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Enhancing the Number of African Americans Who Pursue STEM PhDs: Meyerhoff Scholarship Program Outcomes, Processes, and Individual Predictors

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Abstract

The current study examines the outcomes, processes, and individual predictors of pursuit of a STEM PhD among African-American students in the Meyerhoff Scholarship Program. Meyerhoff students were nearly five times more likely than comparison students to pursue a STEM PhD. Program components consistently rated as important were financial scholarship, being part of the Meyerhoff Program community, the Summer Bridge program, study groups, staff academic advising, and summer research opportunities. Furthermore, focus group findings revealed student internalization of key Meyerhoff Program values, including a commitment to excellence, accountability, group success, and giving back. In terms of individual predictors, multinomial logit regression analyses revealed that Meyerhoff students with higher levels of research excitement at college entry were more likely to pursue a STEM PhD.

The underrepresentation of African-American, Native American and Latino/a students in STEM (science, technology, engineering and mathematics) fields has been a persistent issue for some time now. In 2005, for example, about 9% of doctorates in biological sciences were awarded to underrepresented minorities (URM), even though they comprise more than 25% of the U.S. population (Olson & Fagen, 2007). The problem can be attributed in part to the reality that significantly more URM students than Asian American and White students drop out of STEM disciplines as they proceed academically. For instance, although large percentages of African-American (18.6%) and Latino/a (22.7%) students entering college in 1995 were interested in majoring in STEM fields, only 7% of STEM bachelor's degrees were awarded to each of these groups (Anderson & Kim, 2006).

The disproportionately low participation of URMs in STEM fields has created fears of a shortfall of scientists and engineers in our country in the years ahead (Chubin, May, & Babco, 2005). Research on the “leaky pipeline” phenomenon has suggested several factors that serve as barriers to persistence for many African-American, Native American, and Latino/a students in the sciences. These include cultural (social expectations for different groups), structural (historical regulations and laws that barred the entry of minorities into education and employment), and institutional (discriminatory policies and practices) barriers (Tsui, 2007). The problem of underrepresentation and the understanding of its presumed causes have led to the development and evolution of STEM-related intervention programs in the last two decades.

STEM Intervention Program Outcomes

Major intervention strategies used by colleges to increase diversity in STEM fields and their effects have been reviewed and described in recent years (e.g., Matyas, 1991; Gandara & Maxwell-Jolly, 1999; BEST, 2004; Tsui, 2007). Model programs using these modes of intervention or a combination of them have also been identified and examined in terms of their effects on URM student STEM education access, retention, persistence, and completion.

Recognized for enhancing URM college student access, Xavier University's Biomedical Honors Corps combines a close working relationship with local secondary schools with a collaborative campus effort to enhance student achievement in pre-med majors (Carmichael, Bauer, Hunter, Labat, & Sevenair, 1988; Gandara & Maxwell-Jolly, 1999). As early as eighth grade, students receive help preparing for their college-level education through attendance in summer courses on the Xavier campus in biology, chemistry, and algebra. During the summer preceding their first year at Xavier, many prospective science majors participate in Project SOAR (Stress on Analytical Reasoning), a pre-freshman summer program focused on problem-solving and vocabulary development in mathematics and the sciences (Gandara & Maxwell-Jolly, 1999). Evaluation of the Biomedical Honors Corps indicated that participation in the program greatly increased the likelihood of entry into the medical professions (Carmichael et al., 1988).

The Biology Undergraduate Scholars Program (BUSP) at the University of California in Davis (UCD) is another program that has succeeded in improving the persistence rate of underrepresented minorities in basic math and science courses (Villarejo & Barlow, 2007). BUSP is a program open to all underrepresented minority freshmen at UCD with an interest in the biological sciences. It encourages academic success by providing academic and financial support services through the freshmen and sophomore years at the university. Program components include supplemental academic instruction, academic and personal advising, optional employment in research laboratories, and study groups. In an evaluation of the program, Barlow and Villarejo (2004) concluded that program participants had greater odds of persisting in basic math and science courses and of graduating in biology than did a comparison group (those who opted not to take part in the program). Furthermore, undergraduate research greatly increased the odds of positive graduation outcomes; program participants were more likely to pursue graduate study than were university graduates overall.

Based on Uri Treisman's research findings about the role of study group support in fostering academic success in mathematics among Asian minorities, the Emerging Scholars Program (ESP) is a multi-site program designed to foster success in mathematics classes, specifically in calculus. The initial program was started at UC Berkeley and was replicated in other universities such as the University of Texas-Austin. The program's main components are workshops regularly offered by academic departments as alternatives to traditional discussion sections. At UT-Austin, the ESP sections serve African-American, Hispanic and Caucasian students from rural Texas. Results of the program showed that over 85% of all ESP students routinely earn grades of "A" or "B" in calculus compared to less than one-third of non-ESP African-American and Hispanic students (Moreno & Muller, 1999). An examination of ESP programs across the country reveals that the percentage of students with moderate to very high grades (B- to A) in calculus is 70%, a rate higher than non-ESP comparison groups (Gandara & Maxwell-Jolly, 1999).

Positive findings have also been reported for federal programs that provide funding to support minority STEM initiatives on college campuses. Schultz, Estrada-Hollenbeck, and Wood (2008) examined the National Institute of Health's Minority Access to Research

Careers Program (MARC), which supports juniors and seniors in their academic work and in biomedical research labs. They found that students participating in MARC (and related programs) achieved more positive outcomes than matched comparison students on STEM-related achievement, motivation, persistence and future career goal measures. Clewell, de Cohen, Deterding, & Tsui (2006) evaluated the National Science Foundation's Louis Stokes Alliances for Minority Participation Program (LSAMP), which focuses on multi-campus partnerships within states to improve STEM practices and outcomes. Findings indicated that two-thirds of LSAMP alumni enrolled in doctoral, master's, or professional degree programs.

