Doctorate Degrees in Mathematics Earned by Blacks, Hispanics/Latinos, and Native Americans: A Look at the Numbers

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Introduction

Many within the U.S. mathematics community have a sense that Blacks, Hispanics/Latinos, and Native Americans are underrepresented in earning doctorates in the mathematical sciences. That is, these ethnic groups do not earn doctorates at rates comparable to the percentage of the population that they comprise. But what is the extent of the underrepresentation? What type of increases are necessary to bring these groups to equitable representation in mathematics? As these groups' representation in the general population increases, is there reason to be concerned about the rate at which they participate in mathematics?

Our purpose here is to present and analyze National Science Foundation (NSF) and U.S. Census Bureau data to study the questions posed above. For the remainder of this article we will use BHNs to refer to Blacks, Hispanics/Latinos, and Native Americans, and the term *underrepresentation* (unless otherwise described) will be used only to refer to the underrepresentation of BHNs in earning doctorates in the mathematical sciences.

The Data

We begin with a few words about the data. The NSF publishes its data on science and engineering doctorate degrees for year n on or after October of year $n+1$ and its data on the ethnicity of science and engineering degree recipients for year n on or after August of year $n+2$. In this article we cite the latest NSF published data [3], [5].[1]

Table 1 gives the ethnic breakdown of the doctorate recipients in the mathematical sciences in the U.S. during the past ten years, the respective percentages of the degrees earned by U.S. Citizen/U.S. Permanent Residents (USC/PR) that these represent, the total degrees earned by citizens and permanent residents, the percentage of total degrees that these represent, and the number of total degrees.

One answers the underrepresentation question posed in the introduction by comparing the percentages in Table 1 with the current ethnic makeup of the U.S. population. For analysis, we also compare the data in Table 1 with the projected demographics of the U.S. population in the year 2025 [9], [10]. These comparisons are contained in Table 2. The table shows that the underrepresentation is significant: *Although BHNs represent one quarter of the U.S. population, they have earned less than 5% of the doctorate degrees in the mathematical sciences.* It also shows that if current trends continue, the underrepresentation will become much worse for Hispanics/Latinos as they continue to increase their representation in the total U.S. population.

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[1] *The AMS publishes its data on mathematics doctorate degree recipients based on academic years instead of calendar years. Its 2002–03 preliminary data is available [6], so if we had chosen to use AMS data, we could have included "one more semester's worth" of doctorate data. We decided to limit ourselves to NSF data.*

Table 1. U.S. Mathematical Sciences Doctorates 1993–2002: Ethnicity of Recipients

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	'93–'02
Asian/Pac. Isl.	79	142	207	140	97	71	56	70	48	29	940
% of USC/PR	13.4%	21.6%	26.8%	21.6%	15.4%	10.6%	9.3%	12.2%	9.2%	6.6%	15.4%
Black	8	11	5	8	7	16	12	14	19	14	114
% of USC/PR	1.4%	1.7%	0.6%	1.2%	1.1%	2.4%	2.0%	2.4%	3.6%	3.2%	1.9%
Hispanic/Latino	16	13	15	11	20	27	15	15	15	12	159
% of USC/PR	2.7%	2.0%	1.9%	1.7%	3.2%	4.0%	2.5%	2.6%	2.9%	2.7%	2.6%
Native Amer.	1	2	2	1	1	3	1	2	2	3	18
% of USC/PR	0.2%	0.3%	0.3%	0.2%	0.2%	0.4%	0.2%	0.3%	0.4%	0.7%	0.3%
White	476	479	535	478	479	526	506	464	428	369	4740
% of USC/PR	80.7%	72.9%	69.4%	73.8%	76.2%	78.6%	83.6%	80.8%	81.7%	83.5%	77.6%
BHN	**25**	**26**	**22**	**20**	**28**	**46**	**28**	**31**	**36**	**29**	**291**
% of USC/PR	**4.2%**	**4.0%**	**2.9%**	**3.1%**	**4.5%**	**6.9%**	**4.6%**	**5.4%**	**6.9%**	**6.6%**	**4.8%**
Tot. USC/PR	590	657	771	648	629	669	605	574	524	442	6109
% of Tot. Deg.	51.5%	58.8%	64.8%	57.8%	56.0%	56.8%	55.9%	54.7%	52.0%	48.2%	55.9%
Tot. Degrees U.S.	1146	1118	1190	1122	1123	1177	1083	1050	1007	917	10933

USC/PR = U.S. Citizen/U.S. Permanent Resident

We point out that the penultimate row in Table 1 illustrates the concern that many in the U.S. mathematics community have about the nation's ability to produce "home-grown" mathematicians. Some comments related to this concern are made at the end of this article.

