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The Contribution of HBCUS to the Preparation of African American Women for Stem Careers: A Case Study

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Abstract This study uses case study analysis to explore the ways that Spelman College, a historically Black women's college, promotes the attainment of African American women in STEM fields. Although limited to one institution, the findings shed light on the ways that institutional characteristics, policies, and practices may mitigate the barriers that limit attainment of African American women in STEM fields. Drawing on the findings, the paper concludes with recommendations for improving policy and practice as well as recommendations for additional fruitful research.

Keywords Equity · STEM · Black colleges · Institutional practice

> I had to learn very early not to limit myself due to others' limited imaginations. I have learned these days never to limit anyone else due to my limited imagination.
>
> – Mae Jemison, First African American Female Astronaut, September 12, 1992

Numerous reports assert that the United States must increase its production of highly-educated workers in science, technology, engineering, and mathematics (STEM) fields in order to be competitive in the global marketplace (e.g., Committee on Equal Opportunities in Science and Engineering 2004; National Science Foundation (NSF) 2006a, b; Southern Education Foundation 2005). The share of bachelor's degrees awarded in science in the United States is smaller than in several other industrialized nations. For example, in 2003, only 18% of all bachelor's degrees awarded in the United States were in life sciences, physical sciences, mathematics, computer science, and engineering fields, a smaller percentage than in Australia (24%), Austria (27%), Belgium (25%), Czech Republic (30%), Finland (27%), Germany (30%), Ireland (27%), Italy (26%), Korea (38%), Mexico (28%), Spain (25%), Switzerland (22%), Turkey (22%), and the United Kingdom (31%) (National

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Center for Education Statistics 2007). NSF (2006b) states that growth in science and engineering jobs will outpace job growth in other fields, with projected increases by 2012 of 26% and 15%, respectively.

In the context of this projected demand for additional science and engineering workers, the expected retirement of many current STEM workers, and the need to foster equity in career opportunities, increasing the preparation for science and engineering careers of students from traditionally underrepresented groups is especially important (NSF 2006b; Southern Education Foundation 2005). Although progress has been made, African Americans continue to be underrepresented among degree recipients in STEM fields. Between 1995 and 2004 the number of bachelor's degrees awarded to African Americans in natural and physical sciences, mathematics, and engineering fields increased by 34% (Hill and Green 2007). Even with this growth, however, African Americans continue to represent a smaller share of bachelor's degree recipients in science and engineering fields than of all bachelor's degree recipients (5.6% vs. 7.0% in 2004, Hill and Green 2007). Moreover, the representation of African Americans declines as degree level increases. In 2004, African Americans received only 3.3% of all master's degrees awarded in science and engineering (up from 2.7% in 1995) and only 1.9% of all doctoral degrees in these fields (up from 1.3%, Hill and Green 2007). The low level of doctoral degree production undoubtedly contributes to the low representation of Blacks among the nation's faculty in STEM fields. In fall 2003 Blacks represented only 4.9% of all full-time faculty at four-year institutions in engineering and 3.4% in natural sciences (Cataldi et al. 2005).

Like other racial/ethnic groups, the representation of Black women in most STEM fields is substantially lower than the representation of Black men. The largest gender gaps are in engineering, where Black women received only 36% of all bachelor's degrees awarded to Blacks in engineering in 2001 (NSF 2004). Table 1 shows that, in 2001, African American women received 66% of the bachelor's degrees awarded to African Americans in all fields, but only 36% of the bachelor's degrees awarded to African Americans in engineering, 46% in computer sciences, 56% in mathematics, and 61% in physical sciences (NSF 2004). Only in biological sciences are African American women relatively overrepresented, as African American women received 72% of bachelor's degrees to African Americans in biological sciences in 2001 (NSF 2004). The pattern of gender differences for African Americans is generally similar to the pattern for other racial/ethnic groups, although the magnitude of the gender gap is somewhat smaller for Blacks than for other groups (see Table 1).

Clearly colleges and universities must do more to promote attainment in STEM fields, particularly among African American women. To improve our understanding of effective

Table 1 Percentage of bachelor's degrees awarded to women within racial/ethnic groups by field, 2001

Field	Black (%)	Hispanic (%)	Asian (%)	White (%)
Total	66	61	55	57
Agricultural sciences	61	51	64	48
Biological sciences	72	61	57	59
Computer sciences	46	31	32	22
Mathematics	56	47	47	48
Physical sciences	61	57	52	53
Engineering	36	24	24	18

Source: NSF (2004)

institutional strategies for accomplishing this goal, this study uses case study analysis to explore the ways that one institution, Spelman College, a historically Black women's college, promotes the attainment of African American women in STEM fields. Although limited to one institution, the findings shed light on the ways that institutional characteristics, policies, and practices may mitigate the barriers that limit attainment of African American women in STEM fields. Based on these findings, the paper concludes with recommendations for improving policy and practice as well as recommendations for additional fruitful research.

Literature Review and Theoretical Underpinnings

Many studies have examined the forces that limit the educational attainment of women and students of color in STEM fields in the United States. A review of this literature suggests that the most prominent barriers are inadequate academic preparation by elementary and secondary schools, insufficient attention to the psychological barriers that limit persistence in STEM fields, and inadequate support by colleges and universities.

Academic Preparation and Achievement

Educational attainment in a STEM field depends, at least in part, on the adequacy of prior academic preparation and achievement. Based on its review of relevant data and research, NSF (2006b) concluded that efforts to ensure the readiness of the U.S. workforce for the projected growth in science and engineering occupations must include improvements in K-12 math and science preparation. Two sources that contribute to low levels of math and science preparation especially for minority and low-income students are the insufficient availability of rigorous math and science coursework and a dearth of qualified math and science teachers in the high school attended (NSF 2006b; VanLangen and Dekkers 2005).

Several statistics illustrate gaps in the preparation of African Americans for educational attainment in STEM fields. For example, among high school graduates in 2000, smaller shares of Blacks and Hispanics than of Asians and Whites took Advanced Placement or International Baccalaureate calculus or any calculus (NSF 2006c). While racial and socioeconomic bias in standardized testing may play a role (Freedle 2003), observed test scores are consistently lower for Blacks than for Whites. As an example, using descriptive analyses of data from a survey of 1,891 doctoral students in STEM fields at 21 universities in fall 1996, Nettles and Millett (1999) found that average GRE scores were lower for Blacks and Hispanics than for Whites and Asians. Average scores were particularly low for Black doctoral students in science and math programs on the quantitative portion of the GRE, as average scores were more than 100 points lower for Blacks than for Asians and Whites and more than 50 points lower for Blacks than for Hispanics on this component of the exam.