STEM Intervention Program Components

Intervention strategies to increase participation and success in STEM areas vary depending on the specific goals of programs and presumably, their funding. These approaches can be in the form of summer bridge programs, mentoring, research experience, tutoring, career counseling and awareness, a learning center, workshops and seminars, academic advising, financial support, and curriculum and instructional reform (Tsui, 2007). Earlier studies of effective intervention strategies have identified some of these elements. Matyas (1991) focused on minority engineering programs and found that successful programs tend to contain the following elements: a) assistance with admission procedures, b) assistance with student matriculation; c) academic support services; d) student study center; e) linkage of students with minority student organizations in engineering; and f) summer engineering jobs.

Relatedly, a recent systematic review by a panel of experts identified eight design principles that underpin exemplary and promising higher education-based STEM interventions: a) institutional leadership, b) targeted recruitment; c) engaged faculty; d) personal attention; e) peer support; f) enriched research experience; g) bridging to the next level; and h) continuous evaluation (BEST, 2004). Research to date, however, has not examined the relative importance of different program components.

Meyerhoff Scholars Program

The Meyerhoff Scholarship Program (MSP), the focus of the current research, is a comprehensive intervention program at the University of Maryland, Baltimore County that includes each of the design principles cited above. The program was developed in 1988 in response to the low levels of performance of well-qualified African-American STEM majors. Baltimore philanthropists Robert and Jane Meyerhoff provided initial program funding. The program developers, led by UMBC's then Vice-Provost (and since 1992 UMBC's president) sought to develop a comprehensive, multi-component program. In 1996, the program was opened to non-African-American students with an interest in the advancement of minorities in STEM fields. Currently, between 50 and 65 Meyerhoff students are selected each year (depending upon available funding); the majority are African Americans. The program is situated on a campus with a diverse student population (34% minority), with more than half of the undergraduates and 60 percent of the doctoral students pursuing STEM degrees.

The Meyerhoff Scholars Program incorporates multiple components, briefly described below (for a more detailed description, see Gordon & Bridglass, 2004).

Financial Scholarships—The Meyerhoff Program provides students with a comprehensive financial package including, in many cases, tuition, books, and room and board. This support is contingent upon maintaining a B average in a STEM major.

Recruitment Weekend—The top 100–150 applicants and their families attend one of the two recruitment weekends on the campus.

Summer Bridge—Meyerhoff students attend a mandatory pre-freshman Summer Bridge Program, and take courses in math, science, and African-American studies. They also participate in STEM related co-curricular activities, and attend social and cultural events.

Study Groups—Group study is strongly and consistently encouraged by the program staff, as study groups are viewed as an important aspect of success in STEM majors.

Program Values—Program values include support for academic achievement, seeking help from a variety of sources, peer supportiveness, high academic goals (with emphasis on Ph.D. or MD/Ph.D. attainment), and giving back to the community.

Program Community—The Meyerhoff program provides a family-like social and academic support system for students. Students live together in the same residence hall during their first year and are required to live on campus during subsequent years.

Staff Academic Advising; Staff Personal Counseling—The program employs full-time advisors who monitor and support students on a regular basis. Staff focus not only on academic planning and performance, but on any personal problems students may have as well.

Summer Research Internships and Academic Year Research—Each student participates in multiple summer research internships often at leading sites around the country, as well as some international locations. Many students also participate in academic year research, including a subset who participate in UMBC's MARC program.

Faculty Involvement—Key STEM department chairs and faculty are involved in the recruitment and selection phases of the program. Many faculty provide opportunities for student lab experience during the academic year to complement summer research internships.

Administrative Involvement—The Meyerhoff Program is supported at all levels of the university, including ardent support from the President (the program co-founder).

Mentors—Students are paired with a mentor who is in a STEM or health care profession in the greater Baltimore/Washington DC area.

An initial study of the program focused on first-year academic outcomes of the first three cohorts of students (Hrabowski & Maton, 1995). Controlling for key background variables, Meyerhoff students achieved both a higher mean overall GPA (3.5 vs. 2.8) and a higher mean science GPA (3.4 vs. 2.4) than an historical sample of equally talented students. In addition, Maton, Hrabowski, and Schmitt (2000) investigated the longer-term impact of the MSP among the first four program cohorts (1989–1992). Meyerhoff students were found to earn higher grades in STEM, graduate with STEM degrees at a higher rate, and attend graduate school in STEM fields at a higher rate than multiple comparison groups.

Individual Predictors of STEM Outcome

Capacity/talent—Although there is an increasing push for a more integrative and comprehensive approach to increasing retention and graduation of minority students in the sciences, traditional cognitive measures of academic preparation and capacity remain

significant predictors of academic success. Among these predictors are grade point averages for high school and college, as well as standardized test scores (e.g., SAT scores). Not surprisingly, overall undergraduate grade point average has been found to be the strongest predictor of applying to graduate school (Doolittle, 1997; Pascarella & Terenzini, 1991; Tsapogas & Cahalan, 1996). For example, Melaney and Isaac (1988) found that honors students and those with an A-average were most likely to pursue advanced degree programs after receiving their baccalaureate degree. Millett (2000) found that high grades in undergraduate coursework predicted the pursuit of a graduate degree for minority students.

Research Excitement—Pre-college interest, expectations and involvement in research have been linked to pursuit of STEM careers. Russell, Hancock and McCullough (2007), for example, found that those who have a pre-college expectation of obtaining a PhD (14%) were two times more likely to participate in undergraduate research than those who did not have such an expectation (7%). Furthermore, those who participated in research because they were truly interested and who became involved in the culture of research were the most likely to experience positive outcomes. Similar inquiries also found that students who engaged in research “described the intrinsic pleasure...in figuring out on (their) own how to address pieces of their research puzzle” (Seymour, Hunter, Laursen, & Deantoni, 2004, p. 528).

The Current Study

The current study extends previous research on the MSP, with a focus on outcome analyses, program components and student experience, and individual predictors of outcome. African-American participants are the primary sample. Specifically, five research questions are addressed: 1) Are MSP students (first 15 cohorts) more likely to enter STEM PhD programs than a comparison sample, with covariates controlled? 2) Which Meyerhoff Program components do students rate as especially helpful? 3) Will factor analysis reveal an underlying dimensional structure (i.e., parsimonious and meaningful grouping of subsets of program components)? 4) When students are asked to spontaneously describe their experiences of program impact in focus groups, what are the major themes that emerge? 5) Are students with higher levels of pre-college research excitement, more positive perceptions of the helpfulness of MSP components, and higher undergraduate GPAs more likely to pursue a STEM PhD, with covariates controlled? Taken together, these five research questions provide insight into the effectiveness of the program in enhancing PhD pursuit, and enhance understanding of both program-level and individual-level factors that appear to contribute to program impact.

