Developing Talent to Increase Diversity in Biomedical Sciences Workforce: Introduction to Third Article in Feature Series. Feature Eds: Terry A. Krulwich, PhD, and Suman Saran, MPH, Mount Sinai School of Medicine, New York, NY, and Richard McGee, Jr., PhD, Feinberg School of Medicine, Northwestern University, Chicago, IL. The article by Maton *et al.* in this issue of the *Mount Sinai Journal of Medicine* is the third article in a series of four articles whose theme is increasing diversity of the biomedical sciences workforce. Maton *et al.* describe the history and theoretical framework behind an acclaimed institution-wide effort at the University of Maryland Baltimore County to increase diversity, with the "strengths-based" undergraduate Meyerhoff Scholars Program at its center. The review summarizes results of ongoing evaluation of outcomes and describes research into how the Meyerhoff Program educates and empowers students to enter and successfully navigate PhD and MD/PhD programs.

Meyerhoff Scholars Program: A Strengths-Based, Institution-Wide Approach to Increasing Diversity in Science, Technology, Engineering, and Mathematics

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Published online in Wiley Online Library (wileyonlinelibrary.com).
DOI:10.1002/msj.21341

ABSTRACT

The Meyerhoff Scholars Program at the University of Maryland, Baltimore County is widely viewed as a national model of a program that enhances the number of underrepresented minority students who pursue science, technology, engineering, and mathematics PhDs. The current article provides an overview of the program and the institution-wide change process that led to its development, as well as a summary of key outcome and process evaluation research findings. African American Meyerhoff students are 5× more likely than comparison students to pursue a science, technology, engineering, and mathematics PhD. Program components viewed by the students as most beneficial include financial scholarship, being a part of the Meyerhoff Program community, the Summer Bridge program, study groups, and summer research. Qualitative findings from interviews and focus groups demonstrate the importance of the Meyerhoff Program in creating a sense of belonging and a shared identity, encouraging professional development, and emphasizing the importance of academic skills. Among Meyerhoff students, several precollege and college factors have emerged as predictors of successful entrance into a PhD program in the science, technology, engineering, and mathematics fields, including precollege research excitement, precollege intrinsic math/science motivation, number of summer research experiences during college, and college grade point average. Limitations of the research to date are noted, and directions for future research are proposed. ***Mt Sinai J Med 79:610–623, 2012.*** *© 2012 Mount Sinai School of Medicine*

Key Words: African Americans, engineering and mathematics support program, evaluation research, science, strengths-based, technology.

In recent decades, there has been strong emphasis on the need for producing more American researchers in the areas of science, technology, engineering, and mathematics (STEM).[1] To prepare the future US workforce to be competitive globally, it is critical for our nation to invest in and build a cadre of scientists who are prepared to embrace innovative approaches to STEM research. One of the ways to address the current shortage of STEM researchers is to focus on increasing the broad participation of Americans from a range of racial/ethnic backgrounds, especially those groups that have previously been underrepresented in STEM, such as African Americans, Hispanics, and Native Americans. Efforts to increase diversity are especially important for the biomedical workforce.[2,3] As the nation grows increasingly more diverse, so do the consumers of our nation's health care. Therefore, the participation of underrepresented minority groups in research is critical to address the burgeoning health needs of our increasingly diverse population. Data from the 2010 US Census indicate that African Americans, the focus of the current article, make up 12.6% of the population (with Hispanics making up 16.3% and American Indians and Alaska Natives 0.9%).[4] However, in 2010, African American students represented only 2.5% of U.S. doctoral degree recipients in STEM fields.[5]

As our nation grows increasingly more diverse, it provides our country with a unique challenge. Specifically, American colleges and universities increasingly need to be able to train and supply our economy with the brightest and most talented students in STEM fields and simultaneously address the underrepresentation of minority-group members by making sure that all demographic groups have the opportunity and preparation to contribute to the STEM workforce. It is clear that diversification of the STEM workforce cannot be achieved by simply increasing the number of underrepresented minority students that pursue STEM degrees; a more sophisticated approach is needed to cultivate students who are adequately prepared to pursue careers in research.[6]

American colleges and universities increasingly need to be able to train and supply our economy with the brightest and most talented students in the fields of science, technology, engineering, and mathematics (STEM) and simultaneously address the underrepresentation of minority-group members by making sure that all demographic groups have the opportunity and preparation to contribute to the science, technology, engineering, and mathematics workforce.