The reported success of programs designed to improve academic preparation further suggests the role of academic barriers in limiting the attainment of students of color in STEM fields. For example, one study suggests that, compared with non-participants, students of color who participated in the Pre-Freshman Academic Enrichment Program at the University of Maryland, College Park had higher retention rates in science majors and at the university, as well as higher graduation rates (Armstrong and Thompson 2003).

Psychological Barriers

Although important, research also suggests that academic preparation alone does not ensure the attainment of women or Blacks in STEM fields. Psychological theories of self-efficacy and stereotype threat suggest additional reasons for the low levels of STEM attainment for these groups.

Research demonstrates the relationship between self-efficacy and educational attainment in STEM fields, especially for women and students of color (Colbeck et al. 2001; Lent et al. 2005; Leslie et al. 1998; Rayman and Brett 1995; Zeldin and Pajares 2000). For example, using Bandura's work to define self-efficacy as "beliefs about personal capabilities" and using structural equation modeling, Lent and colleagues showed that self-efficacy is positively related to students' expectations of earning a bachelor's degree in engineering, interest in engineering-related activities, and plans to major in engineering (p. 84). Although the relevance of the findings to today's students is unclear as the data are more than 20 years old, Leslie and colleagues (1998) found that measures of self-efficacy and self-concept are important positive predictors of the likelihood of choosing a STEM major field and that White men have higher levels of self-efficacy than other students.

Similarly, noting that social cognitive theory predicts that "people are more likely to perform tasks they believe they are capable of accomplishing and are less likely to engage in tasks in which they feel less competent" (p. 216), Zeldin and Pajares (2000) showed the role of other individuals' encouragement in promoting a woman's perceptions of her capacity for a math-related career. Using data from interviews with 15 women in math-related careers in which women are underrepresented, Zeldin and Pajares found that participants' self-efficacy for math-related careers was shaped by positive perceptions of family members', teachers', and peers' math-related skills and careers; support and encouragement for academic success from family members, teachers, and peers; and successful past experiences with math-related activities. Self-efficacy beliefs enabled women to continue in these careers despite academic, financial, and other barriers, as well as "negative verbal persuasions" especially from peers about the decision to pursue a career in math (Zeldin and Pajares 2000, p. 236).

A second relevant psychological theory is stereotype threat. A self-evaluative threat, Steele and Aronson (1995) argue that stereotype threat negatively influences performance by shifting an individual's focus from performing a particular task to worrying that low performance will confirm a negative stereotype about a group to which the individual belongs. With only a few exceptions (e.g., Cullen et al. 2004), research consistently shows that stereotype threat contributes to gaps in academic performance between Blacks and Whites (Brown et al. 2000; Gonzales et al. 2002; Steele and Aronson 1995) and between women and men (Brown et al. 2000; Brown and Josephs 1999; Gonzales et al. 2002; O'Brien and Crandall 2003).

The Role of HBCUs and Women's Colleges in Promoting STEM Attainment

Clearly substantial barriers limit the attainment of African American women in STEM fields even before enrolling in higher education. The contribution of these pre-college forces is perhaps best illustrated by the tendency of African American women to choose non-STEM majors. Regardless of race/ethnicity, the share of female freshmen attending four-year colleges and universities nationwide in 2002 who reported plans to major in a science or engineering field was smaller than the share of men (NSF 2004). Although a higher share of Black women than White women reported plans to major in a science or

engineering field (32% vs. 24%), the share of women who intended to major in science or engineering was smaller than the share of men among both Blacks and Whites (NSF 2004).

Despite the importance of pre-college characteristics and experiences, however, research also suggests that institutional structures, policies, and practices contribute to the attainment of women and minorities in STEM fields. In particular, colleges and universities that serve predominantly Black populations and/or women appear to be disproportionately effective in promoting the educational attainment of these groups overall, and in STEM fields in particular (Kim and Conrad 2006). For example, of the top 20 leading producers of African American bachelor's degrees in STEM fields, all but three are HBCUs (Borden and Brown 2004). Our analyses of Integrated Postsecondary Education Data System (IPEDS) data show that, nationwide in 2004, HBCUs were the source of 22% of all bachelor's degrees to Blacks but 30% of the bachelor's degrees to Blacks in STEM fields. HBCUs are also a relatively more important source of STEM degrees for Black women than Black men. Analyses of IPEDS data also reveal that 33% of the bachelor's degrees awarded to Black women in STEM fields in 2004 were from HBCUs, compared to only 26% of the bachelor's degrees in STEM fields for Black men.

Other studies suggest that HBCUs are important producers of African Americans in STEM fields. Wenglinsky (1997) concluded that undergraduates attending HBCUs were more likely to plan to enroll in a graduate program in science, engineering, or business and were less likely to consider enrollment in a graduate program in the social sciences or health/agriculture than undergraduates attending traditionally White colleges and universities. Solorzano (1995) found that, after controlling for institutional size, 30 of the top 50 baccalaureate producers of African American female doctorates in science and engineering (and 23 of the top 50 baccalaureate producers of African American male doctorates in science and engineering) between 1980 and 1990 were HBCUs. Using descriptive analyses of data from the 1993 National Study of Postsecondary Faculty (NSOPF:93), Perna (2001) found that HBCUs were an especially important producer of African American faculty in STEM fields. Lent et al. (2005) found that undergraduates enrolled in introductory engineering classes at two HBCUs not only had higher self-efficacy than their counterparts attending one predominantly White university, but also had greater interest in engineering-related activities and greater interest in pursuing an engineering major field. The structural equation analyses suggest variations by institutional type in the predictors of intentions to major in engineering, as the analyses suggested that HBCUs provide greater social supports to address the barriers that limit persistence in an engineering major field (Lent et al. 2005).