Method

Research Participants

Table 1 presents characteristics of the samples for each of the primary aspects of the study.

Post-college outcomes—The 395 African-American Meyerhoff students from the first 15 entering classes (Fall 1989–Fall 2003, median year of entry = 1995) with full study data constituted the Meyerhoff sample for the outcome analyses. An additional 95 African-American Meyerhoff students were not included in the study sample because they were still enrolled as undergraduates in a STEM major (N=26; 5.3% of the potential sample), could not be located at the time of the study and therefore did not have a confirmed post-college outcome status (N=68; 13.9% of the potential sample), or were missing high school GPA (N=1; 0.2% of the potential sample).

The “Declined” comparison sample consisted of 197 African-American students with full study data who were offered admission to the Meyerhoff Program between 1989 and 2003 and declined the offer. In the vast majority of cases these students attended other institutions, mostly selective or highly selective universities. Only students who had declared a science major or who enrolled their freshman year of college in 4 or more STEM courses (or 12 or more STEM credits)—thus viewed as likely pursuing a STEM major—were retained in the sample. The median year of college entry was 1996. An additional 49 African-American students who declined the offer were not included either because they were still enrolled in college in a STEM major (N=16; 6.5% of the potential sample), could not be located at the time of the study and therefore did not have a confirmed post-college outcome status (N=27; 11% of the potential sample), or were missing high school GPA (N=6; 2.4% of the potential sample).

Preliminary analyses revealed several statistically significant differences between samples. The Declined students in the study sample, compared to the MSP students, had a later year of college entry, $t(590) = 2.3, p < .05$, higher high school GPA, $t(590) = 2.8, p < .01$, higher SAT verbal scores, $t(590) = 2.9, p < .01$, and were more likely to be female, $X^2(1) = 14.2, p < .01$ (means are reported in Table 1). SAT math scores did not differ significantly. All of these variables, along with Math SAT, were included as covariates in the outcome analysis. Also of note, although there were no differences between groups in undergraduate GPA, the Declined students (76.5%) were less likely to complete STEM bachelor's degrees than those entering the MSP (90.9%), $X^2(1) = 22.6, p < .01$.

Program components—The 317 African-American Meyerhoff students from the first 15 entering classes (fall 1989–fall 2003) who completed the items assessing program components constituted the Meyerhoff sample for both the descriptive analysis and factor analysis of the program component ratings. Table 1 presents the sample characteristics.

Focus groups—To understand more fully how the program works from the students' perspective, in 2006 we conducted 12 focus groups with students from four different cohorts: 2002 (seniors), 2003 (juniors), 2004 (sophomores) and 2006 (summer prior to freshman year). Table 1 presents the sample characteristics of the 45 African-American participants (African-American Meyerhoffs were the majority of the focus group participants, and the focus of the current study).

Predictors of post-college outcome—The 179 African-American Meyerhoff students from the third through the fifteenth entering classes (Fall 1991–Fall 2003) with no missing data on predictor variables, covariates, or graduate outcomes constitute the sample for the analyses linking predictor variables to outcomes. Students from the first two entering classes (N=34; 6.9% of the potential sample) were not included since we did not begin collection of research excitement data until Summer 1991. An additional 277 African-American Meyerhoff students were not included in the study sample either because they were still enrolled as undergraduates in a STEM major (N=25; 5.1%), did not have a confirmed post-college outcome status (N=65; 13.3%), were missing high school or undergraduate GPA (N=3; 0.6%), did not complete the research excitement measure (N=33; 6.7%), or were missing the program component scales (N=151; 30.8%).

Procedure

Informed Consent—Students completed an informed consent form at the time they applied to the program.

Post-college outcomes—When applying to MSP, students completed a form providing permission to obtain college and future graduate school transcripts from registrar offices at other institutions they might choose to attend. Information on post-college destination was obtained from multiple sources, including program records (in the case of Meyerhoff students), the students, family members, or through Internet or paid searches. Information was confirmed (or clarified) in the vast majority of cases through review of transcripts or by phone calls to graduate and professional school registrar offices.

Program components—Program component items were included as part of process evaluation surveys administered periodically to students. Identifying information was obtained on the cover page. The survey was administered during program-wide meetings in the early years of the program, in later years directly sent to students, and most recently included as part of an exit survey emailed to graduating students (see Maton, Hrabowski, Ozdemir, & Wimms, 2008).

Focus groups—All participants were recruited by research staff either via email or in person and completed written consent. Students from the 2003, 2004, and 2006 entering cohorts were randomly selected to participate while those from the 2002 cohort were a convenience sample of volunteers drawn from the entire class. Students received no monetary compensation for their participation but were provided dinner and, in the case of the 2003, 2004 and 2006 cohorts, credit toward their scholarship program participation requirements. Each focus group lasted an average of an hour and a half and was audio recorded and transcribed. Participants were assigned pseudonyms and the 706 single-spaced pages of text were analyzed using NVIVO 7 software.

Predictors of post-college outcome—Data on research excitement at college entry were collected from the Meyerhoff students in a group meeting during the six-week Summer Bridge orientation program. The research excitement measure was included in a larger set of survey items, and administered by graduate student research assistants. Identifying information was obtained on the cover page.

Undergraduate transcripts were obtained either from the UMBC data base, or for students who chose other universities, from the university registrar's office.

Measures

Demographic and academic background variables—Ethnicity, gender, university entrance date, SAT scores (both math and verbal), and high school GPA were obtained from university application records. Information about parental education was available only for MSP students, obtained at a session during the program's summer bridge orientation session. The highest education level completed by each parent was assessed using a 9-point scale (1=grade school; 2=some high school; 3=high school diploma or equivalent; 4=business or trade school; 5=some college; 6=associate or two-year degree; 7=bachelor or four-year degree; 8=some graduate or professional school; 9=graduate or professional degree). In most cases data were provided on both parents and the scores were averaged; otherwise the sole score provided was used.

