BEING DIFFERENT: WOMEN OF COLOR IN ENGINEERING

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Abstract — *Statistics on women in engineering make no distinction based on race/ethnicity. When that distinction is made, women of color are an even greater minority than women in general. Just as being female poses certain barriers in the pursuit of science, technology, engineering and math (STEM), women of color surely face additional barriers. Little research has been done to effectively design engineering programs to recruit and serve women of color. We will present current statistics on women of color in STEM fields. Through evaluating current outreach programs and university climates we will show the importance of creating an approach more inclusive for women of color. Just as there are cultural differences between races, there are differences between women of different races. Finally, we will provide recommendations for the design of outreach programs and WIE, WISE, WESP at the university level that cater to the needs of women of color.*

Index Terms — minority women, outreach programs, recruit, women of color

INTRODUCTION

Diversifying the work force has become very important in today's global network. Nowhere is this more obvious than in fields that require strong preparation in science, technology, engineering, and mathematics (STEM). Our colleges and universities are not producing enough technically trained professionals to keep pace with the jobs being created [1]. In order to diversify the workforce, we must train and educate a diversified classroom. How do we get a diversified population of students into the classroom? Why do they not choose engineering as their field of study?

Prior to 1972, the year in which both the Equal Employment Opportunity Act and Title IX of the Education Amendments were passed, women never comprised more than one percent of engineering graduates annually [2]. Fortunately, some progress has been made. During the 2000-2001 year, women contributed to 20.1% of the total engineering degrees [1]. The 1970's also marked a rapid increase in minority graduates, both male and female, in engineering. This increase was a result of nation wide efforts to recruit more women and minorities into the science, math, engineering, and technology fields. Of these three groups (women, minority men and minority women), minority women have made the least progress. In order for women and minorities to attain parity, attention must be specifically focused on minority women as a separate category. For the purposes of this paper, minority women will refer to African Americans, Hispanics, and Native Americans. Nonminority women will refer to all other population groups.

STATISTICS

Participation rates for engineering do not distinguish minority women as a separate classification. In order to find the statistics, one has to either separate them from their male counterparts or separate them from all women. When that is done, minority women have the lowest participation rates in engineering.

In the following sections of the paper, we present the statistics of minority women; comparing them with their male peers and non-minority women [1].

TABLE 1 shows the statistics for minority women and nonminority women in engineering (Bachelors degrees) from 1977 through 2000.

TABLE I
WOMEN ENGINEERING GRADUATES – BACHELOR DEGREES

Year	Minority Women(Percent)	Non-Minority Women (Percent)
1977	0.3	4.1
1981	0.8	9.4
1985	1.1	13.3
1989	1.7	13.4
1993	2.3	13.6
1997	3.2	15.1
2000	3.6	16.8

Although the percent of minority women increased by a factor of 12 in the past 25 years, minority women still remain a small fraction of engineering graduates.

The National Action Council for Minorities in Engineering (NACME) in its 1992 research letter [3] measures the level of participation in engineering relative to the population distribution (i.e. the percentage of college-age population in that year). NACME also devised a new parameter called Engineering Participation Factor (EPF). EPF for a particular group in the graduating class, EPF_g, is the ratio of the percentage of engineering graduates to the percentage of college-age population. An EPF of 1 implies exact parity (i.e., participation in engineering is comparable with the population). When EPF is less than 1, the inverse is

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the under representation factor (URF). An EPF greater than 1 is a direct measure of overrepresentation.

Table II presents the percentage of graduates, percentage of college-age population, and EPF_g for the various population groups.

TABLE II
EPF FOR DIFFERENT POPULATION GROUPS

Population Group	Graduation (Percent)	College-age Population (Percent)	EPF_g
Minority Women	3.6	15.5	0.232
Nonminority Women	16.8	33.3	0.504
Minority Men	8.9	16.9	0.526
Nonminority Men	70.5	34.1	2.067

As the table illustrates, all population groups, except nonminority men, are below parity. The under representation factor (URF), which is the inverse of the EPF, is 4.3 for minority women, 1.9 for non-minority women, and 1.9 for minority men.

In the year 2000, minority women constituted 15.5% of the college-age population, but were only 3.6% of the bachelors' degrees, 1.6% of the masters' degrees and only 0.8% of the doctoral graduates.

Contributors to Under-representation

These low numbers persist despite a number of science, mathematics and engineering advancement programs for women and minorities developed and implemented over the past 30 years.

Programs that are designed for women often tend to ignore the differences among women from different racial/ethnic and socioeconomic backgrounds. Programs that reach out to minorities often overlook the needs of women. Cultural differences between the sexes are thought to be non-existent, unimportant, or divisive [4]. The circumstances that result from disregarding the specific issues faced by minority women are exacerbated by the myth that, as members of two affirmative action categories, they have a distinct advantage [5].