Other research suggests the historical and current role of women's colleges in promoting the attainment of women in science and engineering careers. In an historical examination of Mount Holyoke Seminary (now Mount Holyoke College) between 1837 and 1941, Shmurak and Handler (1992) concluded the institution's success in educating women for science careers was attributable to an institutional climate where focusing on science was "the norm." Among the important characteristics of this climate were the presence of substantial numbers of women who served not only as institutional leaders and faculty but also as role models, the college's reputation as a leader in providing science education, the tendency of students interested in science to choose to attend the institution, and the college's "collaborative research orientation" (Shmurak and Handler 1992, p. 342). Similarly, Rayman and Brett (1995) concluded that "the relatively high" rate of entrance into science careers among students who graduated with a science or math major from one women's college suggests the positive role of single-sex colleges in promoting the attainment of women in STEM careers.

Summary

Prior research sheds light on the importance of self-efficacy to the educational attainment of Black women in STEM fields (Colbeck et al. 2001; Lent et al. 2005; Leslie et al. 1998; Rayman and Brett 1995; Zeldin and Pajares 2000), as well as the ways that inadequate academic preparation and achievement (Armstrong and Thompson 2003; Nettles and Millett 1999; NSF 2006b; VanLangen and Dekkers 2005) and stereotype threat (Brown et al. 2000; Brown and Josephs 1999; Gonzales et al. 2002; O'Brien and Crandall 2003; Steele and Aronson 1995) limit the attainment of African American women in these fields. Prior research also suggests that HBCUs (e.g., Borden and Brown 2004; Lent et al. 2005; Perna 2001; Solorzano 1995; Wenglinsky 1997) and women's colleges (e.g., Rayman and Brett 1995; Shmurak and Handler 1992) may be particularly effective at addressing these barriers. Nonetheless, little is known about the ways that HBCUs or women's colleges promote the attainment of Black women in STEM fields. Even less is known about the role that Black women's colleges play in influencing Black women's success in the STEM fields. Using case study analysis, this study addresses this knowledge gap.

Research Method

This study uses case study methodology to explore the following guiding question: What are the characteristics, policies, and practices of Spelman College that promote the attainment of African American women in STEM fields? Case study methodology is appropriate given our interest in understanding the "contextual conditions" that shape the attainment of African American women in STEM fields (Yin 2003b). Moreover, many scholars recommend using the case study method when examining particular situations in which the phenomenon being examined is unique, as in the case of Spelman College, one of two African American women's colleges in the United States (Wilson 1979). The goal of this case study is not to generalize the results to all institutions of higher education since the case is influenced by a number of specific and unique factors. Instead, our goal is to identify strategies that may be particularly effective in increasing the attainment of African American women in the STEM fields, a goal that is well-supported by case study methods (Merriam 1998). Furthermore, since the case study method is used to examine a specific phenomenon, it allows collection of data that are "rich and holistic … offering insights and illuminating meanings that expand its readers' experiences. These insights can be construed as tentative hypotheses that help structure future research; hence, case study plays an important role in advancing a field's knowledge base" (Merriam 1998, p. 41).

We purposively selected Spelman College for several reasons. Located in Atlanta, Georgia, Spelman College is a private, highly selective, historically Black women's college with a $258 million endowment (www.spelman.edu). The institution has a rich history that boasts myriad successful African American graduates who have contributed to the advancement of our nation since Spelman College's founding by missionary philanthropists in 1881 (Read 1961; Watson and Gregory 2005). In 2006, the average SAT score of entering students was 1,068, published tuition and fees were $17,005, the four-, five-, and six-year graduation rates were 67%, 76%, and 79%, respectively, and the total FTE enrollment was 2,290 (www.Spelman.edu). In 2007, the institution was ranked the top Black college in the nation by *U.S. News and World Report* based in part on its high retention and graduation rates (www.usnews.com). Most relevant to this study, Spelman College has a notable record in awarding bachelor's degrees in STEM fields to African

American women. Between 1997 and 2001, only eight other colleges and universities nationwide awarded more bachelor's degrees in all STEM fields to Blacks (Florida A&M, Howard University, Southern University A&M College at Baton Rouge, North Carolina A&T, Xavier University of Louisiana, University of Maryland at College Park, Morgan State University, and Hampton University) (NSF 2004), and all of these institutions, save Xavier University of Louisiana, enroll considerably more students than Spelman College. In 2006, Spelman awarded the 57th 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, the third highest number in physical sciences, and the fourth highest number in biological sciences (*Diverse Issues in Higher Education* 2007). Others have observed that Spelman College has implemented programs that are explicitly designed to promote the educational and occupational attainment of Black women in STEM fields (Bozeman and Hughes 2004).

Data Collection and Analyses

In accordance with Stake (1995), prior to conducting the case study research, the research team developed, critiqued, and analyzed the data collection protocol. Reflecting Yin's (2003a) emphasis on the role of theory in guiding case study research, we developed a data collection protocol based on our review of the relevant literature. The data collection protocols focused on collecting information that described the institutional culture; interactions among faculty and students; and available supports for students' educational and career attainment in STEM fields.

After considering issues of gender and race, we decided that having women of color lead the focus groups would elicit the most fruitful responses (Sprague 2005). To create a diverse team, the focus group leaders were assisted by one or two researchers of a different race and/or gender (Sprague 2005; Zinn 1979). The research team completed the data collection protocol using multiple sources of data and information, including institutional documents, focus group interviews with students, faculty, and administrators, and observations (Stake 1995; Yin 2003a). Over a two-day period, the research team conducted five focus groups, three with students and two with faculty and administrators. The research team developed the focus group protocol based on findings from the review of relevant prior research. See Appendix A for a copy of the focus group protocol. Each focus group lasted approximately 65 min, was audio- and video-recorded, and transcribed. A total of 19 students, three faculty members, and five administrators participated in the study. All 19 students were Black women majoring in STEM fields. The eight faculty members and administrators included six Black women, one Black man, and one Latina and have been employed at Spelman for between 2 and 26 years. Two of the faculties were tenure track assistant professors (biology and mathematics) and one was a tenured professor in chemistry. The administrators included an academic STEM program coordinator, a STEM retention program coordinator, a laboratory manager, biology laboratory technician, and biology research associate. One of the administrators also serves as an adjunct instructor in STEM courses.

To analyze the data, we first created a case study database to organize the information that we collected (Yin 2003b). The database included transcriptions from the focus groups and interviews, as well as data from institutional documents and observations. We used data from the institutional documents and observations to triangulate the interview data. We developed a preliminary list of themes using our knowledge of prior research, while also allowing additional themes to emerge. According to Stake (1995), researchers should

remain open to new insights, opportunities, and discoveries throughout the case study process. To assist in the coding and compiling of data into categories, we employed HyperResearch software. Following this process, we worked together to better characterize and substantiate overlapping themes, eventually condensing the data to four overarching themes.

