Identifying Strategies for Increasing Degree Attainment in STEM: Lessons from Minority-Serving Institutions

Laura W. Perna, Marybeth Gasman, Shannon Gary, Valerie Lundy-Wagner, Noah D. Drezner

To compete in the global marketplace, numerous reports (for example, Committee on Equal Opportunities in Science and Engineering, 2004; National Science Foundation, 2006a, 2006b; Southern Education Foundation, 2005) point to the need for the United States to increase its production of highly educated workers in science, technology, engineering, and mathematics (STEM). Although estimates suggest (National Science Foundation, 2006b) that the number of STEM-related jobs will grow faster than other jobs, the rate of bachelor’s degree production in STEM fields in the United States is now lower than that of many other nations (National Center for Education Statistics, 2007). Furthermore, the projected retirement of many current STEM workers exacerbates the need to increase the supply of STEM-educated workers (National Science Foundation, 2006b).

Differences in degree attainment in STEM fields across groups suggest that women, American Indians/Alaskan Natives, Blacks, and Hispanics...
are not only a relatively untapped resource for addressing this national economic need, but they are also less likely to realize the individual economic benefits that result from participating in this high-growth sector of the economy. Although progress has been made, these groups continue to represent a smaller share of degree recipients in science and engineering fields than of all other degree recipients (Hill and Green, 2007; National Science Foundation, 2008b). Table 4.1 shows that in 2005, women received 58 percent of the bachelor's degrees awarded in all fields, but only 22 percent of computer sciences degrees, 43 percent in physical sciences, and 20 percent in engineering (National Science Foundation, 2008b). Blacks received 9 percent of all bachelor's degrees awarded, but only 6.1 percent of the degrees in mathematics and statistics, 6.7 percent in physical sciences, and 5.2 percent in engineering (National Science Foundation, 2008b). Hispanics earned 7.9 percent of all bachelor's degrees, but only 6.8 percent of the degrees in computer sciences, 5.8 percent in mathematics, and 6.5 percent in physical sciences (National Science Foundation, 2008b). In contrast, although the Asian/Pacific Islander category masks variations in attainment across groups within this category (for example, Chinese, Hmong, Laotians), Asian/Pacific Islanders are relatively overrepresented among STEM degree recipients. In 2005, Asian/Pacific Islanders received 6.5 percent of all bachelor's degrees awarded, but 13.4 percent of the degrees in biological sciences, 13 percent in computer sciences, 10 percent in mathematics and statistics, and 13 percent in engineering (National Science Foundation, 2008b).

For reasons of global competitiveness and social justice, defined as “exploring the social construction of unequal hierarchies, which result in a social group's differential access to power and privilege . . . and the deconstruction of unjust and oppressive structures” (Lewis, 2001, p. 189), higher education institutions must do more to improve the educational attainment of groups that are underrepresented in STEM fields. One approach to achieving this goal is to explore the characteristics of colleges and universities that appear to be especially successful at promoting degree attainment in STEM for these groups. This chapter summarizes how we used this approach in a recent study (see Perna and others, 2009) and offers related recommendations for future research. But first we highlight some literature about the institutional context in which we conducted our study.

STEM at Historically Black Colleges and Universities

A first step in developing a greater understanding of how institutions may increase the conferral of STEM degrees to students from historically underrepresented groups is to identify institutions where lessons are likely to be learned. Our review of available data and research suggests that historically Black colleges and universities (HBCUs) are fruitful venues
Table 4.1. Distribution of Bachelor's Degrees Awarded by Sex, Race/Ethnicity, and Field, 2005