Findings indicate several junctures on the route to a STEM career where underrepresented students are displaced.[7] These junctures can and do occur at a

DOI:10.1002/MSJ

range of time points, including prior to college, after selecting a STEM major, and even after receiving a graduate degree. Even among those who persist and complete the PhD, research indicates a steep decline in the representation of African American students at the postdoctoral and junior faculty levels. Furthermore, a recent study found that African Americans are less likely than their White peers to successfully attain funding for National Institutes of Health Research Project (R01) grants even after controlling for several factors, including publication record and training.[8] Together, these findings imply that comprehensive interventions are needed to assist minority students at a variety of transitions to ensure that they are adequately prepared to pursue STEM research careers.

THEORY OF PROBLEM

Four sets of factors appear necessary to enhance minority students' success in the sciences,[9] including academic and social integration, knowledge and skill development, support and motivation, and monitoring and advising.

Academic and social integration appear to be critical to the success of African American STEM majors, including highly able students. Black students are more likely than White and Asian American students to experience both academic and social isolation on majority White campuses and in science majors. Contact with faculty outside the classroom and mentoring relationships with faculty can decrease academic isolation and contribute to positive outcomes. Additionally, a critical mass of highly able Black peers can enhance academic and social support and reduce perceptions of racism–contributing to persistence and success in STEM fields.[6,10,11]

Mastery of the subject material and development of several critical skills using proven methods are essential for student self-confidence and success. For example, involvement in peer study groups has been found to result in enhanced technical knowledge mastery and course performance for STEM minority students (EW Gordon and BL Bridglass, data from unpublished report on Meyerhoff Scholars Program). Furthermore, strong study habits, time-management skills, analytic problem-solving capacity, and the willingness to use available campus resources have been linked to positive outcomes.[6,12]

Support and motivation represent a third wave of factors that have been linked to minority-student success in STEM majors. Financial aid continues to be a cornerstone of support; it is difficult to succeed in these fields if students have to worry about expenses or work (outside of STEM) to pay bills. The rigor of STEM courses and the attractiveness of other majors necessitate additional support, including high faculty expectations, hands-on resource experience, academically supportive friendship networks, involvement with faculty or staff, tutoring, as well as emotional support during times of stress and difficulty.[6,13,14]

Ongoing monitoring and advising can help STEM students make prudent academic decisions in selecting course work, assist with preparation for graduate study, and prevent or counter the influence of academic or personal problems. Consistent monitoring can help ensure regular assessment of a student's academic and social situation and provide early warning signs of emerging problems each semester. Advising and feedback can provide students with valuable input about their strengths, areas for improvement, and decision options. Taken together, personalized monitoring and advising can help ensure that students do not fall short due to inadequate counsel and support.[6,12,14]

MEYERHOFF SCHOLARS PROGRAM AT UNIVERSITY OF MARYLAND, BALTIMORE COUNTY

The Meyerhoff Scholars Program at the University of Maryland, Baltimore County (UMBC), was founded in 1988 as a multifaceted support program to enhance the achievement of African American students in the sciences.[15] The program was created with the goal of developing a comprehensive program focused on the specific factors associated with minority-student success in STEM subjects noted above.[16] The program provides students with financial, academic, and social support while encouraging collaboration, close relationships with faculty, and immersion in research.

The Meyerhoff Scholars Program at the University of Maryland, Baltimore County, provides students with financial, academic, and social support while encouraging collaboration, close relationships with faculty, and immersion in research.

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The program incorporates multiple components, briefly described here.

- Financial scholarships: The Meyerhoff Program provides students with a comprehensive financial package that generally includes 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 2 recruitment weekends on the campus.
- Summer bridge: Meyerhoff students attend a mandatory prefreshman Summer Bridge Program and take courses in math, science, and Africana studies. They also 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 PhD or MD/PhD 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. The 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 participates in UMBC's Minority Access to Research Careers 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 laboratory 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).
- Community service: Meyerhoff students are encouraged to volunteer in the city of Baltimore to help inner-city neighborhoods and youth.
- External mentors: Students are paired with a mentor in a STEM or health care profession in the greater Baltimore/Washington, DC area.
- Family involvement: Parents are included in social events and kept advised of their student's progress.

DEVELOPMENT OF MEYERHOFF SCHOLARS PROGRAM: INSTITUTIONAL CHANGE PROCESS

The development and evolution of the Meyerhoff Program cannot be understood in isolation from the larger university context and institutional change process within which it was embedded. Change efforts were initiated at UMBC in the latter part of the 1980s to address a negative racial climate at UMBC, particularly as perceived by African American students and faculty. The institution-wide change effort was spearheaded by Freeman Hrabowski, who began working at UMBC in spring 1987 as vice-provost. Specifically, the UMBC President's Council, led by then-president Michael Hooker, decided to undertake a major initiative focused on inclusive excellence. A fundamental element of this institutional change included establishing a dialogue on campus through campus-wide focus groups held with students, faculty, and staff in order to develop further understanding of the problem.[17] As part of this process, administrators and faculty members in science, engineering, and math were assembled to develop a greater understanding of why students were not succeeding in the STEM disciplines–with the ultimate goal of improving academic performance. An important part of these efforts was the use of data-based reviews of minority student performance, which revealed that the grade point averages (GPAs) of black students were far below those of whites and Asians.