Efforts to Address the Underrepresentation: Past and Present

For several decades the U.S. mathematics community has engaged in efforts to strengthen home-grown participation in graduate mathematics. Many of these efforts have centered and continue to center on undergraduate research summer programs, e.g., NSF Research Experience for Undergraduates (REUs), whose aim is to develop the skills and knowledge and thus cultivate the talent of mathematically promising undergraduates. While we know of no study that "proves" that these programs work, there seems to be a general consensus that these programs are indeed effective in contributing to the mathematical development of talented students.[2]

Unfortunately, such programs have not been successful in recruiting significant numbers of BHNs. Indeed, data collected from many mathematics undergraduate summer programs in 1999 show that only 3.8% (63 of 1,668) of the students who participated in these programs were BHNs [2].

Table 2. Ethnic Make-up of U.S. Population and Doctorate Degrees (Percentages)

	U.S. Population		Math. Sci. Doc.
	2000	2025	1993–2002
Asian/Pac. Isl.	3.8	6.2	15.4
Black	12.2	12.9	1.9
Hispanic/Latino	11.9	18.2	2.6
Native Amer.	0.7	0.8	0.3
White	71.3	62.0	77.6
BHN	**24.8**	**31.9**	**4.8**

During the past few years, there have been and there continue to be efforts within the U.S. mathematics community to address and correct the underrepresentation. At the undergraduate level these efforts also have centered on summer programs.[3] Like REUs, the primary aim of these summer programs is the cultivation of mathematical talent. Most of these programs also emphasize the development of a "road map" to graduate school as well as the establishment of a network for the programs' participants that will facilitate admissions and funding, and increase the likelihood of success in graduate programs [7], [8], [11]. Although it is too early to tell if these programs will result in a significant increase in the representation of BHNs in mathematics graduate programs, a large percentage of students who have participated in these

[2] *We comment that to verify the effectiveness of such efforts would be extremely difficult. One would need to take two groups of students with comparable mathematical promise, ambition, work ethic, etc., and have one participate in a "typical" REU and the other not. The success of the groups in graduate mathematics programs would then have to be compared years later. It is highly unlikely that such an "experiment" with proper controls could take place.*

[3] *At the graduate level there are several national fellowship programs whose funding is aimed at BHNs; these include the National Physical Sciences Consortium (NPSC), Graduate Assistance in Areas of National Needs (GAANN), Ford Foundation, and Sloan Foundation fellowships.*

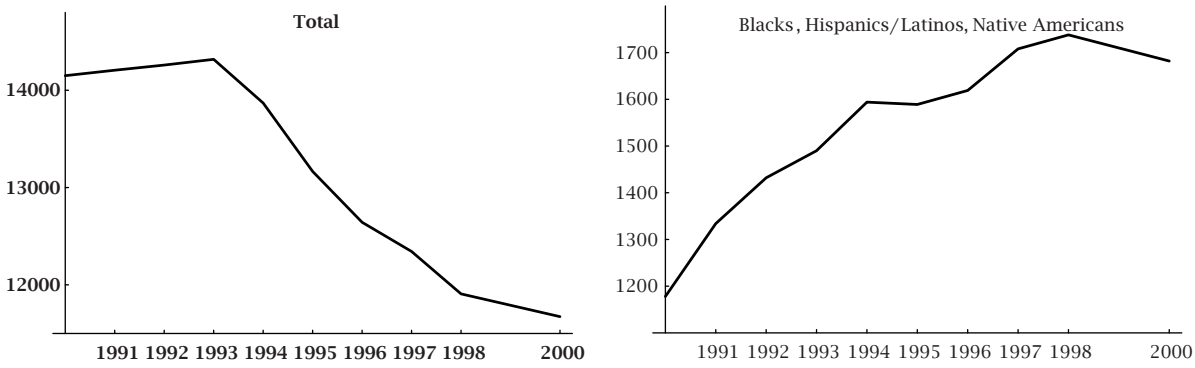

Figure 1. Mathematical Sciences Bachelor's Degrees. (The NSF did not publish 1999 data.)