Successful Institutions

The institutions that are successful at graduating minority women graduates have to be separated based on the ethnicity of the women for the following reasons:

- There is no equal distribution of all three groups of women in any college. Each is dominated by a particular group. For example, an institution successful at graduating African-American women is generally not also successful with the Hispanic women or Native American women.
- Of the three ethnic groups (African-American, Hispanics, Native American), African-American women do better than the other two, followed by Hispanic women and Native American women. So, if one just takes the top 20 universities graduating minority women, a majority of these top 20 universities would be African-American graduating universities and there would not be any universities that graduate Native American women.

The universities that are successful in graduating minority women usually fall under one or both of the following categories.

- These universities are located in states that are considerably populated by minorities. So it is natural that these universities graduate more minority women.
- These universities are either Historically Black Colleges or Universities (HBCU) or are members of Hispanic Association of Colleges and Universities.

In order to better understand the strategies and intervention programs effective in traditional settings, the universities that fall under either or both of the two categories (listed above) are eliminated.

In the case of Table III, the institutions included are in states with less than 6 percent of the African-American population. For Table IV, the institutions eliminated are in states with more than 7 percent of the total Hispanic population. For Table V, the institutions included are in states with less than 1 percent of the total Native American population. After removing institutions with these advantages, Tables III, IV and V list the top five universities successful in graduating each minority women group.

TABLE III
TOP FIVE UNIVERSITIES RANKED BY NUMBER OF AFRICAN-AMERICAN WOMEN GRADUATES, 2001

University	Percent of Minority women graduates
Massachusetts Institute of Technology	15:660 = 2.3
Tufts University	5:196 = 2.6
Colorado School of Mines	3:359 = 0.8
Brown University	3:79 = 3.8
Arizona State University, Main	2:427 = 0.5

TABLE IV
TOP FIVE UNIVERSITIES RANKED BY NUMBER OF HISPANIC WOMEN GRADUATES, 2001

University	Percent of Minority women graduates
University of Michigan at Ann Arbor	12:1036 = 1.2
Massachusetts Institute of Technology	10:660 = 1.5
Georgia Institute of Technology, Main Campus	10:1169 = 0.9
Carnegie Mellon University	6:301 = 2.0
Virginia Polytechnic Institute and State University	5:961 = 0.5

TABLE V
TOP SEVEN UNIVERSITIES RANKED BY NUMBER OF NATIVE AMERICAN WOMEN GRADUATES, 2001

University	Percent of Minority women graduates
Massachusetts Institute of Technology	4:660 = 0.6
University of Missouri – Rolla	2:498 = 0.4
University of Florida	2:749 = 0.3
Texas A&M University, Main Campus	2:895 = 0.2
Kansas State University	2:279 = 0.7
Georgia Institute of Technology, Main Campus	2:1169 = 0.2
Drexel University	2:333 = 0.6

One common observation not listed in the tables is that as the number of minority women graduates decreases, the number of universities representing that number of graduating women increases. For example, in the case of African-American women, two universities graduate 3 each while 24 universities graduate just one African-American woman. The numbers are similar in the case of the other two ethnic groups.

DISCUSSION

As pointed out in the previous section, institutions in states with a large minority population and/or institutions designed to serve those populations (such as HBCUs and members of Hispanic Association of Colleges and Universities) do relatively well in recruiting women of color into their science and engineering programs. Likely, there is a natural draw to those colleges and universities that is not necessarily due to effective recruitment strategies. If we consider, then, all other institutions that do not fall under these categories, statistics suggest that minority women face considerable barriers. In addition to the challenges faced by nonminority women, minority women encounter cultural barriers. Consequently, effective programs need to be sensitive to cultural differences in addition to gender differences well documented in the literature. As Senator Ron Wyden pointed out, "before Title IX, one in 17 girls in school played sports. Now it is one in 2.5. This country needs that kind of progress in math, science, and technology. But it will not happen as long as subtle and not-so-subtle discriminations persist in our educational institutions." [6]

At what point in the educational system does the problem begin? Where do we start evaluating what changes need to occur? There is plenty of evidence that girls begin to lose self esteem and self confidence starting at the middle school level. Sometimes girls excel in their math and science classes, but are not encouraged equally and lose interest. Believing that math and science are male domains, boys sometimes take over classrooms, eventually silencing the girls. The competitive style often embedded in the "race to be first" found in science and math cultures also alienates girls, who often prefer cooperative styles of interacting. Thus, girls often lose interest, not because they can't succeed, but because they are not drawn to the climate in math and science classrooms. Once girls lose interest, it is still possible to draw them back. A reintroduction into science and engineering fields can re-spark their interest and get them re-involved in these areas [7]. For example, outreach programs can be designed to allow women to explore science and engineering in more cooperative and non-competitive environments. Another example would be embedding science and engineering concepts into contexts that are more interesting to girls. Environmental concerns or the application of science and engineering to human problems have both proven to be effective in re-sparking girls' interests.