Based on what was learned from the meetings and focus groups, additional meetings were held with department chairs and faculty to develop strategies for giving more support to students. Solutions included encouraging group study, strengthening the tutorial centers, encouraging faculty to provide feedback to students earlier in the semester, raising admission standards, helping students understand how much time and effort are needed to succeed, and enhancing the freshman experience (eg, improving orientation, communicating what it takes to succeed). Furthermore, a vision was generated to develop a more positive climate for students of color by creating a core group of African American students in

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science and engineering who would become leaders and role models for the country. Once funding was obtained, the latter vision resulted in the creation of the Meyerhoff Scholars Program.

The Meyerhoff Scholars Program began in 1988 with generous support from Robert and Jane Meyerhoff, local philanthropists interested in enhancing the representation of African American males in science and engineering. The funding was used to provide financial assistance, mentoring, advising, and research experience to African American male undergraduate students committed to obtaining STEM PhD degrees. In the first year, the program admitted only African American males. In 1990 the program was expanded to include female students, and in 1996 the program was opened to students of all backgrounds who were committed to increasing the representation of minorities in science and engineering. The opening of admissions has not resulted in a decline in the quality of entering students, their experience in the program, or their academic outcomes.[18] The current composition of the program is 53.4% African American (N = 156), 21.9% White (N = 64), 18.5% Asian/Pacific Islander (N = 54), 5.8% Hispanic (N = 17), and 0.3% American Indian (N = 1).

The program continues to use a nomination-based application process, which is open to prospective undergraduate students of all backgrounds who plan to pursue doctoral study in the sciences or engineering and who are interested in the advancement of minorities in those fields. Prospective students are identified primarily through extensive professional networks of educators, advisors, and counselors who share information about the program and nominate potential students. Applicants are evaluated by Meyerhoff Program staff based on academic criteria and a demonstrated interest in research and coursework in the STEM fields, including SAT scores, high school GPA, performance in rigorous courses in math and science, references from science or math instructors, and prior research experience. Additionally, a student's interest and commitment to research and graduate study in the sciences, as well as a desire to contribute to their community, are strongly considered. The UMBC received >2500 nominations and >520 applications (86% from Maryland students) for 60 available positions in the 2012 freshman Meyerhoff Class. The top 100–150 applicants are identified and invited, with their families, to one of 2 recruitment weekends in the spring semester on the campus of UMBC, during which time applicants and their families receive further information about the program and engage with current students, faculty, and administrators. For a more detailed description of the selection process, we refer the reader to a study of the Meyerhoff Program currently in press.[19]

The Meyerhoff Scholars Program is now more than 1000 strong, with 700 alumni across the nation and 300 students currently enrolled in graduate and professional programs. Of note, Freeman Hrabowski, the program co-founder, was appointed UMBC president in 1992, a position he holds to this day.

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MEYERHOFF PROGRAM EVALUATION

The evaluation of the Meyerhoff Program has been ongoing since 1990. Key evaluation questions include (1) is the program successful in terms of academic outcomes? (outcome evaluation) and (2) if so, why? (process evaluation). The evaluation of the program has been funded over the years by various public and private sources, including the National Science Foundation, the National Institutes of Health (National Institute of General Medical Sciences), and the Atlantic Philanthropies. Over the past 2 decades, a large number of graduate and undergraduate students have contributed to the evaluation effort. Key evaluation tasks include (1) obtaining signed consent from students at the time they apply to the program, as well as written permission to obtain transcripts in future years from university registrar's offices; (2) tracking of Meyerhoff and comparison sample students (>1500 students) through their undergraduate and graduate education, including payment for periodic brief interviews about current status and future plans; (3) obtaining transcripts from university registrar's offices related to undergraduate and graduate fields of study and academic outcomes; and (4) completion of surveys, and participation in interviews and focus groups that focus on academic experience and program components (primarily Meyerhoff students).