<table>
<thead>
<tr>
<th>Field</th>
<th>Total Number</th>
<th>Women</th>
<th>Whites</th>
<th>Asian/Pacific Islanders</th>
<th>Blacks</th>
<th>Hispanics</th>
<th>American Indian</th>
</tr>
</thead>
<tbody>
<tr>
<td>All fields</td>
<td>1,437,200</td>
<td>57.7%</td>
<td>70.2%</td>
<td>6.5%</td>
<td>9.0%</td>
<td>7.9%</td>
<td>0.7%</td>
</tr>
<tr>
<td>Agricultural sciences</td>
<td>17,111</td>
<td>51.0</td>
<td>85.2%</td>
<td>2.6%</td>
<td>2.6%</td>
<td>4.2%</td>
<td>1.0%</td>
</tr>
<tr>
<td>Biological sciences</td>
<td>67,982</td>
<td>62.2%</td>
<td>66.3%</td>
<td>13.4%</td>
<td>7.7%</td>
<td>7.3%</td>
<td>0.8%</td>
</tr>
<tr>
<td>Computer sciences</td>
<td>50,564</td>
<td>22.2%</td>
<td>59.1%</td>
<td>13.0%</td>
<td>11.4%</td>
<td>6.8%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Earth, atmospheric, and ocean sciences</td>
<td>3,959</td>
<td>41.9%</td>
<td>86.8%</td>
<td>2.2%</td>
<td>1.8%</td>
<td>3.9%</td>
<td>0.6%</td>
</tr>
<tr>
<td>Mathematics and statistics</td>
<td>14,840</td>
<td>44.6%</td>
<td>72.2%</td>
<td>10.1%</td>
<td>6.1%</td>
<td>5.8%</td>
<td>5.0%</td>
</tr>
<tr>
<td>Physical sciences</td>
<td>15,030</td>
<td>42.7%</td>
<td>71.7%</td>
<td>9.2%</td>
<td>6.7%</td>
<td>6.5%</td>
<td>0.7%</td>
</tr>
<tr>
<td>Engineering</td>
<td>66,133</td>
<td>20.0%</td>
<td>68.7%</td>
<td>13.4%</td>
<td>5.2%</td>
<td>7.5%</td>
<td>0.6%</td>
</tr>
</tbody>
</table>

Source: National Science Foundation (2008b).
of promising practices for improving the attainment of Blacks in STEM fields.

HBCUs graduate a disproportionately large number of Black STEM workers and researchers. For example, in 2005, HBCUs awarded 21 percent of all bachelor's degrees in all fields to Blacks, but 41 percent of bachelor's degrees to Blacks in biological sciences, 35 percent in computer sciences, 32 percent in mathematical sciences, 37 percent in physical sciences, and 22 percent in engineering (National Science Foundation, 2008b). About one-third of the 866 Blacks who received doctorates in science and engineering fields in 2006 earned their bachelor's degree from an HBCU (National Science Foundation, 2008a). The eight institutions that awarded the most bachelor's degrees to Black doctoral recipients in science and engineering fields between 1997 and 2006 were all HBCUs: Howard University, Spelman College, Hampton University, Florida A&M University, Morehouse College, North Carolina A&T State University, Southern University A&M College at Baton Rouge, and Xavier University of Louisiana (National Science Foundation, 2008a). HBCUs are the source of similar numbers of bachelor's degrees to Black doctorates in science and engineering as non-HBCUs after adjusting for the number of bachelor's degrees awarded in all fields nine years earlier. After this adjustment, Spelman College is the only HBCU in the top twenty-five of bachelor's degree producers of doctorates in STEM fields (ranking fifteenth).

Consistent with these descriptive reports, some quantitative analyses also show better STEM-related outcomes for Blacks who attend HBCUs than for Black students elsewhere (for example, Lent and others, 2005; Perna, 2001; Solórzano, 1995; Wenglinsky, 1997). However, despite many indicators of the success of HBCUs in promoting the STEM degree attainment of Blacks, few studies have examined how these institutions achieve such results.

**Study Description**

Building on these data and prior research, our study addressed the following guiding question: What are the characteristics, policies, and practices that promote the attainment of African American women in STEM fields at an exemplary case? We purposively selected Spelman College, one of the nation's only two historically Black women's colleges, as the exemplary case because of its consistently high performance on indicators of STEM bachelor's degree production for Black women. In 2006, Spelman awarded the fifty-seventh highest number of bachelor's degrees in all fields to Black women, but the highest number of bachelor's degrees to Black women in mathematics, third highest number in physical sciences, and fourth highest number in biological sciences (Diverse Issues in Higher Education, 2010).
To address the guiding question, we used case study methodology, which seeks to understand the contextual conditions that influence a phenomenon (Yin, 2003b) and when the phenomenon is unique (Wilson, 1979). Following the recommendations of case study experts (for example, Yin, 2003a), we used our understanding of prior research to guide data collection and analysis. We gathered data from multiple sources, including focus groups with students, faculty, and staff; institutional documents; and observations (Stake, 1995; Yin, 2003a).