We used several strategies to ensure the trustworthiness and credibility of the findings and conclusions. To ensure construct validity, we collected information from multiple sources including participants with different perspectives (i.e., students, faculty, and administrators). We used multiple members of the team to evaluate the coding and categories and to ensure inter-rater reliability. The use of the case study protocol and case study database also helped ensure reliability (Yin 2003b).

Despite the strength of the research design, the study has several limitations. First, the study relies on data from a relatively small number of students, faculty, and administrators at just one institution. Although the number of participants is small, the focus group interviews probed deeply participants' perceptions of institutional culture, interactions, and supports and triangulated conclusions about these perceptions with data from documents and observations. Second, the purposeful selection of a Black women's college as a single, rich case confounds the contribution of a women's college with the contribution of an historically Black college to the attainment of African American women in STEM fields. Nonetheless, through this purposeful sampling strategy, the study provides insights into how students, faculty, and administrators perceive institutional culture, interactions, and supports at an exemplary case. Third, the analyses examine the institutional characteristics, policies, and practices that appear to promote the attainment of African American women in STEM fields at one point in time, without following the actual attainment of these women.

Findings

The following four themes emerged from the data analyses. First, participating students chose to attend Spelman College at least in part because of the institution's well-known success in promoting the success of Black women in STEM fields. Second, participating students enter Spelman College with high STEM-related educational and occupational aspirations and maintain these aspirations while enrolled. Third, participating students and faculty acknowledge the academic, psychological, and financial barriers that limit the persistence of Black women in STEM fields. Fourth, most relevant to the guiding research question, the potential negative impact of these barriers on the attainment of Black women in STEM fields is mitigated by several institutional characteristics and practices, including: structural characteristics, the cooperative rather than competitive peer culture, the efforts of faculty to actively encourage and promote students' success, the availability and use of academic supports, and the availability of undergraduate research opportunities. Each of these themes is discussed in turn.

Institutional Reputation for Advancing Attainment of Black Women in STEM Fields

Although a few participating students describe the pull of strong family connections to the institution, several report choosing to attend Spelman specifically because of the institution's strong reputation for advancing the attainment of African American women in STEM fields or, as some students summarized, "putting African Americans into medical

school." After enrolling, students continue to see examples of Spelman's success in educating African American women in STEM fields. For example, a few participants note that some faculty members illustrate Spelman's success by inviting alumnae "to come back and tell the other sisters what they are doing now." Among other potential benefits, these alumnae visits convey to current students that Spelman provides high-quality preparation for graduate and professional school in STEM fields. In the words of a participating faculty member:

> We have students who come back and there's always talk about how students can look back and see that he or she [a particular instructor] was not that hard—they were demanding—but when they get there with students from other institutions they find out that they can compete, that they have been exposed to some of the same things.

Educational and Occupational Plans of Participating Black Women

Given our sample selection criteria, it is not surprising that participating students consistently report aspiring to STEM-related careers. In addition to consistently reporting STEM-related career aspirations, participants also report high degree goals. About one-third of participating students describe plans to attend medical school, one-third plan to enter an M.D./Ph.D. program, and the remainder plan to pursue other graduate and professional programs including dental programs, dual medical and other master's degree programs (e.g., master's of business administration, master's of public health), and doctoral programs. Comments from participating faculty confirm the high STEM-related degree goals of Spelman women. In the words of one faculty participant: "At least half of our science graduates are going on to post-baccalaureate degree programs. It's probably more than that. Within a five-year period, it's much higher."

At least some faculty members actively encourage students to expand their consideration of post-baccalaureate programs to those for which they have less knowledge. In the words of one participating faculty member:

> Obviously, I favor those who chose academic careers. I push that all the time, because we don't have to encourage them to go to medical school… That's almost a given when the students come here and want to major in biology and chemistry because that's something that they've heard all their lives about being a medical doctor. But I like to think that we can take some credit in giving them other options.

Other participants suggest that faculty intentionally reinforce students' aspirations. In the words of one faculty member:

> One of our goals is telling them, 'You're going to med school,' during the research lab now. 'So, you need to balance; you need to learn here how to balance your academic load with your research load. That will give you a hint of how if you will make it into med school.'

Some faculty members also work to identify ways for lower performing students to achieve their aspirations in difficult required core classes. In the words of one faculty member:

> They're like, 'No, my mother was a physician, my father was a physician, my grandfather…and I'm going to be a physician.' I have to tell them, 'You can be a physician but you may have to take another route. You don't have to be a biology major. You can be a Spanish major and be pre-Med.'

Barriers to Educational and Occupational Attainment in STEM Fields

Participants identify four types of challenges that limit the educational and occupational attainment of Black women in STEM fields: academic, psychological, social, and financial. For example, comments from participating students and faculty consistently reflect the common understanding that STEM coursework is academically demanding. In one representative comment, a participating student states, "Organic chemistry is a hard course at Spelman or 'Backyard University'… It is just a hard course, and you have to deal with it." Faculty and administrators also recognize the rigor of STEM coursework, with one saying: "It's not easy…. As a STEM major, you have a lot of classes. They're rigorous, they're intensive, and they [the students] all want to do well in them."

A few participants recognize the negative implications of inadequate academic preparation during high school for persistence in a STEM field. In the words of one student:

> When you come here every thing is fast pace and you have all of these classes. People come from different high schools and when they are in class they say, 'I am sure you remember this from when you where in high school,' but some students didn't have good teachers in high school. So you are sitting there and everybody else is like this is a review and you are like this is the first time I have heard this.

In terms of psychological challenges, a faculty member describes the potential negative implications of majoring in a STEM field for students' self-esteem.

> They're valedictorians and salutatorians and they don't understand when they go to post-graduate studies, everybody else may be first in their class or even when they get to Spelman, everybody else may have been first or second in their class, so it gets a little bit difficult … So we have to instill in them that sense of self-esteem.

One potential social challenge for these African American women pertains to the ways that majoring in a STEM field limits time for non-STEM friends. In the words of one student:

> One of my really good high school friends actually goes to Spelman, but she is a different major. So, we talk, but our schedules are very different because I am usually busy 95% of the time… You need to have friends who are in your major but also outside of your major so you are not always surrounded by the exact same thing. But, someone who's major maybe doesn't require as much work or [isn't] as intense, she can't really understand why I am in the science center all day, why I never leave.