OUTCOME EVALUATION FINDINGS

Academic outcomes of the Meyerhoff Scholars Program have been reported in a number of articles and chapters since 1995. The earliest published accounts focused on freshman-year performance, followed by a focus on graduation rates and college GPA, and in

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recent years a focus on graduate-school matriculation. Throughout, the primary focus has been on outcomes for the African American students in the program. The earliest comparison samples were limited to equally talented UMBC students not involved with the program, but since 2000 research has focused on comparisons between Meyerhoff students and "Declined" students—students who applied to and were accepted into the Meyerhoff Program, but declined the offer. In the vast majority of cases, these students attended other institutions, mostly selective or highly selective universities. Only Declined sample students who (1) had declared a STEM major or (2) during their freshman year of college enrolled in ≥4 STEM courses (or ≥12 STEM credits)—thus viewed as likely pursuing a STEM major—were retained in the sample. Analyses of the comparability of the African American Meyerhoff and Declined samples on precollege academic characteristics for the sample examined in the current article (see below) indicate that the Declined sample had significantly higher SAT math (mean, 667.4) and verbal (mean, 646.2) scores than the Meyerhoff students (math 658.7, verbal 630.2), and that the groups did not differ on high school GPA. Findings by time period (earlier versus later cohorts) and by gender have also been examined. Finally, STEM PhD receipt has been examined in national data comparing UMBC with other universities in terms of baccalaureate origins of STEM PhDs. The various findings are summarized below, beginning with the earliest studies.

COLLEGE OUTCOMES IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS

An initial study of the program focused on first-year academic outcomes of the first 3 cohorts of students.[16] Controlling for key background variables, Meyerhoff students achieved both a higher mean overall GPA (3.5 versus 2.8) and a higher mean science GPA (3.4 versus 2.4) than a UMBC historical sample of equally talented students. In addition, Maton *et al* investigated the longer-term impact of the program among the first 4 program cohorts (1989–1992).[9] Meyerhoff students were found to earn higher grades in STEM and graduate with STEM degrees at a higher rate than the Declined comparison sample.

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POSTCOLLEGE OUTCOMES

Entry Into PhD Programs for Science, Technology, Engineering, and Mathematics

Postcollege outcomes of the Meyerhoff Scholars Program have been reported in a number of articles and chapters since 2000.[2,9,20,21] Findings have consistently shown that Meyerhoff students are much more likely to enter STEM PhD programs than the Declined comparison sample. The most recent findings were calculated for the current article (Table 1). As seen in the final 2 columns of Table 1, African American Meyerhoff students in the 1989–2005 entering cohorts were 5.3× more likely to enter STEM graduate programs than equally talented Declined

Table 1. *Postcollege STEM Outcomes for African American Meyerhoff and Declined Comparison Sample Students: 1989–1995, 1996–2005, and 1989–2005.*

	1989–1995 Entering Cohorts		1996–2005 Entering Cohorts		1989–2005 Entering Cohorts*	
	Meyerhoff	Declined	Meyerhoff	Declined	Meyerhoff	Declined
STEM PhD	25.3%	5.6%	54.6%	9.2%	41.1%	7.8%
MD	20.4%	42.7%	13.7%	20.0%	16.8%	29.2%
STEM MS/Allied Health	25.8%	24.7%	14.9%	20.8%	19.9%	22.4%
No Grad STEM	28.4%	27.0%	16.8%	50.0%	22.2%	40.6%
Total	100.0% (N = 225)	100.0% (N = 89)	100.0% (N = 262)	100.0% (N = 130)	100.0% (N = 487)	100.0% (N = 219)

Abbreviations: OR, odds ratio; STEM, science, technology, engineering and mathematics.
*For 1989–2005, Meyerhoff students were significantly more likely than Declined students to enter STEM PhD programs than to enter: (1) MD programs (OR: 10.3, Wald[df = 1]: 54.8, B: 2.3, $P < 0.001$); (2) master's/allied health programs (OR: 7.2, Wald[1]: 38.3, B: 2.0, $P < 0.001$); and (3) no graduate STEM program (OR: 11.6, Wald[1]: 65.3, B: 2.5, $P < 0.001$).

DOI:10.1002/MSJ

sample students (41.1% versus 7.8%). Meyerhoff students were less likely to enter medical school than Declined students (16.8% versus 29.2%), and about equally likely to enter STEM master's or allied health programs (19.9% versus 22.4%). Of note, Declined students were almost twice as likely not to pursue any graduate or professional education after college as Meyerhoff students (40.6% versus 22.2%).

To examine the statistical significance of the differences in STEM PhD entry, logistic regression analyses were conducted, with gender, high school GPA, SAT math and verbal scores, and year of entry included as covariates. Meyerhoff students were significantly more likely than Declined students to enter STEM PhD programs than to enter: (1) MD programs (odds ratio [OR]: 10.3, Wald[df = 1]: 54.8, B: 2.3, $P < 0.001$); (2) master's/allied health programs (OR: 7.2, Wald[1]: 38.3, B: 2.0, $P < 0.001$); and (3) no graduate STEM program (OR: 11.6, Wald[1]: 65.3, B: 2.5, $P < 0.001$).

