, white woman (A) lived hand-to-mouth, toiling at menial labor for low wages. And while the poor white male (C) had full citizenship rights due to his sex and race, he would have been disadvantaged by his lower class position. All three of these hypothetical people would have experienced both advantage and disadvantage associated with race, class, and gender simultaneously. In other words, a simplistic assessment that the white woman was privileged by her race or that the black woman was privileged by her class status or that the white man was advantaged by his gender and race overlooks how these dimensions produce complex outcomes and differential daily experiences.

In this paper I discuss how race/ethnicity and sex/gender work, together, to affect the engineering pipeline in the United States. Here, I will not be able to fully explore the dimension of class but challenge other researchers to be mindful of how class does impact the engineering pipeline along with race and gender.

A few quick words about terminology. You will notice that I often interchangeably use the terms race and ethnicity and sex and gender, which reflects the current theorizing about these terms. Increasingly, social scientists are coming to view these two pairs of terms to reflect socially constructed statuses occupied by individuals. In past usage, race was understood to have some biological basis while ethnicity was based upon culture and community. But increasingly race is viewed as socially constructed as much as is ethnicity (see, for example, Ignatiev 1995, Rodriguez 2000, Waters 1999). Likewise, sex was seen as biologically based and gender was viewed as a more complex set of socially constructed meanings associated with sex. And, while the diversity of ethnicity has long been attended to in the social science literature, it has been taken for granted that

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sex is an essential feature. But, again, recent research (e.g., Fausto-Sterling 2000) has problematized sex categorization in some of the same ways that the concept of race is seen as flawed. In my usage, because I will be focusing on macro-level processes, all of these terms refer to large, usually heterogeneous categories rather than reflective of the individuals' sense of belonging to any specific communities.

ANALYTICAL FRAMEWORK: THE CONCENTRIC CIRCLES MODEL OF EDUCATION AND CLASS, RACE AND GENDER

The promise of equal educational opportunity is part of the value system of the United States. The dominant mythos is that anyone who works hard enough can earn educational credentials and get ahead. Increased educational attainment does result in placement in "better" jobs, higher pay, and lower levels of unemployment (Statistical Abstract of the United States 2003). Unfortunately, this belief in an "American Dream" assumes that racism, classism and sexism no longer exist in the United States. Much social scientific research (e.g., Feagin 1991, Frehill 1997, Frehill 2000, Gregory 2003, Kozol 1991, Oliver and Shapiro 1995, Wenglinsky 1997)--has documented the continued salience of class, race and sex in the everyday lives of Americans in general and educational and occupational outcomes in particular.

Table 1 provides a general synthesis of research findings to date concerning how class and race simultaneously impact young people's secondary education. For the sake of simplicity, I have compared black and white outcomes but it should be noted that the outcomes associated with other racial and ethnic groups will be affected by the fundamental mechanism of residential segregation---indices of which vary greatly between racial ethnic groups (see Mumford Center 2004).

TABLE 1
RACE AND CLASS EFFECTS ON SECONDARY EDUCATION

Class	Race	
	Black	**White**
Upper	Wealthy children have access to better schools regardless of race.	
Middle	More likely than whites to live in neighborhoods with high levels of poverty, resulting in poorer schools.	Whites have more wealth, less debt burden and are more likely to live in neighborhoods with better schools.
Lower	Poor children of both races have access to poor schools.	

Oliver and Shapiro 1995 in conjunction with Massey and Denton 1993 show that persistent racial and class residential segregation means that wealthy children of any racial group are advantaged, while poor children are disadvantaged in terms of secondary education. Middle class children—those that have formed the historical "pool" from which engineering students have been drawn—have access to vastly different secondary education because it is this group that most dramatically experiences the effects of racial residential segregation. Furthermore, the "middle class," almost by definition, represents a very heterogeneous group. As a result, white middle class young people experience a privilege due to racial segregation with access to better schooling in less dangerous neighborhoods. Racial residential segregation produces negative outcomes for black middle class youngsters, who are more likely than their white counterparts to find themselves in poorer schools and to have parents with lower levels of family wealth (because of past racial educational and occupational discrimination), which affects their post-secondary educational options.

In short, this means that the educational outcomes for males and females share similar patterns based on racial and class segregation. Given the significance of class as a primary determinant of educational access and the existence of racial residential segregation as another important determinant of students' secondary school experiences, the concentric circles model would have us examine how gender is constructed differently within these different race X class contexts. That is, if we are interested in understanding educational outcomes, then gender occupies the innermost circle within larger circles inscribed by race and class.