A final challenge articulated by several participating students and faculty pertains to the financial difficulties associated with paying the price of attendance. Although one student indicates that she "came to Spelman because it was just actually cheaper than the schools that I had applied to," more students indicate that they "are very challenged with funding." A faculty member perceives that, for at least some students, financial challenges may diminish the quality of students' educational experiences. In the words of the faculty member:

> Spelman is in a moderate cost level but, for African-Americans, it's very expensive. So, some come and struggle financially. Sometimes, we find that's why they are not doing well. You find that they are working until 1:00 and 2:00 a.m. at night and trying to carry—Spelman is a school where 90+% of the students are carrying full loads.

Financial challenges may be especially great for the small share of Spelman students who are "non-traditional," e.g., commuting rather than residential students; students who are financially independent rather than dependent on their parents; and students who transfer into Spelman. A small number of students also describe challenges associated with the institution's timely processing of their financial aid awards.

Institutional Characteristics and Practices that Promote Attainment in STEM Fields

While acknowledging the barriers, participants more frequently describe the success of African American women at Spelman in STEM-related fields. Participants' views are best summarized by the words of one student: "It is just an environment where you're set up to succeed." Similarly, another participating student states that, "There's no reason why you should not be doing okay or pretty well in your classes because you have all the resources; everything is here." One participating student attributes Spelman's success to the perceived magnitude of resources that the institution devotes to STEM programs. In the student's words: "I think they really, really invest a lot of time, a lot of resource and a lot of money into STEM research because they really want to see more women of African descent in those types of careers."

One student attributes the ability of the institution to "give you more confidence in who you are as an individual and person" to the institution being small in size and enrolling only Black female students. Potentially influential characteristics are organized into the following categories: structural characteristics, peer support, faculty encouragement and involvement, academic support services, and undergraduate research opportunities.

Structural Characteristics

Two structural characteristics that appear to promote interactions between African American women and faculty in STEM fields are small class sizes and the physical location of faculty offices. A number of participants describe the benefits of the small size of STEM classes, particularly in terms of opportunities for students to interact with faculty and the development of cohesive peer groups. Both types of benefits are summarized in the following statement from one participating student: "I'd say a positive about being a biology major here at Spelman is that the class sizes are very small so I know most all of my classmates and we have study groups and everything … Here, I know my professors and they know me on a name basis." Small class sizes also appear to minimize students' reluctance to inform faculty and peers when they do not understand course content. In the words of one student: "Here there's only 12 of us. It's okay to tell her I didn't get it." Through small class sizes, faculty members may be better able to promote the placement of students in available research opportunities. In the words of one participating student: "If I didn't go to a small school like Spelman, I don't think I would have had that [research] opportunity because she knew me and that's why she recommended me for that position."

A second structural characteristic that appears to promote student–faculty interaction is the accessibility of faculty offices. In the words of one faculty member: "When we designed that new Science Center … we deliberately spread the faculty offices throughout the building so the students can knock on the door at any time" without having to pass through an administrative gatekeeper.

Peer Support

Whereas some observers note the competitive nature of many science programs (e.g., Anderson 1990; Armstrong and Thompson 2003; Busch-Vishniac and Jarosz 2004; Zhao et al. 2005), participants in this study consistently describe the support they receive not only from faculty but also from their peers. The supportive rather than competitive nature of many peer interactions is best captured in the following comment from one student: "I don't feel like I'm competing with my sisters here just because we're trying to get to the same place."

Spelman begins to encourage a supportive peer culture as soon as students arrive on campus. Specifically, Spelman initially communicates the norm of peer support during the one-week freshman orientation. During orientation, students participate in planned activities that result in a sense of "sisterhood." The effects of orientation on the development of a supportive peer culture are best summarized by the following student comment: "When you're in orientation, you know by the end of the week that you have sisterly bonds. You're supposed to say, 'This is my sister,' as opposed to, 'That's just a regular student.'" Another student acknowledges the supportive nature of this peer culture, giving particular emphasis to the importance of supporting each other in order to strengthen African American representation in STEM fields. The student believes there is:

> in a sense, kind of an accountability factor in that you're not in it for just yourself because there are so many other students who are trying to do the same thing you are so why not just help uplift one another and then we can all move on and benefit the society as a whole together as a group so that comes into play in taking our classes also.

Faculty members also encourage a supportive peer culture by promoting student participation in study groups. Participating students believe that faculty members encourage students to participate in study groups in order to promote students' academic achievement. Although some faculty members simply advise students to form study groups in order "to do well in this class," others appear to take a more active role by identifying "a mix of people who are doing well and some people who are not doing well and they will mix them up in the class."

Participants believe that some degree of competition in STEM coursework is inevitable. For example, one administrator and Spelman alumna acknowledges underlying competitive pressures by stating: "You know that others are competing with you who you might actually study with. It's not that you're going to do anything underhanded—it's just that you know that competition is there and that's a challenge."

Others note that some level of competition among students enrolled in STEM courses may promote higher levels of student achievement. For example, one Spelman administrator and alumna explains that competition is "not bad" as competition "keeps you motivated and keeps you pushing harder because you know that you're friend right there is making those as and getting those grades. You know that you need to do the same thing in order to get in the type of programs that you want to get into." Similarly, a student suggests the educational benefits of observing peers participate in research activities, by stating that, "If you go around, you see your peers giving poster presentations and oral presentations, you want to participate next year. So, it's kind of like helping convince other students to participate in research."

Nonetheless, while recognizing that they are competing with their Spelman peers and other college students for jobs, internships, and research opportunities, participating

students clearly voice their interest in advancing the success of all Spelman women. In one representative comment, a student states, that if "another student knows what is going on…people aren't usually selfish about sharing information." Another student summarizes the peer culture by stating, "You really have to depend on your sisters."

Faculty Encouragement and Involvement

Participants uniformly report that Spelman's faculty members "do everything they can" to promote the attainment of African American women in STEM fields. A review of participants' comments suggests at least five ways that Spelman faculty members encourage students' academic success. First, faculty members assume that all Spelman students in STEM courses can achieve their educational goals. In a representative comment from one faculty participant, "I feel that if they have been admitted to Spelman, they are capable."