Meyerhoff students were significantly more likely than Declined students to enter science, technology, engineering, and math PhD programs than to enter: (1) MD programs (odds ratio: 10.3, Wald[df = 1]: 54.8, B: 2.3, p < 0.001); (2) master's/allied health programs (odds ratio: 7.2, Wald[1]: 38.3, B: 2.0, p < 0.001); and (3) no graduate science, technology, engineering, and math program (odds ratio: 11.6, Wald[1]: 65.3, B: 2.5, p < 0.001).

Entry by Time Period

A recent study analyzed trends over time by dividing the Meyerhoff sample into subgroups of 1989–1995 and 1996–2003, which delineate the period before and after the program was opened to students who were not underrepresented minorities.[20] The first 4 columns of Table 1 provide the most recent findings across time periods. The 1989–1995 African American Meyerhoff students were 4.5× more likely to enter STEM PhD programs than Declined students (25.3% versus 5.6%), whereas the 1996–2005 Meyerhoff students were 5.9× more likely (54.6% versus 9.2%). It is noteworthy that the 1996–2005 Meyerhoff students entered STEM PhD programs at a rate double that of the 1989–1995 Meyerhoff students. Equally striking is that the percentage of Meyerhoff students not entering any graduate STEM program declined from the earlier to the later time period (28.4% to 16.8%), whereas the percentage of Declined comparison students almost doubled (27.0% to 50.0%). More than half of the African American Meyerhoff students entered STEM PhD programs from the most recent cohorts; in direct contrast, fully half of the academically talented African American declined students did not pursue any STEM graduate or professional education.

Entry by Gender

Over the years, gender has not emerged as a significant predictor of STEM PhD program entry among Meyerhoff students. The most recent findings, calculated for the current article, continue to reveal relatively equal percentages of African American males and females who have entered STEM PhD programs (37.9% and 44.1%, respectively). For the current article, logistic regression analyses were conducted, with high school GPA, SAT math and verbal scores, and year of entry included as covariates. There were no significant differences in African American male and female Meyerhoff students in terms of their relative odds of entering STEM PhD programs versus (1) medical school, (2) STEM master's or allied health programs, or (3) not entering STEM graduate or professional programs.

PhD Receipt: National Data on Baccalaureate Origins

The most recent data available from the National Science Foundation indicate that UMBC has become, among predominantly white universities, the number one baccalaureate origin of African American doctorates in the natural sciences and engineering.[6] When the numbers are disaggregated by STEM area, it is in the life sciences where UMBC is especially strong in generating future African American STEM PhDs. Furthermore, African American Meyerhoff students have received their STEM PhDs (or MD/PhDs) from leading STEM graduate institutions, including, for example, Columbia University, Duke University, Johns Hopkins University, Stanford University, the University of Michigan, and the University of Pennsylvania.

DOI:10.1002/MSJ

African American Meyerhoff students have received their science, technology, engineering, and math PhDs (or MD/PhDs) from leading science, technology, engineering, and math graduate institutions, including, for example, Columbia University, Duke University, Johns Hopkins University, Stanford University, the University of Michigan, and the University of Pennsylvania.

PROCESS EVALUATION FINDINGS

Process evaluation findings of the Meyerhoff Scholars Program have been reported in a number of articles and chapters since 1995. The process evaluation research has primarily focused on identification of program components that appear most important to student outcomes. Both quantitative and qualitative data have been collected over the years. In terms of quantitative information, students have been asked over the years to rate how helpful they felt the various program components were, based on a 5-point scale in which a rating of 5 indicates "very helpful." Program component ratings by time period (earlier versus later cohorts) and by gender have also been examined. In terms of qualitative information, there have been individual interviews, observations, and focus groups conducted periodically over the years. Findings related to each of these aspects of process evaluation are summarized below.

Most Highly Rated Program Components

From our earliest reports on student ratings of program components[9,16,22] to our most recent,[20,21] a small set of program components have consistently been rated as especially valuable by students (defined as a mean rating of ≥4.0 on a 5-point scale). For the current article, the mean ratings of the program component items for the 1989–2005 cohorts were calculated (Table 2). As indicated in the last column of Table 2, 5 components were rated ≥4.0: financial scholarship (mean, 4.6), being a part of the Meyerhoff Program community (mean, 4.4), Summer Bridge (mean, 4.3), study groups (mean, 4.1), and summer research (mean, 4.0).

Next Most Highly Rated Program Components

Another 7 received overall ratings between 3.5 and 3.9 on the 5-point scale (Table 2). These were staff academic advising (mean, 3.9), staff personal counseling (mean, 3.8), faculty involvement in the program (mean, 3.7), family involvement in the program (mean, 3.6), academic tutoring services (mean, 3.6), community service in Baltimore (mean, 3.6), and cultural activities (mean, 3.5).