Graduate education—The STEM graduate education outcome variable contained four post-college categories: 1) entered PhD STEM program (includes MD/PhD program); 2) entered medical school; 3) entered a STEM master's program or STEM-related professional school (e.g., dental; these categories were combined due to the low numbers of allied health entrants); or 4) no post-college education in STEM (includes students who did not complete college, those who graduated in a non-STEM major, STEM graduates who did not pursue

graduate or professional education, and those who attended non-STEM graduate programs). If a student entered a STEM master's program upon graduation but later entered a STEM PhD program, the latter (i.e., the higher degree program) was coded. However, if a student entered a STEM PhD program but left the program with a terminal master's, or entered a PhD/MD program but only completed the MD aspect, then the degree actually received was counted. STEM was defined to include programs in the physical and life sciences, computer science, engineering, and mathematics; the behavioral and social sciences were excluded.

Program components—Survey items were developed by the research team to assess student perceptions of the majority of the program components. Items included 1) the Summer Bridge program, 2) financial support, 3) being part of the Meyerhoff community, 4) study groups, 5) staff academic advising, 6) staff personal counseling, 7) faculty involvement in the program, 8) academic tutoring services, 9) UMBC administrators' involvement and support, 10) Baltimore/DC-assigned mentor, and 11) summer research experience (this item was added later). The wording of items and the anchors on the 5-point Likert scale were somewhat modified over the years (see Maton, Hrabowski, Ozdemir, & Wimms, 2008). In the most recent version, the question stem reads: “Please indicate the degree to which the following aspects of the Meyerhoff Program have been helpful in your experience as a student.” The most recent rating scale includes five anchors: 1=not at all helpful 2=a little helpful 3=somewhat helpful 4=helpful 5=very helpful. For the subset of students who completed surveys on more than one occasion, responses on the most recent survey were used.

Focus group interview protocol—The focus group protocol focused on how the program works from the students' perspectives. The same types of questions were generally asked in each group, with slight changes in wording and time frames so as to be cohort-specific. Participants identified the program components that were most helpful to them, and more generally discussed what it means to be a Meyerhoff scholar, their goals, and ways in which the program contributes to their success. Examples of questions are, “What has been helpful to you in this program? What are some things that have not been particularly helpful?” and “What does it mean to be a Meyerhoff Scholar?”

Pre-college research excitement—Pre-college research excitement was assessed with a single item developed by the research team. The item read: “I am excited about the idea of doing scientific research.” Students respond on a 5-point Likert-type scale, indicating how accurate a statement this is for them (1=not at all accurate; 3=somewhat accurate; 5=completely accurate).

Undergraduate GPA—Undergraduate GPA was obtained from student transcripts. For students who graduated college, this was their final GPA; for the small number of students who dropped out of college, this was their cumulative GPA before leaving.

Data Analysis Procedures

The five research questions were examined using a variety of analytical procedures. Differences in post-college outcomes between Meyerhoff and Declined students were examined using multinomial logit regression. The relative rankings of student perceptions of the helpfulness of program components were based on calculation of mean scores. The underlying dimensional structure of the helpfulness ratings of program components was established using principal components analysis. As described earlier, qualitative analysis was used to examine the focus group data concerning students' lived experiences in the program. Finally, the independent contributions of predictors of program outcome were examined using multinomial logit regression analysis.

Results

Post-College Outcomes

The first research question addressed program outcomes. To examine trends in outcomes over time, the sample was divided into 1989–1995 and 1996–2003 subgroups (Table 2; as noted earlier, 1996 was the year that the program was opened to students who were not underrepresented minorities). The 1989–1995 African-American Meyerhoff students were 4.3 times more likely to enter STEM PhD programs than their African-American Declined sample counterparts (25.1% vs. 5.8%); this ratio increased to 5.7 when the 1996–2003 Meyerhoff students are compared to their Declined sample counterparts (51.2% vs. 9.0%). Of note, the percentage of Meyerhoff students entering STEM PhD programs doubled from 1989–1995 to 1996–2003. Equally striking is that the percentage of Meyerhoff students not entering any graduate STEM program declined from the earlier to the later time period (28.3% to 19.8%) while the percentage of Declined comparison students doubled (24.4% to 51.4%). Although both Meyerhoff and Declined comparison samples show a dramatic decrease in the percentage of students entering medical school and master's/allied health programs across the two time periods, only the Meyerhoff students appear to be attending STEM PhD programs instead.

Across the entire study period, Meyerhoff students were 4.8 times more likely to attend STEM PhD programs than the Declined comparison students (36.5% vs. 7.6%). A multinomial logit regression analysis was conducted for the full study sample comparing STEM PhD outcome to each of the other graduate outcomes to determine if the observed differences achieved statistical significance. High school GPA, SAT Math and Verbal scores, gender, and year of entry were included as covariates. With the covariates controlled, a significant difference emerged, $X^2(3) = 66.1, p < .001$. Meyerhoff students were significantly more likely than Declined students to enter STEM PhD programs than to enter MD programs (odds ratio = 11.1), master's/allied health programs (odds ratio = 7.9), or no graduate STEM program (odds ratio = 16.7).

A secondary, chi square analysis did not reveal a significant difference between the three subgroups of Meyerhoff and Declined sample students in the “no graduate STEM program” outcome category, $X^2(3) = 4.9, p = .085$. Of the 97 Meyerhoff students who did not pursue STEM graduate education, 64 (66.6%) received STEM undergraduate degrees, 20 (20.6%) graduated in a non-science major, and 13 (13.4%) did not graduate college. In turn, of the 78 Declined students who did not pursue STEM graduate education, 45 (57.7%) received STEM undergraduate degrees, 27 (34.6%) graduated in a non-science major, and 6 (7.7%) did not graduate college.

Program Components

The second research question addressed student perceptions of the relative helpfulness of the different Meyerhoff Program components. Mean scores of African-American MSP students from 1989–1995 and 1996–2003 for each program component item were calculated (Table 3). Across both time periods, the six most highly rated components were: financial scholarship, being part of the Meyerhoff Program community, Summer Bridge, study groups, staff academic advising, and summer research. The two components with the lowest ratings in each time period reflected influences from outside the MSP: UMBC administrators' involvement and support, and Baltimore/DC-area assigned mentors. Although changes in item wording and scaling over the years preclude formal statistical testing of mean level change over time, there appears to be a trend towards increased scores across the two time periods.