Our exploratory case study sheds light on the institutional characteristics and practices that contribute to Spelman’s success in conferring STEM bachelor’s degrees to Black women. Several implications and recommendations arise from the methods used in our study. Our research confirms the utility of case study methodology in improving knowledge of the ways that successful institutions promote the awarding of STEM bachelor’s degrees to underrepresented groups. Case study methodology is certainly not without limitations. Perhaps most noteworthy, the generalizability of results to other institutions is limited since both the characteristics of the case (Spelman College) and the forces that influence the case are unique. Spelman College is unique in many ways, so some findings from this case are not transferable to other institutions (for example, large, predominantly White public universities). Nonetheless, as with other qualitative research methods, the goal of case study research is not to produce conclusions that are generalizable across institutions but to provide a richer and deeper understanding of a phenomenon (Yin, 2003b). For a phenomenon that is not well understood, such as the institutional culture, practices, and characteristics that promote the degree attainment of students of color in STEM fields, case study methodology has much to offer. (See Perna and others, 2009, for more information on the procedures we used to collect and analyze the data and ensure the trustworthiness of our findings and conclusions.)

Summary of Key Findings

The findings from our study reveal how Spelman’s institutional culture, norms, and activities contribute to its success in conferring STEM bachelor’s degrees to Black women. Some attributes are relatively unique to Spelman. For example, we found that many students chose to attend Spelman at least in part because of the institution’s well-known record of promoting the attainment of Black women in STEM fields. In other words, Spelman’s past success at awarding STEM degrees to Black women seems to be one force that promotes future success.

Although researchers will not be able to replicate this reputation and other characteristics easily, other findings likely have greater transferability to other institutions. Many Spelman women we interviewed faced the academic, psychological, and financial barriers that other research shows
limit persistence in STEM fields (for example, Lent and others, 2005; National Science Foundation, 2006b, 2006c; Steele and Aronson, 1995). But our findings suggest that at Spelman College, the potential negative impact of these barriers on the attainment of Black women in STEM fields is mitigated by institutional practices such as small class size, ease of student access to faculty offices, presence of a cooperative rather than competitive peer culture, efforts of faculty to encourage and promote students’ success in STEM fields, accessibility and use of academic support resources, and the availability and use of undergraduate research opportunities.

New Directions for Future Research

Researchers should consider using case study methods to explore the ways that institutional culture, practices, and characteristics contribute to the success of other leading producers of underrepresented racial minority graduates in STEM fields. One potentially insightful case study would examine ways that coeducational HBCUs comparatively promote the degree attainment of Black women and men in STEM fields. In our study, the purposeful selection of a Black women’s college as a single rich case combines the contribution of a women’s college with the uniqueness of a historically Black institution to help explain the attainment of African American women in STEM fields.

Future case study research should also explore ways that other minority-serving institutions may be promoting STEM degree attainment for other underrepresented minority groups. Case studies of some Hispanic-serving institutions (HSIs) may generate lessons for promoting the STEM degree attainment of Hispanics. In 2001, HSIs awarded 38 percent of all bachelor’s degrees to Hispanics (National Science Foundation, 2008b). However, HSIs awarded a disproportionate share of bachelor’s degrees to Hispanics in several STEM fields, including biological sciences (45 percent), physical sciences (46 percent), and engineering (40 percent; National Science Foundation, 2008b). Four of the five institutions awarding the highest numbers of bachelor’s degrees to Hispanics in biological and biomedical sciences in 2007 were HSIs: University of Texas, Pan American; University of Texas at San Antonio; Texas A&M University; and University of Texas at El Paso (Diverse Issues in Higher Education, 2010). HSIs would be a particularly interesting setting for STEM research because their designation is based on Hispanic student enrollment numbers rather than an institutional identity that has been historically tied to a specific racial or ethnic group (Contreras, Malcom, and Bensimon, 2008).

Similarly, although the total number of bachelor’s degrees to American Indians/Alaskan Natives is small (9,556 in 2005), our findings also suggest the potential benefits of examining the strategies used by tribal
colleges and universities (TCUs) to promote STEM degree attainment. In 2005, TCUs awarded only 1.4 percent (a total of 137) of all American Indian/Alaska Native bachelor's degrees (National Science Foundation, 2008b). In contrast, TCUs awarded a relatively large share of bachelor's degrees to American Indian/Alaskan Natives in several STEM fields, including agricultural sciences (6.3 percent) and computer sciences (2 percent; National Science Foundation, 2008b).