Program Component Ratings by Time Period

The ratings of a number of the program components have increased over time (Table 2). Six that increased to a rating of ≥4.0 between the 2 time periods include study groups, summer research, staff academic advising, staff personal counseling, faculty involvement, and family involvement in the Meyerhoff Program. The largest change in rating occurred for the summer research component, which increased from 3.4 to 4.4, a full 1-point increase. It should be emphasized, however, that various changes over the years in how and when the surveys were administered to students (eg, earlier versus later years of college) and in the actual wording of items temper any conclusions that can be drawn for the observed increases.[18]

Program Component Ratings by Gender

Prior publications have not examined gender differences in program ratings. For the current article, *t* tests were conducted to examine possible gender differences in the program component ratings for African American Meyerhoff students entering the program between 1996 and 2005. Significant differences emerged on 4 of the items. Females perceived greater benefit than males from staff academic advising (means of 4.0 and 3.8, respectively), program cultural activities (3.6 and 3.3, respectively), and community service in Baltimore (3.7 and 3.4, respectively). In turn, males reported greater benefit than females from program-wide discussions of individual student academic performance (3.6 and 3.2, respectively).

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QUALITATIVE INTERVIEW, OBSERVATIONAL, AND FOCUS GROUP FINDINGS

Over the years, qualitative information has been collected to examine students' experiences within the Meyerhoff Program. The earliest studies were based either on observation of key program components[16] or interviews.[9,11,22] The most recent studies were based on focus groups.[21,23]

Across studies, the qualitative findings underscored the importance of the most highly rated program components (see above), and provided an extensive, contextual understanding of the mechanisms through which these components led to outstanding levels of student academic success. For example, interview and focus groups emphasize the importance of student internalization of key Meyerhoff Program values, including a commitment to excellence, accountability, group success, and giving back. Overall, the qualitative findings illustrate the importance of the comprehensive approach that the Meyerhoff Program employs to promote student achievement.

Whereas most publications from the research program have utilized the qualitative findings to supplement the quantitative findings, 2 recent articles focused exclusively on the qualitative results, allowing a more in-depth portrayal of emergent themes. One article, titled "The Meyerhoff Way," provides a detailed understanding of facets central to students' experiences in the program, including the formation of the Meyerhoff identity, belonging to the Meyerhoff family, and developing networks.[23] A second article focused exclusively on why students found the Summer Bridge to be particularly important.[24] Specifically, students indicated that they valued the Summer Bridge experience because it allowed them to be a part of a community of Black scholars, introduced them to professionals in STEM fields, taught them skills about professional networking, assisted with the development of their academic skills, and provided them with multiple opportunities to put all of their various skills into practice.

Students indicated that they valued the Summer Bridge experience because it allowed them to be a part of a community of Black scholars, introduced them to professionals in science, technology, engineering, and math fields, taught them skills about professional networking, assisted with the development of their academic skills, and provided them with multiple opportunities to put all of their various skills into practice.

PULLING IT ALL TOGETHER: FOUNDATIONAL PROGRAM ELEMENTS

Based on the quantitative and qualitative process evaluation information obtained from students over

Table 2. *Perceived Benefit of Meyerhoff Program Components: African American Meyerhoff Students, 1989–1995, 1996–2005, and 1989–2005.*

	1989–1995	1996–2005	1989–2005
Financial scholarship	4.5	4.7	4.6
Being part of the Meyerhoff Program community	4.2	4.7	4.4
Summer Bridge	4.1	4.5	4.3
Study groups	3.9	4.3	4.1
Summer research	3.4	4.4	4.0
Staff academic advising	3.5	4.3	3.9
Staff personal counseling	3.4	4.2	3.8
Faculty involvement	3.2	4.1	3.7
Family involvement in the Meyerhoff Program	3.1	4.0	3.6
Academic tutoring services	3.2	3.8	3.6
Community service in Baltimore	3.1	3.9	3.6
Cultural activities	3.4	3.5	3.5
Group discussions about academic performance	3.0	3.6	3.4
Baltimore/Washington, DC–area assigned off-campus mentor	2.5	3.2	2.9

Ratings are on a scale of 1 to 5.

DOI:10.1002/MSJ

the years, as well as in-depth knowledge of the program, we have identified 3 foundational program elements.[21]

First is the recruitment of a critical mass of talented African American students interested in research careers. The multifaceted recruitment/selection process is reflected in the following quotes from African American Meyerhoff students:

> "In tenth grade, UMBC was the first college or university to send me a letter and...an invitation to come and visit the campus."

> "When I went to Selection Weekend, I just saw the caliber of students who were here and also trying to get into the program...I just thought, 'I want to be a part of that group.'"

The financial support provided represents a key part of the attraction of the program. When asked, "What made you decide to become a Meyerhoff?" many students answer, "The money and...," as indicated in the following excerpt:

> "The full scholarship...and the fact the program is catered towards getting you to your graduate degree goal, MD/PhD, whatever it might be."