The third research question addressed the underlying dimensional structure of the program components. A principal components analysis was conducted for 10 of the 11 components (summer research involvement was excluded due to low sample size). A three-factor solution was selected, consistent with eigenvalue and theoretical considerations (Table 4). The first factor is labeled Core Components, and contains six items: staff academic advising, staff personal counseling, being part of the MSP community, faculty involvement, Summer Bridge, and financial scholarship. The Cronbach alpha coefficient was .78. The second factor is named Academic Help, and contains two items: Study groups in STEM, and Academic tutoring. The correlation between the items was $r=.42$, $p < .001$. Finally, the third factor is called Outside Support and Influence, and also contains two items: UMBC administrators' involvement and support, and Baltimore/DC-area assigned mentor. The correlation between the items was $r=.18$, $p < .01$. The three scales reveal the interrelated nature of most MSP components, and the specificity of a few.

Focus Groups

The fourth research question focused on the themes that emerged in focus groups when students were spontaneously asked to describe their experiences in the program. The focus groups provided rich detail about varied aspects of the student experience. Specific program components, such as financial aid, the program community, Summer Bridge, study groups, and staff academic advising were cited as being particularly helpful. For present purposes, given previous work already published on these components (Maton, Hrabowski, & Schmitt, 2000), we limit attention to what was particularly interesting and somewhat unexpected—the students' focus on program values. We found that program values, a component not generally explored in the academic intervention literature, is central to the students' understanding of, participation in, and successful completion of the MSP. The MSP places high value on supporting outstanding academic achievement, seeking help from a variety of sources, peer supportiveness, high academic goals (i.e., pursuit of the PhD), and giving back to the community and, as such, lists Program Values as one of the key elements of the program. From the onset of their involvement in the program, students are taught to ask for help, discuss challenges, analyze their weaknesses and failures, and to value opportunities to help others. In our analysis, we discovered that, over the course of their undergraduate experience, students have internalized these programmatic values and express them in their own terms as a commitment to excellence, accountability, group success, and giving back. Sample quotes below are from African-American focus group participants.

Commitment to excellence. “I think being a Meyerhoff scholar means being the best.”

A commitment to excellence compels students to achieve in every area of their experience, including attaining exceptional academic marks, participating in research, and taking leadership roles in the campus community. Many students discuss their responsibility to represent themselves, their peers, and future Meyerhoff scholars in the best possible light. They feel a duty to perform to the best of their ability in every endeavor so as to improve both their personal chances for success and the chances of current and future Meyerhoff students.

Accountability. “It helps you stay on point. It's like when you have to get things done, like papers turned in. Even for our meetings...I always forget but then there's someone who will just be like ‘Oh, we have a meeting tomorrow.’ ...So now I let my apartment mates know...”

Accountability is exemplified in the way students discuss interactions with other Meyerhoff peers. Students hold each other accountable for attending meetings or classes, applying for

internships, and submitting graduate school applications. They are also aware and mindful of how their actions reflect on others in the group.

Group success. “Well, like we're a family. So...if we all stand together, work together, we'll all have a bright future.”

The value of group success reinforces the students' commitment to excellence and motivates them to interact with other students in the Meyerhoff community who may be struggling to achieve in a specific area. They also acknowledge that their success is partly due to the efforts of the students who came before them. As a group, students discuss their responsibility to make sure that everyone in the group is successful. The other aspect of that responsibility is the benefit of understanding that if they are the ones needing help, it will be forthcoming.

Giving back. “I think there is a large part of the program that's about giving back to those who are younger than you and to really try to be something that somebody else would look up to. And trying to help younger kids figure out what they want to do.”

Meyerhoff students explicitly state that they feel a responsibility to give back to the program as well as to the larger community. Students give back to the program itself through program promotion, and advising and tutoring their Meyerhoff peers. Many also work as tutors on campus and with high school students. Volunteer work in the larger community is another way in which the students give back. Furthermore, many students mention the value of giving back as a contributing factor to their career goals, finding avenues through which they can tutor, mentor, provide networking, training or employment opportunities, or even direct service to others in their communities. They express gratitude for the opportunities they received and a desire to lead both by example and deed.

Predictors of Post-College Outcome

The final research question examined pre-college research excitement, perception of the helpfulness of program components, and undergraduate GPA as predictors of pursuit of a STEM PhD. The top half of Table 5 presents the mean values on each predictor variable for each of the four categories of graduate outcome. The bottom half of the table presents the corresponding information for the covariates.

Zero-order correlations among the five predictor variables were calculated. Research Excitement was positively related to Core Components, $r=.18$, $p < .05$, and Outside Support and Influence, $r=.24$, $p < .01$. Undergraduate GPA was positively related to Core Components, $r=.23$, $p < .01$. Finally, each of the three Meyerhoff component scales was positively and significantly related to each other (r s ranging from .25 to .41).

A multinomial logit regression analysis was conducted to determine the unique contributions of the predictor variables, with graduate outcome the criterion variable. Contrasts were examined between STEM PhD and each of the other outcome categories, as it seemed reasonable to assume that students pursuing medical school, master's degree programs and no STEM post-college would not be equivalent in either pre-college or college characteristics. High school GPA, SAT Math and Verbal, Gender, Parental Education, and Year of Entry were included as covariates.

Meyerhoff students pursuing STEM PhDs reported significantly higher levels of pre-college research excitement than those in the three other outcome categories (Table 6). Specifically, for each full point increase on the research excitement measure, they were 2 times more likely to pursue a STEM PhD than those pursuing medicine, 1.8 times more likely than those pursuing a master's, and 1.9 times more likely than those not pursuing any post-college

STEM. Furthermore, for each full-point increase in undergraduate GPA, students were 23.4 times more likely to pursue a STEM PhD than a STEM master's, and 97.1 times more likely to pursue a STEM PhD than not to pursue any post-college STEM. There was not a significant difference between STEM PhD and medical school in terms of undergraduate GPA, however.

