BRIDGING STEM PROFESSIONS *for* MCNAIR SCHOLARS

THROUGH FACULTY MENTORING AND ACADEMIC PREPARATION

IN 2007 AND 2010, THE NATIONAL RESEARCH COUNCIL REPORTED THAT THE UNITED STATES WAS NOT PRODUCING ENOUGH GRADUATES IN THE STEM (SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS) FIELDS TO MEET THE DEMANDS OF AN INCREASINGLY COMPETITIVE GLOBAL ECONOMY. DESPITE RECENT CHALLENGES TO THESE FINDINGS, ONE THING REMAINS CLEAR: UNDERREPRESENTED MINORITIES (URMS) CONTINUE TO BE THE MOST UNDERREPRESENTED POPULATIONS IN THE STEM DISCIPLINES. (THE TERM "UNDERREPRESENTED MINORITIES," OR URMS, IS USED TO DESCRIBE RACIAL/ETHNIC GROUPS THAT ARE NOT REPRESENTED IN THE POOL OF STEM PROFESSIONALS COMMENSURATE WITH THEIR REPRESENTATION IN THE GENERAL U.S. POPULATION—NAMELY, AFRICAN AMERICANS, HISPANIC AMERICANS, AND AMERICAN INDIANS [CLEWELL ET AL. 2006]). FURTHER, THE LACK OF APPROPRIATE INSTITUTIONAL SUPPORTS MAY MAKE IT DIFFICULT FOR STEM DISCIPLINES TO ATTRACT AND RETAIN A DIVERSE POOL OF STUDENTS. ONE PROGRAM THAT HAS BEEN IDENTIFIED IN THE RESEARCH LITERATURE AS EFFECTIVELY PREPARING URMS FOR DOCTORAL STUDIES IS THE RONALD E. MCNAIR POST BACCALAUREATE ACHIEVEMENT PROGRAM. PROGRAMMATIC FEATURES, INCLUDING FACULTY MENTORING AND ACADEMIC PREPARATION, HAVE BEEN SHOWN TO MITIGATE MANY OF THE OBSTACLES THAT URMS TYPICALLY ENCOUNTER. IN THIS PAPER, WE DEMONSTRATE THE CONTRIBUTIONS OF FACULTY MENTORING AND ACADEMIC PREPARATION IN HELPING STUDENTS TRANSITION FROM BACCALAUREATE TO GRADUATE PROGRAMS IN THE STEM DISCIPLINES AT ONE RESEARCH I UNIVERSITY IN THE SOUTHEASTERN UNITED STATES.

By Matthew Fifolt, Jeffrey Engler, and Gypsy Abbott

According to recent reports, underrepresented minorities (URMs) continue to be the most underrepresented populations in the STEM workforce (Bell 2009; George *et al.* 2001; National Science Foundation 2006). The number of U.S. citizens from minority groups who have earned doctorates in science and engineering has increased over the past decade; however, URMs continue to represent a small proportion of the scientists and engineers in the United States (NSF 2007, 2009, 2011, 2013).

In the fields of science and engineering, African Americans accounted for 4.5 percent, Hispanics for 5.5 percent, and American Indians for 0.3 percent of the doctoral degrees awarded by U.S. institutions in 2011 (NSF 2012) whereas these groups accounted for 13.1 percent, 16.9 percent, and 1.2 percent, respectively—and combined, approximately 31 percent—of all U.S. residents in the comparable age bracket (U.S. Census 2012). Researchers also have noted that women are less likely than men to major and earn degrees in the fields traditionally defined as "hard" sciences and engineering (Nixon, Meikle and Borman 2013), though this is beyond the scope of this investigation.

In 2007 and 2010, the National Research Council reported that the United States was not producing enough graduates in the STEM fields to meet the growing demands of an increasingly competitive global economy. Despite equivocal data in the research literature regarding the existence of a STEM shortage in the United States (Anft 2013, Mangan 2013), failure to develop the talents of all members of the nation's diverse citizenry will compromise its ability to meet future demands for a highly skilled and technically proficient workforce at a time when the opportunity for great advances is accelerating (Bell 2009; Lavrakas 2012; National Research Council 2007; Nixon, Meikle and Borman 2013).

Friedman and Kay (1990) note that while enrollments of women and URMs in STEM curricula may increase as a result of strong recruitment programs, issues related to retention and completion rates have yet to be adequately addressed at the institutional level. Indeed, attrition appears to be one of the greatest threats to the STEM pipeline (DeSantis 2013). Finally, researchers have indicated that in the absence of culturally competent role models (Flores 2009, Kwan and Taub 2003), URMs will continue to exist on the margins of the STEM professions (Aguirre 2009, Bordes and Arredondo 2005, Laden 2000).