Second, faculty members not only believe that all Spelman women can be academically successful but also intentionally work to ensure that students share this belief. A math professor suggests that such efforts are particularly important given stereotypes about women's ability to be successful in math and science fields. In the professor's words:

> I want to build their self-esteem and their self-confidence. Math is one of those fields that, sometimes, women can be intimidated by and I need to let them know that they can do math. They can do anything they set their minds to.

Third, faculty members are working to ensure that STEM curricula encourages rather than discourages academic attainment. For example, with the support of external grants for time to focus on curriculum development (e.g., the National Aeronautics and Space Association's (NASA) Models of Excellence (MIE) Program), faculty members have reconceptualized introductory STEM courses to serve not as mechanisms to "weed-out" poorly performing students (i.e., the traditional view of these courses) but as "gateways" to more advanced STEM coursework.

Fourth, faculty members recognize that ensuring the success of all students in STEM courses requires not only curricular changes but also changes in instructional approaches, particularly given the differences between the academic preparation students received during high school and the demands and expectations of college-level STEM coursework. One faculty participant describes the need to explicitly address differences between high school and college instruction and demands by stating that: "They're coming from an environment where a lot of things are, I'm going to say, spoon fed to them, and you just repeat it back the way I've told them. What has been skipped, I believe, is the interpretation of the data."

The efforts of Spelman faculty members to help students understand academically challenging materials are best represented by the words of one participating student:

> We were looking at molecules to see if they were, the mirror image, and I didn't see it whatsoever. I'm in her office, I'm stressed out, I don't see this. She was like, 'Come on follow me,' and I was, 'Where are we going?' She said, 'Into the bathroom.' She takes me into the bathroom with this model set and puts it up against the mirror. And I was, 'Oh, I see it.'

Finally, as noted in the structural section above, STEM faculty members at Spelman encourage students' academic success through their accessibility. In the words of one student, "Most professors have an open door policy." Students feel that professors often go well beyond their roles to support them and to make sure that they understand the material.

One transfer student best describes the availability of faculty at Spelman by comparing her current experience with interactions with faculty at her prior institution:

> The [Spelman] professors will spend time with you until you understand. They will sit there and work with you, work with you and work with you. I even had a professor that is not teaching physics this semester but he takes time out just to show me and my friends—sometimes we'll be there until 8:00 or 9:00 at night and he'll just show us different things that we don't understand in our physics class.

Academic Support Services

Several institutional structures and programs are designed to address the academic challenges that often limit students' success in STEM fields. These mechanisms include the Office of Science and Engineering and Technical Careers, the Health Careers Office, Support for Continuous Research Excellence (SCORE), and Research Initiative for Scientific Enhancement (RISE). For example, many participants describe the academic support and career development activities that the Health Careers Office provides. Particularly striking is the intensity of oversight of an individual student's academic progress, with one student stating that, "Each year, they [the Health Careers Office staff] meet with freshmen, sophomores, juniors, and seniors to see if you're doing the right thing."

Through an early warning system, the institution also actively intervenes to assist students who are experiencing academic difficulties. For example, under the early warning system, faculty members provide Health Careers counselors with a list of low-performing students and then counselors and faculty members meet one-on-one with the students. The Health Careers Office also facilitates students' acquisition of STEM-related research opportunities by compiling information on internship and summer research opportunities. The office posts and disseminates via email information on particular research opportunities and "empowers the students" to identify opportunities by serving as a repository of relevant information. In the words of one student:

> They will compile a really big binder during the semester with every kind of summer program or opportunity that is possible out there. All you have to do is come in the office and look through it and see what the deadlines are, how much the stipend is, what city it's in and a description of the program so it's not like you have to go on the internet and try to find something to do for the summer, because they have already compiled all of that information.

In addition to ensuring students' academic success while attending Spelman, the Health Careers Office also focuses on promoting students' interest in, readiness for, and successful transition into graduate and professional school. For example, among other activities, the office disseminates information to students about post-baccalaureate degree programs and careers. In the words of one participating student, the Health Careers Program focuses "on a lot of things that we need to do—for us, as a minority, African-American women, to get into medical school." Other programs and clubs (e.g., the pre-dental club) focus on preparing students for admissions tests and providing career-related information via speakers, job shadowing, and other activities.

A second type of institutional mechanism for recognizing differences in students' academic preparation and promoting students' academic success in STEM courses is peer tutoring. Known in some classes as peer tutors and others as "supplemental instructors," these individuals, according to one faculty participant, typically "sit in on the classes and

they have office hours themselves to help the students and they are free to give them quizzes and whatever, to try to put them in a setting that they would be in when they're taking examinations." Faculty members nominate high-achieving "students who have taken the course already and [have] done very well in it" to work (and be paid) as supplemental instructors or peer tutors. Participants imply that peer tutoring is readily available, with one student remarking that, "We have a math lab up on the third floor and everybody knows where it is. If they have any problems on any math level, there are always people to help you."

Undergraduate Research Opportunities

Spelman also offers several structured initiatives that serve to develop students' research interests and expertise and promote students' confidence in conducting STEM-related research. These initiatives include opportunities to conduct research with a faculty member, the school-wide annual "research day," and summer research opportunities.

Participants' comments reflect the value that both faculty and students place on the availability of opportunities for students to conduct research with a faculty member. One faculty member articulates the perceived importance of opportunities that "expose the students to research" as early in their college careers as possible. In an effort to create such opportunities the faculty member "wrote in funds for the Research Intern Program. So, we got the sophomores into the research laboratories even if they were only observing that year. It actually became more hands on." Students report that participating in research with faculty members promotes their interest in STEM-related research careers. In the words of one student, "I feel that [my research experience] has helped me to stay attracted to the STEM field."

Created by faculty "a number of years ago," research day provides students with an opportunity to present their individual studies to the Spelman community. Students from across disciplines, including biology, education, English, mathematics, and various social sciences, participate. The faculty and administration present awards within the various disciplines and all participants receive certificates. Students' comments suggest the motivational value of research day, with one student stating that, "We just had research day last week. Going and seeing all the students present their information about what they have been researching was really inspiring."