Development of a tight-knit learning community focused on STEM excellence constitutes a second foundational program element. As noted above, one important contributing factor is the Summer Bridge Program, as indicated in the following quotes from African American students:

> "The idea of family is established through Summer Bridge...This idea that, you know, together we can accomplish much. And if you're doing well, you should pull your brothers and sisters along with you."

> "I think it's kind of like boot camp...When you spend that much time [together]...you form bonds...transition [to] college."

Persistent, high-quality staff engagement in supporting, counseling, monitoring, challenging, and advising students is also central to the learning community. This is reflected in the following 3 excerpts:

> "You can talk to staff about the problem that you're having. We feel so close to them."

> "My grades began to go down...Mr. A. [staff] was my encouragement...I could have given up completely on physics...but I didn't."

> "E-mailing me, calling me, 'You need to do this. You need to do that. You have a deadline to meet...'"

Multiple high-quality STEM research and academic experiences constitute the third foundational program element. The required summer research experiences represent one program component contributing to this foundational element. The importance of summer research is reflected in the following 2 excerpts:

> "[Meyerhoff provides]...a huge connection...to get into good summer internships. It's been a huge help."

> "This summer I had a very good research experience...the give and take with the professor...You're interacting with them as a colleague, they're helping you to formulate your plan...I really enjoyed that. It just cemented that I loved research."

Highly committed and engaged STEM faculty involved in laboratory research, STEM coursework, and positive experiences in various STEM departments are also critical. The first 2 quotes below are from African American students:

> "[During selection weekend]...Dr. P. [eminent researcher] made a promise that I would be able to work in his lab."

> "I'd never worked in a lab before...I had a really good mentor. She taught me different techniques...I got to do a lot of research."

A faculty member interviewee is the source of the final quote:

> "The overwhelming majority...of the department is impressed...and in favor of [the Meyerhoff] program."

PRECOLLEGE AND COLLEGE PREDICTORS OF ENTRY INTO SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS PHD PROGRAMS

Over the years, the evaluation effort, as described above, has included important precollege factors as covariates in the outcome analyses and examined college experience variables in a descriptive fashion. More recently, however, we have begun to examine precollege variables and college-experience variables as predictors of postcollege success.[20,21,25,26] These analyses indicated that 2 precollege variables, research excitement and intrinsic math/science

DOI:10.1002/MSJ

motivation ("effectance" motivation),[27] and 2 college variables, number of summer research experiences and undergraduate GPA, were especially important to postcollege student outcomes. In order to examine the independent contributions to STEM PhD outcome with the most recent data, multinomial logit regression analyses were conducted for the current article. Analyses included the 4 predictor variables, along with 7 covariates (gender, high school GPA, SAT math score, SAT verbal score, mother educational level, father educational level, and year of entry). The findings indicated that all 4 of the predictor variables were significantly and independently related to STEM PhD entry: precollege research excitement ($\beta = 0.43$, $P < 0.001$), precollege intrinsic (effectance) math/science motivation ($\beta = 0.65$, $P < 0.01$), number of summer research experiences during college ($\beta = 0.48$, $P < 0.001$), and college GPA ($\beta = 1.6$, $P < 0.001$). Multinomial logit regression analyses conducted for the current article examined the impact of precollege and college predictors on STEM PhD entry separately for African American male and female students (same covariates as above). Precollege research excitement, summer research, and cumulative GPA were significantly related to STEM PhD entry for both males and females. However, whereas precollege intrinsic (effectance) math/science motivation was significantly related to STEM PhD entry for males ($\beta = 1.1$, $P < 0.01$), it was not for females ($\beta = 0.38$, $P = 0.18$).

The findings indicated that all 4 of the predictor variables were significantly and independently related to science, technology, engineering, and mathematics PhD entry: precollege research excitement ($\beta = 0.43$, $P < 0.001$), precollege intrinsic (effectance) math/science motivation ($\beta = 0.65$, $P < 0.01$), number of summer research experiences during college ($\beta = 0.48$, $P < 0.001$), and college grade point average ($\beta = 1.6$, $P < 0.001$).

INSTITUTIONAL CHANGE AS PROCESS AND OUTCOME: A SOCIAL TRANSFORMATION THEORY OF CHANGE

The success of the Meyerhoff Program has gone hand in hand with the larger diversity initiative within which it was embedded, as described above. Of special note, the process of change that led to the establishment of the Meyerhoff program, and the success of the Meyerhoff Program itself, have led over the years to the incorporation of multiple campus-wide changes, including the restructuring of curricula for all students in STEM fields (eg, course redesign in introductory science courses) and development of numerous additional programs (eg, undergraduate scholars programs; Graduate Meyerhoff Program). These campus-wide changes, important in their own right, have in turn impacted the success of the Meyerhoff Program and its students.[1,17]

Of special note, the process of change that led to the establishment of the Meyerhoff program, and the success of the Meyerhoff Program itself, have led over the years to the incorporation of multiple campus-wide changes, including the restructuring of curricula for all students in science, technology, engineering, and math fields (eg, course redesign in introductory science courses) and developmental of numerous additional programs (eg, undergraduate scholars programs, graduate Meyerhoff Program).