For each point increase on the Outside Support & Influence measure, students were 1.5 times more likely to pursue a STEM PhD than a STEM master's, and equivalently were 1.5 more likely to pursue a STEM PhD than not to pursue any post-college STEM. There was not a significant difference between students pursuing STEM PhDs and medical school in terms of this variable. Finally, counter to expectation, STEM PhD students did not differ from any of the other three groups on the Core Components measure, and were significantly less likely to seek academic help than students pursuing a medical degree (odds ratio = 0.8).

Discussion

The current findings suggest that the Meyerhoff Program is an effective intervention, enhancing the number of African-American youth who pursue graduate education in STEM PhD programs. The number of program graduates pursuing the PhD has doubled in recent years. Based on the broad array of core program components rated highly by students, it appears it is the combination of components rather than any one or two individual components that is responsible for program effectiveness. Furthermore, focus group findings point to a potentially important psychological mediating variable contributing to student success: incorporation of the key program values. Finally, multinomial regression findings reveal that research excitement at college entry is the only predictor variable that uniquely distinguishes Meyerhoff students who pursue a STEM PhD program from those who do not, while undergraduate GPA, and benefit perceived from outside influence and support contribute to the success of both those pursuing PhD and medical degrees. Each of the study findings is discussed below.

Program Outcomes

The current findings support earlier published findings of positive Meyerhoff Program impact (e.g., Maton, Hrabowski, & Schmitt, 2000), and more generally positive outcomes from related programs (Carmichael, Labat, Hunter, Preivett, & Sevenair, 1993; Barlow and Villarejo, 2004). Meyerhoff students who entered the program in 1989–2003 were more likely to attend STEM PhD programs than comparison sample students who were accepted into the program but declined the offer and initiated STEM coursework elsewhere. The Meyerhoff students did not have higher SAT scores or high school GPAs than comparison students, suggesting that their higher levels of STEM PhD pursuit were not due to greater pre-college preparation or capability. Also, both Meyerhoff students and comparison students pursued STEM coursework as freshmen, suggesting that the Meyerhoff and Declined students entered college with comparable interest in STEM. Nonetheless, in the absence of random assignment, it cannot be ruled out that the groups differed, at least to some extent, in other characteristics (e.g., research excitement) which may have contributed in part to outcomes.

Of special note, the percentage of Meyerhoff students in STEM PhD programs doubled between 1989–1995 and 1996–2003. This dramatic increase in Meyerhoffs attending STEM PhD programs may be due to a number of factors, including the program attracting more PhD-focused, better prepared students in more recent years, improvements over time in program quality, and the program's enhanced national reputation. Surprisingly, the percentage of comparison sample students not attending any graduate program at all doubled across this span of time. It is not clear what explains this decline; to some extent this may

reflect lower success rates in STEM majors, a retreat from affirmative action, enhanced competition (e.g., international students), and increased opportunities to pursue other career paths.

Program Components

Financial support, being part of the Meyerhoff community, Summer Bridge, study groups, staff academic advising, and summer research opportunities were rated by students in both the 1989–1995 and 1996–2003 time periods as providing the greatest benefit. Each addresses an important challenge facing minority students pursuing undergraduate STEM degrees. Financial support allows students to afford college and to focus exclusively on their studies rather than working during college (Georges, 1999). Being part of the Meyerhoff community, with its critical mass of high achieving African-American peers, contributes to both academic and social integration, which are important for student retention and enhancing student academic success (Gandara & Maxwell-Jolly, 1999; Seymour & Hewitt, 1997). Similarly, the Summer Bridge program helps students become adjusted to college life prior to their first full semester, while developing peer support networks and friendships as they prepare to handle the demands of freshman year. Study groups provide students the opportunity to provide and receive academic help in difficult STEM courses, and have been linked to academic gain in previous research (Gandara & Maxwell-Jolly, 1999; Moreno et al., 1999). Staff academic advising is important to help students make informed, strategic decisions about the number and type of courses to take (and retake), and which possible research opportunities to pursue (Gandara & Maxwell-Jolly, 1999; Seymour & Hewitt, 1997). Finally, participation in research provides students critical experience and knowledge, as well as opportunities to develop personally and professionally rewarding relationships with leading researchers (Bauer & Bennett, 2003; BEST, 2004; Hunter, Laursen, & Seymour, 2007).

In our view, the multi-faceted, comprehensive nature of the program, addressing multiple areas of minority student need and challenge, explains its high levels of success over time. Further evidence of the integrated nature of key program components was provided by the vast majority of highly rated components loading together on the Core Program Components factor in the principal components analysis. Apparently, students who benefit from any core component are also likely to benefit from the others.

Program Values

While focus groups provided even further evidence for the importance of the Core Components, it became clear that the internalization and expression of program values is an important process which supports students' success. Although Program Values is listed as a distinct component of the MSP, it underlies almost all the other components, further illustrating their overlap and integration. Program values are introduced to the students during the interview process and are instilled during Summer Bridge, an intensive 6-week residential program preceding freshman year. During this summer program, explicitly defined program values including support for outstanding academic achievement, a willingness to ask for help and to discuss challenges and analyze weaknesses or failure, and valuing opportunities to support and tutor others underlie all of the students' activities. Throughout their undergraduate careers, students participate in regular Meyerhoff meetings where academic achievement is reinforced and supported, students seek and receive help from peers and staff, and social and academic connections are reinforced. It is this process of explicitly stating and repeatedly reinforcing program values that links the academic with the social and is critical for success. It is clear that Meyerhoff scholars have embraced the programmatic values, internalized them as their own, and use them to guide their actions.

Research we are currently conducting with program alumni supports these findings and indicates that these internalized values are maintained over time and play a large role in participants' aspirations and success. It may be useful for other programs to add or expand value-based components to enhance success, in part, through a more comprehensive approach.

Predictors of Program Outcome

Meyerhoff students with higher levels of research excitement at college entry were more likely to pursue STEM PhDs (or MD/PhDs) than medical school only, a master's or allied health degree, or no graduate education in STEM. This finding is consistent with extant research, linking research interest with PhD pursuit (Russell, 2006). Such research passion likely serves several functions. It motivates students to pursue a research career, and also may help them achieve academically--through enhancement of critical thinking (and related skills) nurtured in the research context. It also may link them to a like-minded community of scholars—including a research mentor and the post-docs, graduate students and other undergraduate students in their lab--who further encourage, support and prepare them for successful entry into a PhD program.