Summer research experiences appear to be the norm for STEM students at Spelman College. Participants indicate that faculty members promote these opportunities by sharing information about opportunities and providing recommendations. "Upperclassmen" are also a source of information about summer research opportunities. Participating students suggest that summer research experiences build students' interest in research and create a "passion" for a particular STEM field. In a representative comment, one student explains that:

> My research spark was the summer after my freshman year; I did a summer program at Emory at the Center for Behavioral Neuroscience. I had always heard about research, but I had never done it before. I really enjoyed my summer program. I came back my sophomore year and I have been doing research since then.

Another commonly articulated benefit of undergraduate research opportunities is financial. Several participating students indicate being recipients of fellowships and scholarships (e.g., Howard Hughes Medical Institute Fellowship, Howard Hughes Academic Years Scholarship Program, Center for Behavioral Neuroscience Undergraduate

Fellowship). One student describes the benefits of a paid research opportunity in the following words:

> I think when students have funding … to do the research, it is easier because some students work outside jobs. It is hard to work outside jobs and then be able to go do research when you are not getting paid for it … So it's like you have no excuse not to be able to do your research and do your academics at the same time. I think that is the biggest success.

Discussion

At least four conclusions may be drawn from this study. First, the findings illustrate the important role that Spelman College is playing in promoting the attainment of African American women in STEM fields. This conclusion builds on other research demonstrating the educational benefits of attending an HBCU. Prior research shows that, compared with their counterparts who attend predominantly White colleges and universities, African American students who attend HBCUs experience less social isolation, alienation, personal dissatisfaction, and overt racism (Harper et al. 2004; Pascarella and Terenzini 2005) and that HBCUs seem to provide a social, cultural, and racial environment that is more supportive, caring, and nurturing for students and promotes academic achievement and success (Harper et al. 2004).

Second, like some other research (e.g., Maton et al. 2000; Stanton-Salazar 1997, 2001; Bensimon 2007), the findings suggest the benefits of adopting a multi-faceted institutional approach that promotes students' academic and psychological readiness to pursue advanced degrees and careers in STEM fields. Together, these structures, policies, and practices reflect the assumption that all African American women at this institution can succeed in STEM fields. These findings mirror the work of Bensimon (2007), who argues that the dominant paradigm around student success places the responsibility for success on the student rather than the institution. Along with Stanton-Salazar (1997, 2001), she argues that scholars and practitioners often "assume that institutional support systems are already in place and that motivated students will take advantage of them" (p. 14). Bensimon (2007) urges us not to make these assumptions. The faculty and administration at Spelman College do not seem to make these assumptions as, according to our research, they strive to increase support systems and take great ownership of their role in boosting student success.

Third, as in studies by Kimbrough and Harper (2006) and Palmer and Gasman (2008), the findings from this case study suggest that supportive, cooperative peer relationships promote the academic achievement of Black women at this HBCU. While recognizing that some element of competition may be "healthy," faculty and administrators at Spelman College also instill in students a sense of care for their fellow students, i.e., their "sisters," beginning in their first year. Students, in turn, see the accomplishments of peers as their own accomplishments, and accomplishments of the institution as a whole.

Finally, the findings imply that, even with Spelman's clear commitment to promoting the attainment of African American women in STEM careers, challenges remain. In particular, the findings suggest the challenges for attainment in STEM fields that result from students' financial difficulties.

Implications for Policy and Practice

Like prior research (Hanson 2004; Leslie et al. 1998; VanLeuvan 2004; VanLangen and Dekkers 2005), findings from this study suggest that barriers to the educational attainment of African American women in STEM fields begin during elementary and secondary school. Nonetheless, the findings also suggest the role that colleges and universities may play in ensuring that individuals who enter their institutions with an interest in a STEM career can achieve their goal.

At least some part of Spelman's success in promoting the attainment of African American women in STEM fields is attributable to the unique characteristics of this institution, including its long-standing reputation for, and commitment to, promoting the attainment of African American women in STEM fields. Resource constraints may also limit the ability of other institutions to realize the suggested benefits of small class sizes. However, many predominantly White institutions that are comparable in size to Spelman have considerably higher endowments, alumni giving, and tuition (Gasman and Anderson-Thompkins 2003) suggesting that an institutional commitment to promoting the attainment of African American women may be more important than the simple magnitude of institutional resources.

The findings from this study suggest that institutions that are interested in increasing the attainment of African American women in STEM fields should consider implementing other changes. Like other studies (e.g., Buncick et al. 2001; Colbeck et al. 2001; Rayman and Brett 1995; Riley 2003; Rosser and Kelly 1994), the findings from this study point to the potential benefits of adapting STEM curricula and instructional practices to promote students' achievement in STEM courses, as well as their confidence in their ability to succeed in STEM fields. In their study of several NSF-funded activities to promote student engagement in college physics courses, Buncick and colleagues found that, when classroom activities encourage students to draw connections between the curriculum and students' real-world experiences and prior learning and actively engage in teaching and learning, students are more confident in their academic abilities and more enthusiastic about the course content. Suggesting the benefits of culturally-relevant pedagogy, these classroom activities appeared to be particularly effective for promoting classroom participation among women and Blacks.

Similarly, using self-efficacy as a guiding conceptual framework and multivariate analyses of data from surveys of engineering students attending seven universities in 1998, Colbeck and colleagues found that measures of instructional practices were more strongly related to students' academic and career perceptions than their background characteristics. Specifically, faculty members' encouragement of collaborative learning strategies (e.g., student discussions with and feedback from peers, interactions with peers outside of class, and active learning) and the quantity and quality of faculty–student interaction were positively associated with students' continued interest in becoming an engineer, as well as students' perceptions of ownership of their learning and "ability to become an engineer," even after controlling for students' academic ability (Colbeck et al. 2001). In addition, clarity of faculty members' "assignments and expectations" was a more important positive predictor of being confident in the ability to become an engineer for women than for men (Colbeck et al. 2001, p. 184). Also drawing on self-efficacy theory, Rayman and Brett (1995) found that, among women who graduated with science majors from one predominantly White women's college and after controlling for other variables, those who received career advice or encouragement from an advisor or other faculty member were

substantially more likely than other women to be employed in a science career after graduation.

Implications for Future Research

The findings from this study suggest several areas for future research. First, future research should further build on the insights generated by this examination of Spelman College by conducting case studies of other HBCUs and predominantly White institutions. These additional studies would provide further insights into the nature of Black women's experiences in STEM fields and the institutional policies and practices that promote their success.

