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Striving Toward Equity: Underrepresented Minorities and Mathematics

On the enthusiastic recommendation of several people who heard Mark Petersen's luncheon address at Diversity Day 2004 (SIAM Annual Meeting, Portland, Oregon), SIAM News *is pleased to run a two-part article based on the talk. In the first part, which appears in the March 2005 issue, Petersen and his co-authors set the statistical stage (with a sidebar on the situation for women in the sciences); in the second part, scheduled for the April issue of* SIAM News*, they consider approaches and programs at all educational levels that have achieved some success in remedying the inequities described here. Eventually,* SIAM News *will post a more extensive version of the entire article on the Web.*

By Mark R. Petersen, Barbara E. Kraus, and Thomas L. Windham

The numbers of underrepresented minorities (URMs) graduating with degrees in the natural sciences and engineering (NS&E) in the U.S. have increased dramatically over the last twenty years. Bachelor's degrees were awarded to 12,500 URMs in 1980, and to 28,400 in 2001. The number of doctoral degrees also increased, from 240 in 1980 to 751 in 2002. These increases are a welcome and laudable achievement, but graduation rates must be evaluated in the larger context of representation per population relative to other groups. In this two-part article, we compare per population graduation rates for URMs and whites in several disciplines, discuss studies of the causes of these discrepancies, and then review recommendations by university professors on improving the odds for URM students in mathematics courses.

In this article, the term "underrepresented minority" refers to demographic groups (African American/black,* Hispanic, and American Indian/Alaska Native) whose populations have historically experienced difficulty gaining access to various academic disciplines, and continue to be underrepresented in those fields. We do not include foreign nationals or Asian Americans among URMs, and we include as "natural sciences" mathematics, computer science, biology, and physical sciences (physics, chemistry, astronomy, and earth science), but not social sciences or psychology.

The Statistics

To compare per population graduation statistics for URMs and whites, we constructed two "parity ratios":

$$\text{bachelor's parity ratio} = \frac{\#\text{ URM bachelor's degrees/24-yr-old URM population}}{\#\text{ white bachelor's degrees/24-yr-old white population}}$$

$$\text{doctoral parity ratio} = \frac{\#\text{ URM doctoral degrees/\# URM bachelor's degrees 8 yrs prior}}{\#\text{ white doctoral degrees/\# white bachelor's degrees 8 yrs prior}}$$

For a bachelor's parity ratio of 1.0, URMs and whites would receive, per population, the same number of bachelor's degrees. The 24-year-old age bracket was chosen to represent the average age at college graduation.

Despite the growth in the numbers of bachelor's degrees awarded to URMs in previous decades, the bachelor's parity ratio for NS&E degrees has grown slowly, from 34% in 1980 to 43% in 2001. In other words, in 2001, on a per population basis, URMs received 43% as many NS&E bachelor's degrees as whites did. Figure 1 shows the bachelor's parity ratio by discipline.

Given the increasing number of bachelor's degrees awarded to URMs, why is the bachelor's parity ratio rising so slowly? The explanation lies partly in demographic changes among

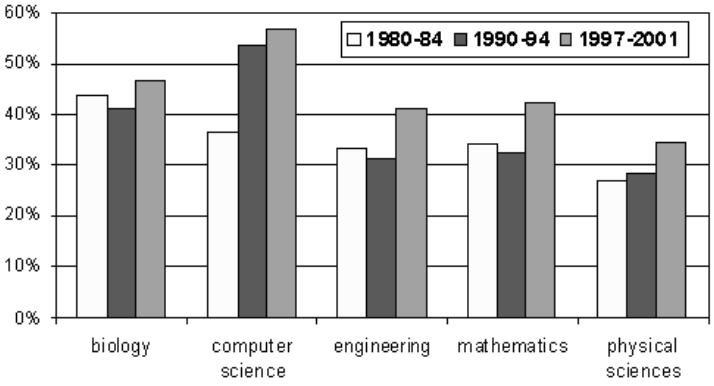

Figure 1. *Bachelor's parity ratio by field for U.S. citizens.*

*The word "black" is used instead of African American throughout this paper. This conforms to the racial/ethnic classifications used by both NSF and the U.S. Census Bureau.