programs have gone on to graduate school. For example, 20 of the 49 students who participated in the Summer Institute in Mathematics for Undergraduates (SIMU) at the University of Puerto Rico-Humacao, a program aimed at Hispanics/Latinos and Native Americans, in 1998 and 1999 went on to doctorate programs in the mathematical sciences. If we look at the yearly totals of degrees earned by members of these ethnic groups in Table 1, we see that 20 is a significant number. A couple of summer programs aimed at BHNs continue, and agencies such as the NSF and the National Security Agency (NSA) continue to have an interest in funding them; but as is explained below, a larger effort is needed if the underrepresentation is to be seriously addressed. (There are, of course, similar programs in other sciences; some information on their structure and effectiveness can be found in [1].)

Addressing the Underrepresentation: The Future

Let us suppose that we aim to solve the underrepresentation by the year 2025. How large do the yearly increases in the number of BHN doctorates have to be?

Table 1 shows that the total number of doctorates awarded in the U.S. during the past ten years has a downward trend, but for the purposes of our analysis here, we will assume that the number in the year 2025 will be 1,093 and that 611 of these degrees will go to U.S. citizens and permanent residents, the averages during the past ten years. (Extrapolating on the number of doctorates during the past ten years gives 494 doctorates in 2025; we believe this number is unrealistically too low to consider.) Using the demographic predictions of the census, the underrepresentation problem would be solved in the year 2025 if 196 or 32% of these degrees went to BHNs. During the last ten years an average of 29 degrees have been awarded to BHNs each year. In order to produce the increase from 29 to 196 degrees per year over a twenty-one-year period in a linear fashion, we would need *a yearly increase of 8 degrees per year each and every year from now until 2025*.

Will this increase happen naturally? Looking at data from Table 1, we see that during the past ten years there has been a slight upward trend in the number of degrees awarded to BHNs, but the regression line for this data gives a slope of only 1.17. Thus, it is not likely that the needed increase will happen without some sort of intervention.

Are current efforts to address the underrepresentation enough? Again, the data seems to suggest that they are not. We first note that there was a sharp increase in the number of degrees awarded to BHNs from 1996 to 1998; it is probably not a coincidence that the first major mathematics summer program for BHNs was established at the University of California, Berkeley, by Leon Henkin and Uri Treismann in 1989. The trend since then optimistically suggests that this increase was more than a spike (mostly because degrees awarded to Blacks have remained in the teens), but it is impossible that the programs still in existence would result in the long run in 8 more doctorates in year $n+1$ than in year n year after year, because these programs plainly and simply do not serve that many students.

In other words, the data suggests that if the U.S. mathematics community hopes to successfully address the underrepresentation, it needs to devise and implement a plan that will result in significantly more doctorates being awarded to BHNs year after year.

What should the plan be? An easy, perhaps sufficient-in-the-short-term answer is to have more successful summer programs for BHNs. This approach begs the question of whether or not there are enough BHNs earning bachelor's degrees in mathematics to produce an increase in doctorates. The answer to this question appears to be affirmative.

While many in the U.S. mathematics community are well aware of the serious decline in the number of bachelor's degrees in the mathematical sciences during the past decade, few are aware of

the significant upward trend in the number of such degrees being awarded to BHNs [3]. The graphs in Figure 1 show both the decrease in total degrees and the increase in degrees being awarded to BHNs.[4]

In the long-term an overarching plan for dealing with the underrepresentation is for the entire U.S. mathematics community to identify early promising BHN undergraduates and invest time, money, and energy in developing and cultivating their mathematical talent. Certainly this practice, although perhaps not a coordinated effort, has resulted in significant progress in solving the underrepresentation of women earning doctorates in the recent past. Indeed, in 1991 21.6% of doctorates in the mathematical sciences awarded to U.S. citizens/permanent residents went to women; that had increased to 30.3% in 2002 [4], [5].