One program that has been identified as effectively preparing URMs for doctoral studies is the Ronald E. McNair Post Baccalaureate Achievement Program (Girves, Zepeda and Gwathmey 2005). Programmatic features, including faculty mentoring and academic preparation, have been shown to mitigate many of the obstacles that URMs encounter (Hirsch *et al.* 2012). In this paper, we demonstrate the contributions of faculty mentoring and academic preparation in helping URM students transition from baccalaureate to STEM graduate programs at one Research I university in the southeastern United States.

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BACKGROUND

The Ronald E. McNair Post Baccalaureate Achievement Program (McNair Scholars Program) is a highly competitive U.S. Department of Education–funded program designed to prepare university juniors and seniors who are low income, first generation, and underrepresented in graduate education for successful completion of doctoral degrees in STEM disciplines. Through a selective grant competition, funds are awarded to higher education institutions for the purpose of engaging students in research and scholarly activities. In 2010, McNair Scholars Programs were funded on approximately 200 U.S. college and university campuses at a total cost of $4.3 million (Ishiyama and Hopkins 2003, U.S. Department of Education 2013).

The McNair Scholars Program was established by Congress in 1986 to honor the memory of Dr. Ronald McNair, a nationally renowned scientist and researcher in the field of laser physics. One of America's first African American astronauts, McNair died when the space shuttle Challenger exploded on January 28, 1986 (U.S. Department of Education 2013).

The McNair Scholars Program at the University of Alabama at Birmingham (UAB) was established in 1999 and was supported by three funded renewal applications (UAB Graduate School n.d.). In its most recent renewal (beginning in 2007), the McNair Scholars Program at UAB was funded for five years at an annual investment of $225,000 per year through federal TRIO programs (U.S. Department of Education 2013); additional program costs were met by state resources. In the most recent cycle, the U.S. Department of Education awarded UAB an additional (*i.e.*, fifth) year of funding (typically, it is a four-year award). Scholars at UAB have benefited not only from a strong, committed faculty who are experienced in mentoring undergraduates but also from outstanding research programs and facilities, a full range of support programs and educational enhancement opportunities, a population of graduate students who serve as role models and mentors, and administrative commitment at all levels (UAB Graduate School 2013).

LITERATURE REVIEW

As noted in the literature, obstacles that often prevent URM students from completing baccalaureate programs and continuing to graduate education include the lack of personal support, mentoring, guidance, and encouragement (King 2003); research experience (Babco 2004); and skills and knowledge to better integrate into the university community (George *et al.* 2001).

Personal Support, Mentoring, Guidance, and Encouragement

URMs confronting the broad choices available in college may be unprepared for the fast pace of courses, unfamiliar with the amount of self-reliance expected of them, and uncertain of their abilities. They may be unaware of the academic and social support systems available to them or may fail to take advantage of services designed to support their academic success (Burger *et al.* 2007). URMs also may be recruited into a demanding STEM curriculum yet be offered insufficient guidance and support (Taningco, Mathew and Pachon 2008; Tornatzky *et al.* 2006).

A report from the National Research Council (2007) identifies faculty mentors as a key link between undergraduate students and potential careers in science and technology; however, the relatively small number of visible and diverse faculty role models for women and URM students has been shown to increase these students' sense of isolation (Johnson 2007; Taningco, Mathew and Pachon 2008; Tornatzky *et al.* 2006).

URMs' need for mentoring is strongly related to issues of self-efficacy and professional role confidence when students are involved in courses and experiences that have been dominated historically by the white male majority (Borg *et al.* 2005, Burger *et al.* 2007, Cech *et al.* 2011, Margolis and Fisher 2002). Role models are cited in the literature as a critical source through which behaviors are learned and efficacy beliefs are formed (Bandura 1986). Mentors may also influence protégés by verbally encouraging them to engage in positive and productive behaviors (Johnson and Ridley 2004, Laden 2000).

Research Experience

Admissions committees for doctoral programs in the STEM disciplines look for evidence that students have had an undergraduate research experience. Previous studies have shown that effective laboratory experiences can help students identify the right major, envision future goals, and add value to their educational experience (Hofstein and Lunetta 2004, NAS 1997). According to Hundt and

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Kurzweil (2007), hands-on research experiences provide URMs with the skills necessary to develop a research agenda, which can significantly increase their chances of being accepted by competitive graduate programs.