24 year olds: The population of white 24 year olds dropped precipitously in the 1980s and 90s, while the corresponding URM population grew slowly (Figure 2). An NS&E bachelor's parity ratio of 1.0 would have required 37,300 URM bachelor's degrees in 1980 and 64,800 in 2001. (The actual numbers were 12,500 in 1980 and 28,400 in 2001.) Because of population changes, equal representation for URMs is a moving target.

In constructing the doctoral parity ratio, we wanted to answer the following question: In a particular group, how many bachelor's degree recipients go on to receive PhDs? Taking eight years as the average time between bachelor's degree and PhD completion, we divided the number of doctoral degrees conferred by the number of bachelor's degrees conferred eight years earlier. This statistic does not exactly answer our question, as some people change fields for their doctorates, but it is a close proxy. For a doctoral parity ratio of 1.0, the same percentages of URM and white bachelor's degree recipients would go on to receive PhDs.

The NS&E doctoral parity ratio increased from 53% in 1985 to 68% in 2002. Per population, in other words, in 2002 URMs received 68% as many bachelor's degrees as did their white counterparts. Figure 3 shows the doctoral parity ratio for several disciplines.

Asian Americans have a much greater representation in NS&E than do whites. Per population, Asians receive 2.6 times as many NS&E bachelor's degrees as do whites, and nearly 50% more Asian bachelor's degree holders receive PhDs than do whites.

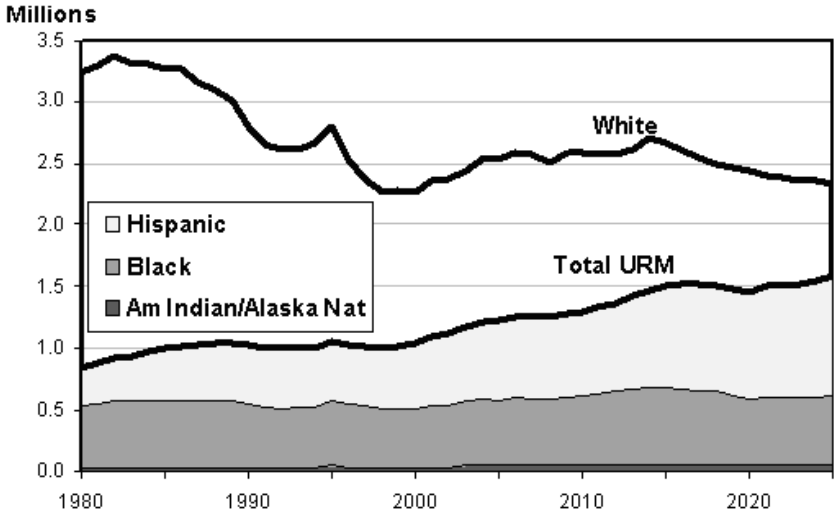

Figure 2. *Population of 24 year olds by demographic group in the United States. Data for 2001 to 2025 reflects the mid-range prediction of the U.S. Census Bureau (http://www.census.gov/popest).*