ENGINEERING AND THE INTERSECTION OF SEX AND RACE/ETHNICITY

Race, class, and gender have long been instrumental forces in shaping engineering in the United States. As engineers sought to professionalize their field in the early part of the twentieth century, non-whites and women were excluded while engineers used various strategies to differentiate their middle class work from that of working class men (Frehill 2004, Oldenziel 2001). Preserving the class, race, and sex bases of inequality enabled engineers to improve the status of their profession within a rapidly-industrializing economy.

By the early 1970's, however, with the Equal Employment Opportunity Act, formation of the Equal Employment Opportunity Commission, Title IX, the expansion of the space program, and social movements that targeted racial and sex-based discrimination, engineering, like many other occupations needed to recruit young women and people of color into the field. Between 1966-1982, diversity in engineering did increase. Over that time, the percentage of bachelors degrees earned by women increased from 1.9% to 20.9% while African Americans earned from

2.2% of engineering bachelors degrees in 1966 to 7.0% in 1982 (U.S. Bureau of the Census 1985). Note: because of changes in U.S. Census definitions, similar data are not available for Hispanics for that period.

Organizational Forces

Change slowed during the two reactionary Reagan administrations, so more schools of engineering added special staff to serve the needs of women and minority students. By 1991, such programs were sufficient in number to spur the founding of the Women in Engineering Programs and Advocates Network (WEPAN) when Suzanne Brainard, Susan Staffin Metz, and Jane Daniels met at Chicago's O'Hare Airport to provide a context for people involved in these efforts to share information.

A similar organization, the National Alliance of Minority Engineering Program Administrators (NAMEPA) serves a function similar to that of WEPAN, with an emphasis on issues related to recruitment and retention of under represented minorities to engineering.

The existence of the two organizations—not unlike the existence of the Civil Rights Movement alongside the Women's Liberation Movement in the 1960s-1970s—means that there is an institutional basis by which issues salient to women of color can in engineering can be "missed" by members of both organizations. NAMEPA's focus on minority issues can result in women's issues being subordinated, while WEPAN's focus on gender equity in engineering can often result in minority issues being overlooked. As pointed out by Hill Collins, minority women simultaneously occupy two subordinated statuses, which must be taken in tandem if WEPAN and NAMEPA program personnel are to serve the needs of women of color.

Weinburgh's evaluation of the efficacy of an NSF-funded Local Systemic Change initiative for predominantly African American schools (90% or more of students) provides insight into the problems faced by young African American women within their schools. Weinburgh found that school-level factors were essential in the program's success. In those schools where the program was seen as important to the principal, where the principal supported teachers' efforts to improve the educational process, the program could be quite successful in improving students' attitudes towards science. On the other hand, in schools where the science reform effort may have conflicted with other reform initiatives, where the principal was less supportive of teachers, where the principal was concerned with maintaining order as the primary goal, or where teachers were allowed to miss training (and, therefore, taught science without the kits), the program was far less effective. Weinburgh also found that many teachers resisted gender equity training because they felt that more attention needed to be paid to the young black males in their schools because of the very negative outcomes this group experienced.

NAMEPA and WEPAN are cognizant of these issues, therefore, every several years they unite to have a joint conference. The conference brings together people engaged in similar work related to increasing the diversity of the U.S. engineering workforce.

Furthermore, in the past couple of years, program personnel have paid more attention to the interlocking dynamics of race and sex simultaneously. Clewell and Campbell (2002) warn that the race/ethnic gap between whites and Asian Americans versus Hispanics, African Americans and American Indians is quite persistent. They suggest that "improving the access of African American, Hispanic, and American Indian girls and boys to advanced mathematics and lab-based science courses taught by knowledgeable teachers" and "having a high school curriculum of high academic intensity and quality" (p. 276) are essential steps in addressing the persistent ethnic imbalance in S & E.

Brown's (2002) results of 22 qualitative interviews with Hispanic students in southern New Mexico indicates the need for schools to encourage familial support of students' aspirations in S & E.

Jayaratne, Thomas, and Trautman (2003) found that there were important differences in program efficacy between white versus minority participants. A careful evaluation of the University of Michigan two-week residential summer program for 8th graders, Summerscience for Girls, found that non-minority girls clearly benefited, as expected, from the program, but that the opposite was the case for the minority students. Indeed, minority girls showed a decline in self- concept, indicated less interest in science, and did not hold strong science career aspirations as reported in the final surveys.