This process of institutional change and program development is consistent with the Inclusive Excellence Change Model proposed by Williams *et al*, which simultaneously embraces the diversity of students and promotes academic excellence for all students.[28] These authors describe "inclusive excellence" as achieved through fundamental modifications in the culture of the university, including its mission, vision, values, traditions, and norms.[28] These aspects of the inclusive excellence

DOI:10.1002/MSJ

change process at UMBC included various elements of change in the structural/bureaucratic, collegial, and symbolic dimensions of the organization. Most prominent within the bureaucratic/structural dimension was the institution of inclusive excellence as a campus priority. This key development was the linchpin for all that followed. Most prominent at the collegial level was building successful coalitions with key science department chairs and faculty. Without such coalitions, it is unlikely that institutional change would have followed. In terms of the symbolic dimension, most noteworthy was the highly visible effort to address a campus history of inequality. This enabled both the campus and the larger institutional environment (eg, the University of Maryland system) to make sense of and rally behind the change process.

Consistent with related literature on institutional transformation, a social transformation theory of change was proposed by Maton and colleagues,[17] combining the empowering settings theory[29] with extant knowledge about transforming campuses to support inclusive excellence[28] in order to explain UMBC's success in the retention and achievement of minority students in STEM. The 3 components of the theory that summarize the mechanisms for success are (1) the development of empowering settings for minority-student achievement, (2) larger institutional change processes, and (3) assessment and evaluation. The proposed social transformation theory simultaneously encompasses a focus on programmatic means to enhance minority student achievement–the development of empowering settings–and the larger institutional change process that is necessary to support such program development and bring about necessary change in the larger institutional environment.

In summary, the change in institutional culture at the university level has both led to and been influenced by the creation of the Meyerhoff Program. Both the evolution of the university and the establishment of the program have resulted in a vibrant setting effective in recruiting a critical mass of talented minority students over the past 23 years, and once on campus, empowering them to achieve at levels that were not seen on campus prior to the program's initiation.

LIMITATIONS

The research to date has a number of limitations. Possible self-selection differences between African American Meyerhoff and comparison students temper the conclusions that can be drawn about the outcome findings. For example, students who opted to attend the program may be more committed initially to obtaining a PhD than those who declined the admissions offer. They may also be more capable of doing what is necessary to succeed in difficult STEM majors and gain entrance to STEM PhD programs, or have greater interest in STEM as a field of interest. It should be noted, though, that all students admitted into the program, whether or not they chose to attend UMBC, had expressed a strong interest in pursuing a STEM PhD, had strong academic preparation, and began college with a STEM focus. Unfortunately, as is often the case for university programs, random assignment to conditions was not possible to arrange, given the program's commitment to the existing recruitment processes and procedures.

A second study limitation concerns the changes that were made over the years in the process evaluation assessment of program components. Specifically, minor changes were made over time in item content and response scales, and how and when the surveys were administered.[18] A third limitation is the lack of focus, to date, on STEM career entry. A fourth is the lack of assessment of institution-level variables, including faculty buy-in and institutional culture change. 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. Increasing numbers of colleges and universities, however, have adopted many of the core components of the program, and in the years ahead it will be important to ascertain if comparable findings emerge.

FUTURE RESEARCH

The limitations notwithstanding, our ongoing program of evaluation research 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, and include the use of more rigorous designs (eg, regression discontinuity; random assignment), process evaluation measures of known reliability and validity, continuous semester-by-semester assessment of student experiences and change, systematic assessment of institutional outcomes including institutional culture change, and longitudinal tracking of outcomes through receipt of the PhD and beyond (ie, STEM career options including academic research, teaching, corporate opportunities, and policy).

DOI:10.1002/MSJ

CONCLUSION

Enhancing the academic success of African American students, as well as other underrepresented minority students in the STEM fields, is a pressing national priority.[6] 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–program components, foundational elements, and individual student predictors that contribute to positive outcomes–represents a critical priority for future work. Our current program of research contributes to this important research agenda.

ACKNOWLEDGMENTS

Financial support was provided by the National Institute of General Medical Sciences, 5R01GM075278.

DISCLOSURES

Potential conflict of interest: Nothing to report.

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DOI:10.1002/MSJ