It is clear that educators are in an important position in the development of girls and their interest in science and math. Many times over, minority students who do well in these areas attribute their successes to their teachers – those who care about the students, recognize cultural differences, and create a classroom environment more inclusive of all races and genders. Referred to by Lowry and Brickhouse as "border crossing," those teachers that can recognize, understand AND incorporate an understanding of diverse cultures into their classroom will have the most success [9]. There may also be a need to consider differing learning styles within cultures. In addition, minority girls often assume that they have to blend in with their nonminority classmates in order to succeed. To combat those effects, it is important to keep familiar environments intact and be careful to not force cultural changes on minority students in the learning environment. [8] [9] [10] [11]

However, it is not just about getting or keeping girls interested in science and math. The expectations of boys, parents, teachers and institutions who influence girls need to change. Boys need to recognize and respect the different interests and strengths girls bring to math and science. Parents need to encourage their daughters as well as their sons to pursue careers in engineering and science. Teachers and institutions need to provide more inclusive classroom environments. Much like the movement of women into sports, if the stage is set to expect minority women to be scientists and mathematicians, then we will make progress toward closing the gap.

What are some important considerations when designing or improving outreach programs? Combine science and engineering with every day activities that girls already participate in. For example Sisters In Sport Science (SISS), a program for minority girls, introduced science and engineering concepts through sports. As indicated in some of the early data collected from this program, there was a demonstrated increase in the participants' interest within science and engineering which lead to greater achievement in math and science in school [9]. Another example introduced Hispanic girls to engineering and science through out the summer where they attended conferences, math/science sessions and other tours or visits which demonstrated careers in science and engineering. Upon their return to school, their grades in math and science improved

as well as their scores on standardized math tests [12, pg. 130].

Role models and family involvement has also proven to be effective. Especially in the consideration of Hispanics, the more the parents can participate and understand what their daughters are doing, the more likely those girls will be encouraged and supported toward science and engineering by family [11]. For example, workshops can include an opening and closing activity that enables parents to see what their daughters have learned. Another example shows that in order for Hispanic girls to participate in a high school program GREATS (girls really enjoy advanced technical skills), "recruitment meant selling the program to the girl's parents, any of whom believed that a woman's place is in the home, a future that did not call for advanced computers classes." Once the parents were convinced that this was a viable area for their daughters, the program took off and was far more successful than anticipated [12, pg. 134].

At the college level it has become apparent that women students respond well to programs involving the community. For example, Engineering Projects In Community Service (EPICS), a program offered from Purdue University drew women participants in from Electrical & Computer Engineering, Mechanical Engineering and Computer Science (no data indicated racial diversity of the women involved). The program coordinators hypothesized that because of the community involvement designed into the program, "girls liked the value of the program – that it provided multidisciplinary teamwork, communication, and engineering in the context of community involvement – that is more appealing to female students... It therefore appears that EPICS, with its focus on engineering in context and strong emphasis on teamwork, communication, personal growth, and commitment, is proving an effective vehicle for encouraging women in engineering and computer science." [13]

Another example was found at Carnegie Mellon University within their efforts to recruit more women in their School of Computer Science. The Associate Dean of the undergraduate program deemed programming experience unnecessary as a requirement to admission. After adjusting this requirement and changing the interview process to include more "non-academic factors" such as leadership experience and community involvement, trends began to shift in favor of women. Admissions statistics indicated a steeper rise in women applicants as well as an increase in women accepted in the CMU computer science program. High SAT scores for entering students were not sacrificed and there was a marked increase in students' outside achievements as well as personal attributes. Since the initiation of this new application and admission process, CMU's retention efforts have focused on mentoring programs and community involvement [14].

CONCLUSION

More research needs to be done regarding recruitment and retention of minority women in science and engineering especially at the college level. Based on our findings, locating specific data that would indicate the success of college programs that encourage and support women minority students has been problematic. Whether the insufficient data is due to lack of research or an inability of locate the information, effort should be made to improve accessibility and then to evaluate how women and minority programs are doing.

On a similar note, the statistical findings within this paper do not necessarily indicate that the top universities listed are making great strides towards reaching parity. A combination of efforts should prove to effectively recruit and retain minority women in all geographic locations.

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