Other researchers have examined sex differences within a particular ethnic group, an approach consistent with the concentric circles model. Eng and Layne (2002) presented a paper on U.S. Asian American engineers based on data collected by the Society of Women Engineers in 1992. Similar to other researchers, Eng and Layne show that early in Asian engineers' careers, men and women are at parity in terms of salary and work but over time, the gap between men's and women's rewards (pay, job satisfaction, work responsibility, etc.) widens. Asian American women engineers reported less satisfactory work experiences than non-Asian women engineers. Asian American engineers of both sexes reported that the "glass ceiling" limited their career advancement into managerial positions.

Quintana-Baker (2002) analyzed the nationally-representative dataset "Survey of Earned Doctorates" to describe the persistent under representation of Hispanics among among doctoral degree recipients between 1983-1997. Her research shows that Mexican Americans were the most under represented Hispanic group and that Hispanic women were slightly better represented in engineering when compared to non-Hispanic women.

Data Reporting and Aggregation

Another way that women of color are "missed" in engineering is in how data are tabulated and reported. In this paper, of course, I provide data to rectify this problem. For example, in a 2001 presentation by the Engineering Workforce Commission, the significance of attention to ethnic diversity was highlighted by showing the contrast in the ethnic composition of the U.S. population under 18 with engineering bachelors degree recipients in 2000. Table 2 shows the under representation of Hispanics and African Americans and over representation of Asian/Pacific Islanders and non-Hispanic whites among the recipients of bachelors degrees in engineering in 2000. Clearly, the message is that if the United States is to maintain a talented engineering profession, then more students from the two under represented groups must be recruited to the field.

TABLE 2
U.S. POPULATION AND BS DEGREES IN ENGINEERING BY ETHNICITY, 2000

	U.S. Population Under 18	BS Degrees, Engineering, 2000
Hispanic	17.1%	7.0%
African American	14.7%	5.4%
Asian American	3.3%	12.9%
American Indian	0.9%	0.6%
Multi-racial	3.1%	N/A
Non-Hispanic White	60.9%	74.1%

But what about sex? The data provide us with no clear understanding of how women's participation in engineering may differ by ethnicity. As I searched the usual sources it was not an entirely straightforward task to locate data that enabled simultaneous analysis of ethnicity and sex. And given the large number of non-U.S. citizens studying engineering in the United States, it is important to control for nationality in order to understand how ethnicity and sex shape the composition of engineering.

ANALYSIS: SEX AND ETHNICITY IN THE ENGINEERING PIPELINE

The NSF's "Science and Engineering Indicators, 2002" provides only one table with data disaggregated by both ethnicity and sex. Table 3 reports data collected by the Higher Education Research Institute at UCLA on first-year college students. I have reported the within sex/ethnic group percentages. For example, while 2.5% of white females reported that they planned to major in engineering, 6.7% of Asian American females indicated similar plans. In addition, consistent with the concentric circles model—which indicates that the secondary school experiences of males and females are likely to be embedded within ethnic communities—I have computed a within ethnicity sex ratio as the percentage of men divided by the percentage of women who indicated an intention to major in engineering within each of the six ethnic groups.

TABLE 3
INTENTION TO MAJOR IN ENGINEERING, FIRST-YEAR STUDENTS

	Males	Females	Ratio: Male/Female
Non-Hispanic White	15.3%	2.5%	6.1
Asian American	22.1%	6.7%	3.3
African American	15.2%	4.4%	3.4
Mexican American & Puerto Rican	16.2%	2.2%	7.4
Other Latino	15.3%	2.8%	5.5
American Indian	14.4%	3.1%	4.6

The intention to major in engineering varied by ethnicity and sex. Asian American males and females were the most likely to indicate an intention to major in engineering within their respective sex groups. Males within each of the ethnic groups were much more likely than females to indicate they intended to major in engineering. But the relative percentage of males and females varied quite a bit when you look at the ratios computed for each ethnic group. Among whites, Mexican Americans, and Puerto Ricans, males were 6-7 times more likely to intend to major in engineering while at the other end of the spectrum, Asian American and African American males were just over 3 times as likely as their female peers to intend to major in engineering.

Table 4 reports within ethnicity sex ratios for several other key locations in the engineering pipeline. Among non-Hispanic whites, the ratio of women to men is about the same at each educational stage. Among Hispanics, the ratio of men:women also did not vary substantially through the pipeline and it is interesting to note that among Hispanics receiving doctoral degrees in engineering, the ratio is lower than for any of the other five groups with Hispanic males accounting for 2.6 times as many doctoral degrees as Hispanic females.