We close with some remarks on the penultimate row of Table 1. From 1993 to 2002, 55.9% of doctorates in the mathematical sciences went to U.S. citizens and permanent residents. Some within the mathematics community see this as a concern, as the U.S. clearly is not able to produce enough homegrown mathematicians to satisfy its mathematical needs. The declining number of total bachelor's degrees in the mathematical sciences suggests that the country's reliance on foreign mathematical talent will increase (perhaps dramatically) in the next few years. If this is indeed a policy issue that warrants attention, then a good strategy to generate an increase in the number of U.S. citizens and permanent residents earning doctorates may be to focus more attention on BHNs studying mathematics. As indicated above, there certainly is lots of room for improvement in identifying and cultivating mathematical talent within these ethnic groups, and there are significantly more BHNs at the undergraduate level studying mathematics now than ever before. Finally, we mention that unless we address the underrepresentation issue, the demographic shifts that the nation will undergo during this century almost certainly will contribute dramatically to our dependence on foreign mathematical talent. Indeed, the U.S. Census Bureau predicts that in the year 2060, 40.7% of the U.S. population will be Black, Hispanic/Latino, and Native American [10]; what percentage of the total U.S. doctorates in the mathematical sciences will go to U.S. citizens and permanent residents if these groups continue to earn so few of these degrees?

References

[1] J. FOERTSCH, B. ALEXANDER, and D. PENBERTHY, Summer Research Opportunity Programs (SROPs) for Minority Undergraduates: A Longitudinal Study of Program Outcomes, 1986–1996, *Council on Undergraduate Research Quarterly* **21** (3) (2000), 114–119.

[2] Summer Program Survey, in *Proceedings of the Conference on Summer Undergraduate Mathematics Research Programs* (J. A. Gallian, ed.), Amer. Math. Soc., Providence, RI, 2000.

[3] National Science Foundation, Division of Science Resources and Statistics, *Science and Engineering Degrees, by Race/Ethnicity of Recipients: 1991–2000*, NSF 02-329 (Susan T. Hill), Arlington, VA, 2002.

[4] National Science Foundation, Division of Science Resources and Statistics, *Science and Engineering Doctorate Awards: 2000*, NSF 02-305 (Susan T. Hill, Project Officer), Arlington, VA, 2001.

[5] National Science Foundation, Division of Science Resources and Statistics, *Science and Engineering Doctorate Awards: 2002*, NSF 04-303 (Susan T. Hill, Project Officer), Arlington, VA, 2003.

[6] D. KIRKMAN, J. MAXWELL, and C. ROSE, 2003 Annual Survey of the Mathematical Sciences (First Report), *Notices Amer. Math. Soc.* **51** (2) (2004), 218–233.

[7] H. A. MEDINA and I. RUBIO, The Summer Institute in Mathematics for Undergraduates (SIMU) at the University of Puerto Rico-Humacao, *Proceedings of the Conference on Summer Undergraduate Mathematics Research Programs* (J. A. Gallian, ed.), Amer. Math. Soc., Providence, RI, 2000, pp. 169–180.

[8] S. TENNENBAUM, Research and Education Activities of the Mathematical and Theoretical Biology Institute at Cornell, *Proceedings of the Conference on Summer Undergraduate Mathematics Research Programs* (J. A. Gallian, ed.), Amer. Math. Soc., Providence, RI, 2000, pp. 41–49.

[9] United States Census Bureau, `http://www.census.gov/population/estimates/nation/intfile3-1.txt`.

[10] United States Census Bureau, `http://www.census.gov/population/www/projections/natsum-T5.html`.

[11] W. O. WILLIAMS, Summer Undergraduate Applied Mathematics Institute at Carnegie Mellon University, *Proceedings of the Conference on Summer Undergraduate Mathematics Research Programs* (J. A. Gallian, ed.), Amer. Math. Soc., Providence, RI, 2000, pp. 13–18.

[4] *We note that even though the trend is a very positive development, BHNs continue to be seriously underrepresented at the bachelor's-degree level. For example, in the year 2000, BHNs earned only 14.4% of the bachelor's degrees awarded to U.S. citizens and permanent residents.*