Second, future research should explore the ways that institutions can address students' financial challenges. Although less prominent than other themes, a small number of participants' comments suggest that financial challenges may be particularly problematic for students in STEM fields, given the academic rigor of these programs. While this study suggests the financial benefits of summer and other research opportunities, other studies suggest that providing sufficient financial aid to cover the price of tuition, books, and room and board has a positive impact on the educational experiences of minority students in STEM fields (Maton et al. 2000). Specifically, Maton and colleagues (2000) found that, compared to two different comparison samples, high-achieving African American students who participated in the Meyerhoff Scholars Program at the University of Maryland, Baltimore County had higher rates of graduating with a science, engineering or math major, higher grade point averages in science, engineering, and math courses, and higher rates of enrollment in science, engineering, and math graduate programs. While the researchers do not attempt to disentangle the relative contribution of particular program components to students' outcomes, participating students believed that financial support was the most important component. Based on this finding, the authors speculate that the financial support provided by the program reduces students' need to work and motivates students to achieve the levels of academic performance that are required to maintain the scholarship (Maton et al. 2000).

Nonetheless, the availability of student financial aid through programs like the Meyerhoff Scholars Program is limited. Moreover, existing federal, state, and institutional financial aid programs typically do not provide enough financial aid to cover 100% of all students' financial need (Perna et al. 2007). Therefore, future research should explore the ways that institutions may assist students with not only financing the price of their STEM education programs while also providing opportunities that enhance students' educational experiences and promote their academic success. This study suggests that undergraduate research experiences are a promising approach. Other potentially promising approaches may include STEM-related work-study employment opportunities and undergraduate teaching assistantships in STEM programs (Perna et al. 2007).

Third, future research should further examine the peer culture in the STEM majors at both Black colleges and predominantly White institutions and the ways that the peer culture contributes to the attainment of Black women and other underrepresented groups. In particular, the findings from this study raise such questions as: Is the supportive peer culture in STEM fields at Spelman College indicative of the culture at other Black colleges? And, how can institutions with more heterogeneous populations and without a historical institutional commitment to ensuring the academic success of all students develop a peer culture that encourages the attainment of African American women in STEM fields?

Concluding Note

Improving the participation of African American women in STEM fields is necessary not only because of social justice goals but also to more fully tap the human resources that ensure our nation's economic competitiveness in a global society. Spelman College's success in promoting the attainment of Black women in STEM fields suggests that colleges and universities can do more to achieve this important goal.

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Appendix A

Spelman Focus Group Protocols

At the Beginning of the Focus Group Session, the Moderator Should Explain the Following to the Participants

Thank you for agreeing to participate in this interview. We are conducting this study to understand more about your experiences as a student here at Spelman. You were invited because you are all studying in what we describe as STEM, or science, technology, engineering, or math, fields. Your participation is completely voluntary. There is no right or wrong answer. We expect that you will have differing points of view. Please feel free to share your point of view even if it differs from what others have said.

Before we get started, please take a few minutes to read and sign the Informed Consent form that we are passing out. If you have any questions about this form or study please ask us.

We will be video taping the discussion and taking notes for us to use when we write about our findings. Everything you say will be treated as anonymous. The names of all participants will be kept confidential. Information that we compile from our visit here will be presented in ways that ensure that none of the individuals are identifiable by anyone beyond the research team. If at anytime you do not feel comfortable answering a question you may simply decline.

It's important that we hear from all of you because you've had different experiences. Throughout our conversation we might ask additional questions to delve further into your answers and find out more about your experience. In the same vein, we might ask for you to answer specific questions, in order to make sure that we hear from all of you.

This focus group session will take approximately 1 h.

Student Focus Groups

1. Let's start by getting to know one another. We're going to go around the group. Please say your name, your year, and your major.
2. Why did you choose to come to Spelman?
   a. How did you first learn about the school?
3. How and why did you select your major?

4. Can you tell me about your experience in your major at Spelman? What aspects are most positive? What have been your greatest challenges? (listen and prompt for…)
    a. School culture
    b. Faculty interaction, in and out of the classroom
    c. Peer interaction
    d. Academic advising
    e. Course and lab experiences
    f. Social clubs and organizations
    g. Academic clubs and organizations
5. Do you have a mentor?
    a. Is he/she faculty or peer? Why do you consider that person to be a mentor?
    b. How did this person come to be your mentor? Was he/she formally or informally assigned?
6. What kinds of supports are there for you if you need academic help? If you are looking for an internship? If you are looking for some other kinds of experiences that will help you with your academic life?
7. What are your educational and career goals? Do you feel that Spelman is preparing you for a successful career in your field? How? Any weaknesses in this preparation?
8. What kinds of support and encouragement do you receive from other people in your life?
    a. What does your family think about your decision to major in your field? Your high school friends? College friends?
9. If you could change one thing to better promote the academic success of students at Spelman in STEM fields, what would it be?

Faculty Focus Groups

1. Let's start by getting to know one another. We're going to go around the group. Please say your name, how long you have been on faculty, how long you have been at Spelman, the courses you teach and your research interests.
2. Why did you choose to come to Spelman?
    a. How did you first learn about the school?
3. Can you tell me about the experiences at Spelman for students who major in science, mathematics, and engineering? What aspects are most positive? What are the greatest challenges? (listen and prompt for…)
    a. School culture
    b. Faculty interaction
    c. Student interaction
    d. Academic advising
    e. Course and lab experiences
4. What are your goals for your students?
5. What do students who major in science, math, and engineering at Spelman do one year after graduating? 5 years? 10 years?

6. Is there a mentoring process in place? What share of students in STEM fields do you think have a faculty or peer mentor? How would you define a good mentor?
7. Are there any clubs or organizations that specifically help students succeed at Spelman in generally and STEM fields in particular? (listen and prompt for…)
   a. Social clubs or organizations
   b. Academic clubs or organizations
8. What kinds of supports are there for students who need academic help? Are looking for an internship? Are looking for some other kinds of experiences that will help them with their academic life?
9. How do you think students at Spelman pay the costs of attending? Do students typically work while attending classes? Where? How many hours per week?
10. Do you feel that Spelman prepares students for successful careers in STEM fields? How? Any weaknesses in this preparation?
11. If you could change one thing to better promote the academic success of students in STEM fields at Spelman, what would it be?
12. What kinds of support and encouragement do you think that students in STEM fields receive from other people in their lives? (faculty, family, high school friends, college friends, others).

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