These data indicate that for four of the groups specified in Table 4, the male:female ratio varies across the educational stages. For example, Among Asian/Pacific Islanders, males were about 3-4 times more likely than females to enroll in engineering at the bachelors and masters levels but were nearly five times as likely to receive doctoral degrees in engineering. The sex ratios were generally the lowest for non-Hispanic Blacks, indicating that for every two males a female of that race was in the pipeline at all stages until the Ph.D. when the ratio exceeded 3:1.

Figure 2 presents a graph of some of the data from Table 4. This graph indicates the sex ratios, again, within ethnicity, for the three degree levels in engineering. This figure illustrates the different experiences of women relative

to men within each ethnic group, differences that would be missed if we looked at all women as a group or all members of each of the ethnic groups.

TABLE 4
SEX RATIOS WITHIN ETHNIC GROUPS: ENGINEERING PIPELINE

	Undergraduate Enrollment (1)					
	FT, 1st Year	Total	Bachelors Degrees (2)	Graduate Enrollment (3)	Masters Degrees (4)	Doctoral Degrees (5)
Non-Hispanic White	4.94	4.73	4.86	4.34	4.45	4.98
Asians/Pacific Islanders	3.63	3.34	3.47	3.06	2.91	4.90
Non-Hispanic Black	2.03	1.98	1.90	2.04	1.93	3.16
Hispanic	3.25	3.27	3.36	3.25	3.53	2.57
American Indian	3.23	2.97	4.40	2.61	5.75	4.96
Temporary Residents	5.44	4.69	6.39	4.54	4.32	7.06

Source: All raw data were taken from the National Science Foundation publication *Women, Minorities and Persons with Disabilities in Science and Engineering, 2002.*

Specific tables: (1) Appendix Table 2-12, 1999

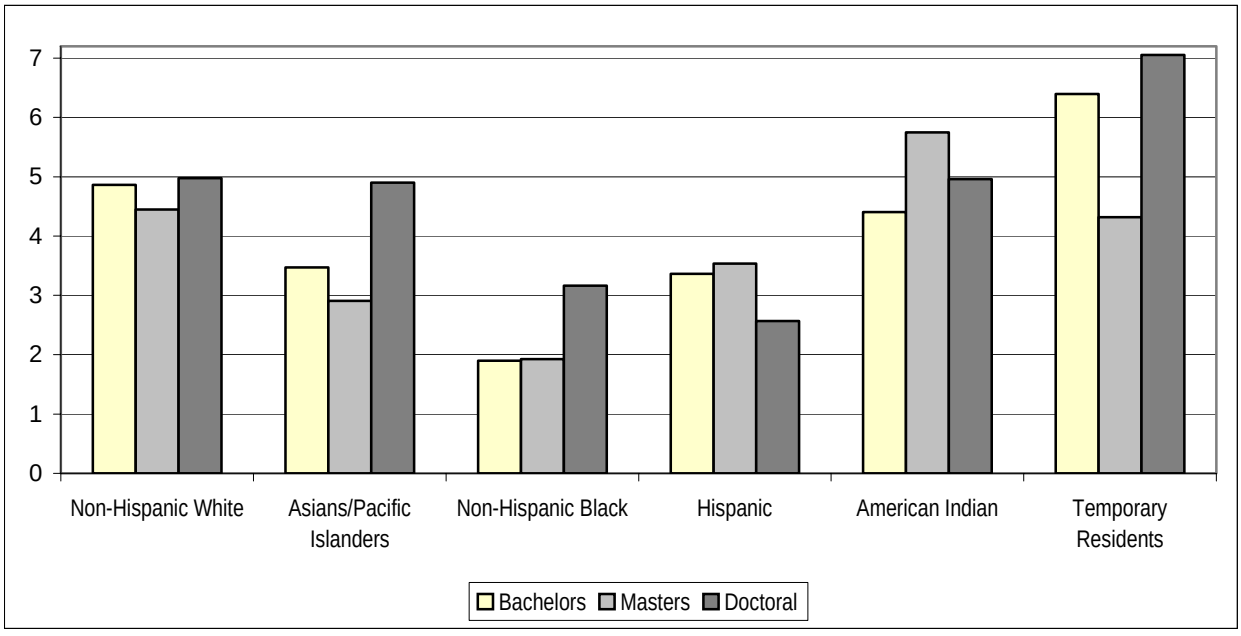
(2) Appendix Table 3-17, 1998

(3) Females: Appendix Table 4-8, Males: Appendix Table 4-9 (1998)

(4) Females: Appendix Table 5-4, Males: Appendix Table 5-5 (1998)

(5) Appendix Table 5-7 and Table 5-17 (1999)

FIGURE 2
SEX RATIO: DEGREE STAGES IN THE ENGINEERING PIPELINE, BY RACE/ETHNICITY



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