Russell, Hancock and McCullough (2007) surveyed students regarding their participation in undergraduate research experiences and concluded that the overall duration of such experiences and the variety of research activities contributed to positive outcomes in terms of student commitment to obtaining a Ph.D. in a STEM career. Respondents' comments suggested that "(faculty) mentors who are able to combine enthusiasm with interpersonal, organizational, and research skills play a large role in facilitating positive outcomes" (Russell, Hancock and McCullough 2007, p. 549).

Skills and Knowledge

For URM students, access to and retention in STEM fields may be compromised by inadequate preparation in math and science courses; poor study skills; and issues of efficacy based on self-confidence, ethnicity-based stereotypes, and stereotype threat (Steele 2010; Taningco, Mathew and Pachon 2008). Additionally, students may not be aware of the wide variety of options available to them at the graduate level or of the ways in which graduate education can prepare them for careers in science and engineering.

One strategy for addressing current deficits in the STEM fields is for colleges and universities to provide positive experiences designed specifically to meet URMs' needs. Jackson (2007) advocates for early access, opportunity, and mentoring to encourage interest and to foster talent among URMs. STEM preparation programs such as the McNair Scholars Program have been cited in the research literature as sources of support for students to identify with individuals who have shared similar experiences and succeeded at the highest levels of their professions (Burger *et al.* 2007; Frehill, Ketcham and Jeser-Cannavale 2005; Handelsman *et al.* 2005; Jackson 2007; Packard 2004–2005; Suarez 2003).

MCNAIR SCHOLARS

During the most recent funding cycle (2007–12), 92 juniors and seniors participated in the McNair Scholars Program at UAB. Female candidates outnumbered male candidates at a ratio of 2:1, and approximately two-thirds of scholars were among the first generation of their families to attend college. The remaining third of scholars were chosen from low-income and/or underrepresented groups. Since 2007, approximately two-thirds of scholars have self-identified as either black or African American, with the remaining third comprising white, Asian, and Hispanic students (bi-racial and multi-racial demographic data were not reported).

METHODOLOGY

Two primary methods were used to evaluate the McNair Scholars Program at UAB: a pre-post evaluation design with composite Graduate Record Examination (GRE) scores as the dependent variable and a longitudinal design in which students were tracked to determine their academic accomplishments. During each year of the program, students were required to take the GRE prior to program participation. During the ten-week program, graduate school staff provided instruction as students prepared for both the GRE and for completing their research projects. During the course of grant implementation, the Educational Testing Service changed the GRE's content and structure so as to include a section on academic writing; as a result, this section was added to the McNair curriculum.

Quantitative and qualitative methods were used to assess program objectives. Formative data were obtained primarily from focus groups held to review scholars' accomplishments at the beginning and end of each program. These data guided the process of continuous program improvement. For example, McNair Scholars initially completed all practice GRE exams in a paper-and-pencil format. However, the actual GRE exam was administered as a computer-based assessment. During focus group discussions, McNair Scholars identified the apparent disconnect between testing modalities and thus informed an immediate change in test preparation methods.

Analyses of quantitative data included both descriptive and parametric statistics (SPSS, ver. 11.0). Paired t-test differences were considered significant at $p \leq 0.05$. We analyzed qualitative data using content analysis procedures as described by Patton (1980) and coded data through an iterative process. Emergent themes were managed through a text-to-table application. Evaluation of the McNair Scholars Program at UAB was conducted with the approval of the Institutional Review Board.

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RESEARCH SETTING

The University of Alabama at Birmingham is a comprehensive research university and medical complex that enrolls more than 17,000 students in schools of liberal arts and science, professional schools, and the university-wide Graduate School (UAB Office of Institutional Effectiveness and Analysis 2012). Graduate training programs encompass all major research areas, including biomedical sciences, natural sciences, and engineering. As a Research I university in an urban setting in the southeastern United States, UAB is committed to increasing participation in K–12 through postdoctoral education by addressing access by minorities and by students from families with low incomes. With more than $400 million in active grants and contracts, UAB is an ideal site for a program to prepare students for careers in science and technology research (UAB Office of Institutional Effectiveness and Analysis 2012).

PROGRAM OBJECTIVES

The primary goal of the McNair Scholars Program is to increase college graduation rates and success in graduate education. This goal was addressed at UAB through specific program offerings. All components of the McNair Scholars Program at UAB were based on a review of research regarding effective strategies for providing assistance to the priority population of URM students. Program objectives guided program improvement efforts for the McNair Scholars Program at UAB, and results of the overall programmatic evaluation informed the present investigation. Specific areas of interest included: (1) research experience, (2) academic preparation, (3) baccalaureate degree attainment and readiness for doctoral education, and (4) application and entry into graduate school.