Undergraduate GPAs were higher for students who entered STEM PhD programs than those who entered master's and allied health programs, or who did not pursue STEM post-college. This finding is not surprising, as a strong GPA is a key qualification for PhD program entry (Millett, 2000). It is not clear, however, why the two latter groups of students achieved lower GPAs, since it does not appear that they were less capable, given that pre-college academic variables were statistically controlled. It is possible, however, that they were less motivated due to different levels of aspiration--either pre-college or resulting from their college experience. Of note, there was not a statistical difference between students pursuing the PhD and those pursuing medical school, perhaps in part because both require high grades for graduate entry.

Unexpectedly, those with higher Core Component scores were not more likely to pursue PhDs than those in the three other outcome categories. This suggests that the PhD students do not perceive unique benefit from the program. This is consistent with the relatively high core components scores for students as a whole, and suggests that the program has something to offer many students, independent of level of graduate education pursued, once all other variables are taken into account.

Outside Influence and Support was reported as more beneficial by students pursuing STEM PhDs than those in master's or allied health or no post-college STEM. Interestingly, overall mean student ratings on the two items that make up this component were modest. The subset of students who rated UMBC administrators' involvement and support high, however, may have benefitted from high levels of motivational influence and personal support from the African-American president of the university (and program co-founder). Similarly, the subset of students who rated the helpfulness of their assigned Baltimore-Washington STEM mentor high may have more likely to be positively influenced by motivating messages and personal support from their mentor related to the pursuit of higher levels of post-college STEM education.

Unexpectedly, students pursuing a medical degree reported greater benefits from Meyerhoff Program related academic help than those pursuing a STEM PhD (although both groups reported relatively high levels of benefit). This may reflect a greater motivation on the part of pre-med students to take advantage of the benefits of study groups and academic tutoring. Alternatively, it is possible that the PhD bound students had less need of such help, and so rated it as less important.

Limitations

This study has a number of limitations. Possible self-selection differences between Meyerhoff and comparison students limit the strength of the conclusions that can be drawn about the outcome findings. That is, students who opted to attend the MSP may be more committed initially to obtaining a PhD than those who declined the admissions offer. It should be noted, though, that all students accepted into the program expressed a strong interest in pursuing a STEM PhD and began college with a STEM focus. Only a random assignment design would provide a definitive means to overcome this design weakness, a design that is difficult to implement in this research area.

A second limitation relates to the unknown reliability and validity of the program component measures. Such ratings are generally of concern methodologically given their subjectivity. Nonetheless, the items do possess strong face validity.

One limitation of the focus group design is the relatively small number of students who took part. Additional analyses are planned with a larger set of groups. Although focus groups have the advantage of stimulating new perspectives and insights in the group context, there is an inherent risk that a few individuals might dominate the discussion or that some participants might be reluctant to express opposing views. We limited these risks in the current study by using experienced moderators, skilled in drawing out all participants and in creating an open environment.

A limitation of the predictors of outcome analysis was the lack of analysis of multiple pathways of influence—that is, both direct and indirect relationships among covariates, pre-college predictors and college predictors. The unknown reliability and validity of the single-item measure of research excitement represents an additional limitation. Yet another limitation was the lack of a measure of the nature, quality and quantity of student's involvement in research, and with a research mentor.

Finally, the generalizability of findings to programs in different universities and with differing arrays of program components is likely limited. The Meyerhoff Program is relatively unique in its focus, its comprehensiveness, its high level of resources and the high levels of commitment of the university administration to its success.

Future Research and Conclusion

The limitations notwithstanding, the current study represents one of the few systematic examinations of a college-based intervention program designed to increase STEM PhDs among underrepresented minority students. Future research should include systematic comparisons of different intervention approaches, use of established measures of known reliability and validity, in-depth examination of the student experience, the role of funding for program staff and students, and longitudinal tracking of outcomes through receipt of the PhD and beyond (i.e., STEM career options including academic research, teaching, corporate opportunities, and policy). Furthermore, in addition to research focused on interventions during college, the results of the current study suggest that research examining interventions that enhance STEM research interest and excitement prior to college entry are important. Relatedly, an interesting question for future research is the relationship between level of pre-college research excitement and quality of subsequent research experiences in college, including students' relationships with research mentors.

In conclusion, enhancing the academic success of underrepresented minority students in the STEM fields is a pressing national priority. It represents both an economic necessity so that our nation can stay competitive in the global economy, and a critical part of our nation's larger social justice agenda. Increased understanding of the effectiveness of STEM

programs, and the program components and individual student predictors that contribute to positive outcomes, represents a critical priority for future work. The current study represents one contribution to this important research agenda.

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Table 1

Sample Characteristics for Each Aspect of Study

	Outcomes		Program Components		Focus Group	Individual Predictors
	Meyerhoff	Declined				
Sample Size (N)	395	197	317	45	179	
Year of Entry	1989–2003	1989–2003	1989–2003	2002–04, 06	1991–2003	
Gender (female)	50%	66.0%	51%	47%	51%	
Verbal SAT	626.4	641.5	621.6	620.7	618.9	
Math SAT	647.1	651.8	644.8	648.6	644.4	
High School GPA	3.67	3.76	3.67	3.89	3.64	

Post-College STEM Outcomes for African-American Meyerhoff and Declined Comparison Sample Students: 1989–1995, 1996–2003, and 1989–2003

Table 2

	1989–1995 Entering Cohorts		1996–2003 Entering Cohorts		1989–2003 Entering Cohorts ^a	
	Meyer.	Declined	Meyer.	Declined	Meyer.	Declined
STEM PhD	25.1%	5.8%	51.2%	9.0%	36.5%	7.6%
MD	20.6%	44.2%	12.2%	20.7%	17.0%	31.0%
STEM MS/Allied Health	26.0%	25.6%	16.9%	18.9%	22.0%	21.8%
No Grad STEM	28.3%	24.4%	19.8%	51.4%	24.6%	39.6%
TOTAL	100.0% (N=223)	100.0% (N=86)	100.0% (N=172)	100.0% (N=111)	100.0% (N=395)	100.0% (N=197)

^aFor 1989–2003, Meyerhoff students were significantly more likely than Declined students to enter STEM PhD Programs than to enter: 1) MD programs (odds ratio = 11.1, wald(1) = 25.7, B = 2.4, p < .001); 2) master's/allied health programs (odds ratio = 7.9, wald(1) = 19.7, B = 2.1, p < .001); 3) no graduate STEM program (odds ratio = 16.7, wald(1) = 45.9, B = 2.8, p < .001).