Another set of implications uses findings from our case study to identify topics for future research. As one example, like some other research (for example, Harper, 2006; Palmer and Gasman, 2008), we found that a supportive and cooperative peer culture may be contributing to the attainment of Black women in STEM fields at Spelman College. Therefore, future research should explore benefits and costs of encouraging a supportive rather than a competitive peer culture to the attainment of Black women and other groups, as well as the ways that institutions may promote such a culture. The institutional belief that Spelman “sisters” should help each other succeed in STEM courses is a clear characteristic of the institutional culture. Therefore, future research also should explore if and how institutions without this same institutional culture may encourage a more supportive peer culture.

As a second topic for future research, the findings from our case study point to the benefits of Spelman's system of providing early alerts to faculty and staff about students' academic challenges. Future research should further explore the benefits and disadvantages of early warning systems. In particular, we need more information about how to encourage faculty and staff to work together to share information about students. Several recent articles in medical education suggest that at least some program directors do not share information with faculty because they worry that information about students' academic challenges may be inappropriately used (Lederman, 2008).

We also recommend exploring more deeply the role of faculty in promoting the attainment of students of color in STEM fields. Findings from our case study imply that faculty behaviors, particularly with regard to teaching practices and interactions with students, promote the attainment of Black women in STEM fields. Additional research is required to better understand how faculty may most effectively promote learning for historically underrepresented groups in STEM fields and the types of interactions that best promote student success. Such research might explore ways to transform teaching in introductory courses to boost students' achievement rather than weed them out. Researchers should also consider the barriers that may limit faculty attention to improving STEM teaching and advising, such as tenure and promotion processes that emphasize research productivity over other activities.

Findings from our case study and related research could inform the design of experiments that test the effects of particular strategies and...
programs on STEM degree attainment for historically underrepresented groups. For instance, like other studies (for example, Maton, Hrabowski, and Schmitt, 2000), our research exposed the value of providing students in STEM fields with paid summer internships and undergraduate research experiences. Paid internships may enable students to secure the resources needed to finance their STEM education and enhance their academic experiences (Perna, Cooper, and Li, 2007). Summer internships and undergraduate research experiences may also produce other benefits, such as reducing minority students’ sense of marginalization and promoting their integration into the STEM community; enabling students to make meaningful contributions to the field; and socializing students to the norms of science and science careers (Hunter, Laursen, and Seymour, 2007).

While shedding light on ways these programmatic experiences may improve students’ STEM-related outcomes, researchers cannot use case study methods to identify whether these experiences cause improved outcomes. To identify a causal relationship, an experimental design with randomized assignment of students to control and treatment groups is required. Only through randomized assignment can research control for the effects of students’ self-selection into such experiences. Some researchers may be reluctant to use a randomized controlled trial because of ethical concerns about denying what some consider a worthwhile treatment. Nonetheless, if the effects of the treatment are uncertain and resource constraints limit the availability of the treatment for all eligible students, then this type of experimental design may be not only possible but also worthwhile.

Another productive type of research that builds off the findings from our study would examine changes over time in the contribution of institutional culture, programs, and characteristics to the STEM attainment of underrepresented groups of students. Our case study reveals nothing about how the needs of students of color in STEM change as they progress from their first year of study through bachelor’s degree completion and onward to STEM graduate programs and careers. A longitudinal design might generate insights into how HBCUs contribute to the production of Black STEM faculty, an outcome that researchers (for example, Perna, 2001) have described but have not fully explained in prior research.

Our final recommendation is for researchers to design a study that compares the experiences of students like those who participated in our study (Black women attending a single-sex HBCU) with others who are underrepresented in STEM fields at colleges and universities across the United States. Using a survey design, such research could measure the magnitude of achievement enablers and pervasiveness of barriers that limit attainment in STEM fields. Researchers could also employ this design in quantitative analyses that examine the relationship between particular
institutional characteristics and strategies and students’ STEM-related outcomes after controlling for other variables.

Conclusion

Colleges and universities can and must do more to improve STEM degree attainment. As indicated throughout this chapter, studies of successful minority-serving institutions can generate useful insights into the ways that other institutions may promote the degree attainment of students of color. Case studies of successful institutions are also a source of promising new directions for future research.

References


LAURA W. PERRNA is a professor of higher education at the University of Pennsylvania, Graduate School of Education.

MARYBETH GASMAN is an associate professor of higher education at the University of Pennsylvania, Graduate School of Education.
SHANNON GARY is associate dean of Pennoni Honors College and director of the honors program at Drexel University.

VALERIE LUNDY-WAGNER is a postdoctoral fellow at New York University.

NOAH D. DREZNER is an assistant professor of higher education at the University of Maryland, College Park.