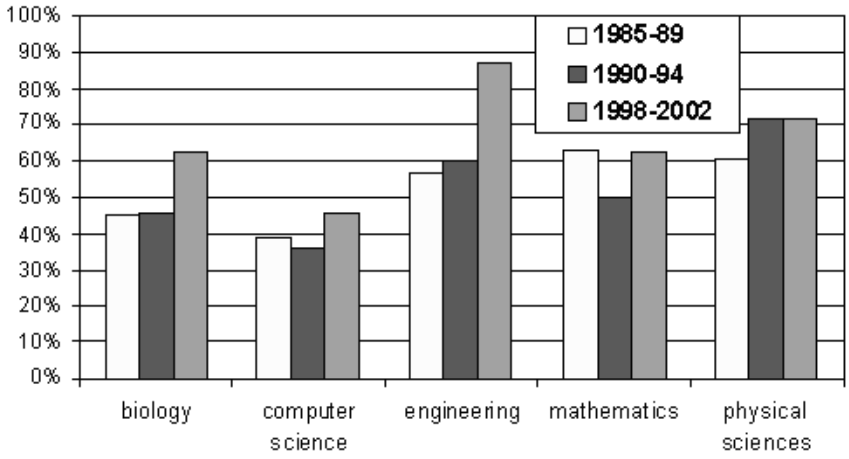

Figure 3. *Doctoral parity ratio by field for U.S. citizens.*

Presenting the statistics in this way reveals a double-filtration system on the path to the PhD: Fewer URMs receive bachelor's degrees per population, and then fewer URM bachelor's recipients go on to earn PhDs. This is not the case in social sciences and psychology, where the bachelor's parity ratio is 55–60% but the doctoral parity ratio is near 100%. Promoting URM success in NS&E, therefore, requires emphasis on both undergraduate programs and the transition from a bachelor's degree to graduate school (to be discussed in the second part of this article).

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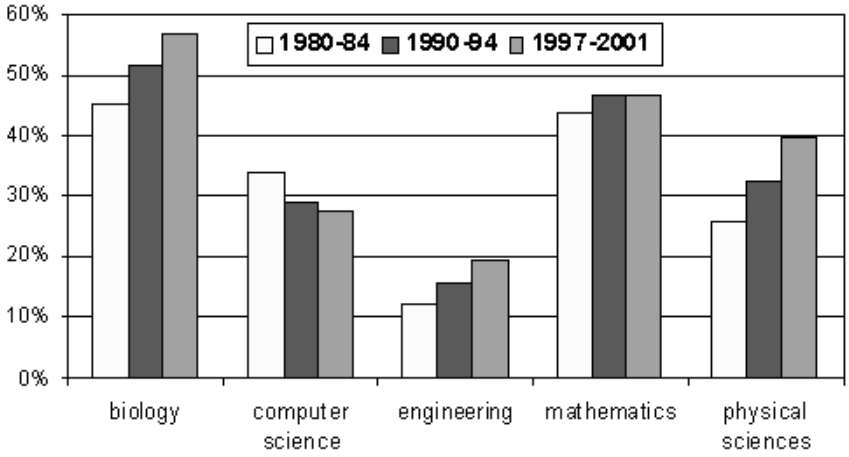
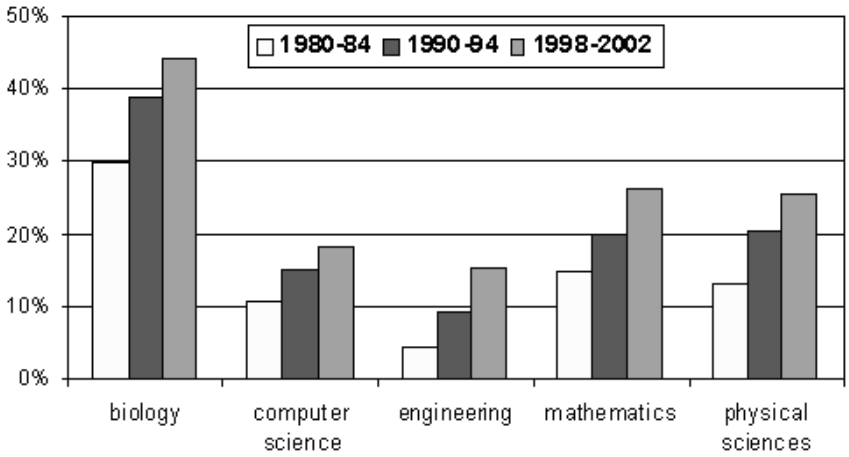
Women in the Sciences and Engineering

The fraction of women graduating with NS&E degrees varies greatly by field, and has been steadily increasing in nearly all fields. Notably, mathematics has had a much higher percentage of undergraduate women than engineering or the physical sciences. Even in 1977, the first year that such data was recorded, 42% of undergraduate mathematics degrees were awarded to women.

Among URMs, the fraction of women in NS&E is much higher than among the general population. In 2001, for example, 55% of African American recipients of bachelor's degrees were female, compared with 40% for all racial groups. Nevertheless, because overall URM numbers are much lower, URM women are still underrepresented per population when compared with white women.



Percentage of female bachelor's degree recipients, by field.



Percentage of female doctoral degree recipients, by field.