Table 3
Perceived Benefit of Meyerhoff Program Components African-American Meyerhoff Students, 1989–1995 & 1996–2003

	1989–1995			1996–2003		
	Mean	Standard Deviation	N	Mean	Standard Deviation	N
Financial scholarship	4.5	1.0	171	4.8	0.7	135
Being part of the Meyerhoff Program community	4.2	0.9	169	4.6	0.8	136
Summer Bridge	4.0	1.2	168	4.5	0.8	136
Study groups	3.9	1.2	168	4.4	1.0	145
Staff academic advising	3.6	1.1	169	4.3	0.9	136
Summer research	3.6	1.4	72	4.1	1.3	53
Staff personal counseling	3.5	1.3	166	4.0	1.2	135
Faculty involvement	3.2	1.2	164	4.0	1.0	135
Academic tutoring services	3.2	1.4	145	3.8	1.1	137
UMBC administrators involvement & support	2.3	1.4	167	3.2	1.1	145
Baltimore/DC-area assigned mentor	3.2	1.2	168	2.9	1.5	125

Table 4

Perceived Helpfulness of MSP Program Components Factor-Derived Scales: African-American Meyerhoff Students, 1989–2003

	Core Components	Academic Help	Outside Support & Influence
Staff academic advising	.80	.10	.15
Staff personal counseling	.79	.11	.06
Being part of the Meyerhoff Program community	.61	.17	.24
Faculty involvement	.61	-.13	.48
Summer Bridge	.60	.28	-.03
Financial scholarship	.45	-.04	.35
Academic tutoring services	.19	.83	.03
Study groups in STEM	.08	.78	.18
UMBC administrators involvement & support	.01	.28	.70
Baltimore/DC-area assigned mentor	.23	.03	.67

Table 5
 Predictor Variables and Covariates by Post-College Outcome: African-American Meyerhoff Students, 1989–2003

	Post-College Outcome				
	PhD (N=58)	MD (N=44)	Master's (N=37)	No Grad (N=40)	Total (N=179)
<u>Predictors</u>					
Research Excitement at College Entry	4.22 (1.1)	3.55 (1.1)	3.54 (1.1)	3.60 (1.2)	3.78 (1.2)
Undergraduate GPA	3.51 (.28)	3.44 (.29)	3.21 (.30)	3.06 (.42)	3.33 (.37)
Core Components	25.0 (4.5)	24.5 (4.1)	24.4 (4.8)	22.2 (3.9)	24.1 (4.4)
Outside Support & Influence	6.2 (2.1)	6.3 (1.9)	5.1 (2.0)	5.0 (1.8)	5.7 (2.1)
Academic Help	7.1 (2.4)	7.8 (1.8)	7.4 (2.1)	7.6 (2.3)	7.4 (2.2)
<u>Covariates</u>					
Gender (female)	57%	57%	30%	55%	51%
High School GPA	3.8 (0.3)	3.7 (0.3)	3.5 (0.3)	3.5 (0.3)	3.6 (0.3)
Math SAT	654.7 (43.6)	637.7 (40.0)	644.3 (42.1)	637.0 (47.9)	644.4 (43.8)
Verbal SAT	612.8 (61.5)	624.8 (42.7)	624.1 (47.6)	616.8 (59.1)	618.9 (53.9)
Parental Education	6.8 (1.6)	6.3 (2.1)	6.3 (2.2)	6.5 (1.7)	6.5 (1.9)
Year of Entry	1996.5 (3.6)	1994.5 (3.5)	1994.7 (3.7)	1994.8 (3.5)	1995.3 (3.6)

Note: Number in parentheses below means are standard deviations.

Table 6
 Multinomial Logit Regression Results: African-American Meyerhoff Students, 1991–2003 (N=179)

Predictor	Overall Effect X ² (df=3)	CONTRAST: STEM PhD vs.											
		MD				Master's				No Grad STEM			
		B	SE	Wald	Odds Ratio	B	SE	Wald	Odds Ratio	B	SE	Wald	Odds Ratio
<i>Variable</i>													
Research Excitement	11.4**	.67	.23	8.8	2.0**	.61	.25	5.9	1.8*	.62	.25	5.9	1.9*
Undergraduate GPA	34.7*	.57	.84	0.5	1.8	3.2	.94	11.3	23.4**	4.6	.99	21.3	97.1**
Outside Support & Influence	16.8**	-.03	.13	0.1	1.0	.40	.15	7.3	1.5**	.43	.16	7.4	1.5**
Academic Help	6.9	-.29	.12	5.3	0.8*	-.19	.13	2.0	0.8	-.26	.14	3.6	0.8
Core Components	6.4	.02	.07	0.1	1.0	-.12	.07	2.9	0.9	.02	.07	0.1	1.0
<i>Covariates</i>													
Gender (female)	8.4*	.02	.47	0.0	1.0	-1.1	.54	4.2	.33*	.25	.55	0.2	1.3
SAT Math	5.5	.01	.01	4.6	1.0*	.01	.01	2.4	1.0	.01	.01	2.8	1.0
HS GPA	4.6	.09	.81	0.0	1.1	1.6	.87	3.5	5.1	.46	.87	0.3	1.6
SAT Verbal	3.6	-.01	.00	1.6	1.0	-.01	.01	3.1	1.0	-.01	.01	1.1	1.0
Parental Education	2.7	.14	.12	1.3	1.2	.09	.14	0.4	1.1	-.06	.14	0.2	0.9
Year of Entry	1.8	.12	.09	1.6	1.1	.03	.11	0.1	1.0	.06	.10	0.4	1.1

* $p < .05$

** $p < .01$