FINDINGS

Research Experience

To support the goal of successfully developing and executing a laboratory research experience, each of the McNair Scholars was paired with a faculty mentor. This mentoring relationship was designed to encourage, motivate, and prepare McNair Scholars for doctoral studies. Faculty mentors served three vital functions: (1) prepare undergraduate students for graduate education, (2) direct the summer research experience, and (3) report the results of faculty/scholar research.

Through focus group feedback, scholars overwhelmingly expressed positive comments about their interactions with faculty mentors, crediting them with providing career and scholarship advice; guidance regarding graduate school options; training in research skills; and opportunities to network with other professionals. One scholar said, "My mentor allowed me to pursue a research subject of my interest and was immeasurably helpful in guiding my readings." Another identified specific types of assistance her faculty mentor provided: "She helped me improve my resume and gave me useful resources for scholarships and great advice on graduate school."

Faculty mentors also spoke highly of scholars' achievements in gaining hands-on experience, developing research skills, and contributing toward the overall success of the research. One mentor commented, "This scholar made significant progress in understanding complex clinical data sets and extracting meaningful information by proposing empirical questions, doing analysis, and interpreting findings under the guidance of myself and my Ph.D. candidate who helped mentor her."

Academic Preparation

The skills necessary to succeed in a baccalaureate program are quite varied and depend to some extent on the academic preparation of each student accepted into the McNair Scholars Program. While scholars undoubtedly benefited from seminars designed to teach academic skills, it was clear from their accomplishments in high school that they had come to college having already embarked on a trajectory toward success.

Indicators of requisite academic skills for the McNair Scholars Program at UAB have included applicants' standardized test scores and high school GPA. Although the same skills required at the baccalaureate level are also required for success at the graduate level, doctoral-level study requires additional proficiencies related to reading and conducting research, writing technical papers, and presenting research findings. The McNair Scholars Program at UAB provides opportunities for students to engage in all of the activities considered essential for success in a doctoral program.

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The ability to communicate research findings is essential for excelling in the STEM fields and achieving success in a doctoral program. Scholars who attended the GRE preparatory classes typically improved their GRE scores—particularly in the academic writing section. Instruction in academic writing was structured and clearly helped students develop effective written communication skills (Crocker 2005). (*See* Table 1.)

Table 1.

Combined GRE Scores on Pre- and Post-Practice Tests (Verbal + Quantitative)

	Pre-McNair GRE Practice Scores ≥ 1000	Pre-McNair GRE Practice Scores ≥ 900–999	Post-GRE Practice Scores ≥ 1000	Post-GRE Practice Scores ≥ 900–999
2006–07 Baseline	1	3	8	3
2007–08 Cohort 1	10	5	14	4
2008–09 Cohort 2	6	6	11	8
2009–10 Cohort 3	3	3	7	6
2010–11 Cohort 4	13	2	14	3
2011–12 Cohort 5	12	7	20	3

- Based on UAB student practice test scores
- In 2007–08 and 2010–11, there are no end-of-program practice test scores; calculations are based on the 2nd or mid-program practice tests.

Baccalaureate Degree Attainment and Readiness for Doctoral Education

One index of scholars' readiness for graduate school is their baccalaureate GPA. As noted in Table 2, in all McNair Scholars cohorts, more than 90 percent of scholars who completed their degree had a GPA of 3.0 or better, with the exception of Cohort 4, in which 89 percent of students attained a GPA of 3.0 or better. It is noteworthy that approximately 75 percent of McNair Scholars graduated with a baccalaureate degree within three years of participating in the McNair Scholars Program at UAB.

Table 2.

Readiness for Doctoral Education

Cohort Year	Readiness for Doctoral Education*
2007–08 Cohort 1	16 of 17 Scholars (94.1%) with GPA of B or better
2008–09 Cohort 2	18 of 20 Scholars (90.0%) with GPA of B or better
2009–11 Cohort 3	15 of 16 Scholars (93.7%) with GPA of B or better
2010–11 Cohort 4	16 of 18 Scholars (88.8%) with GPA of B or better
2011–12 Cohort 5	21 of 21 Scholars (100%) with GPA of B or better

* Numbers based on incoming members of the cohort (does not include scholars who participated in multiple years)

Application and Entry into Graduate School

A requisite for being admitted to graduate school is a competitive GRE score. Prior to 2011, the maximum score on the GRE was 1600 (800 for verbal reasoning plus 800 for quantitative reasoning). In compiling a data-based report on research-doctorate programs in the United States, the National Research Council (2011) asked doctoral programs to supply their students' average GRE scores. Researchers then calculated the averages of these average GRE scores. Given a maximum score of 800 on the quantitative section of the GRE, programs reported average scores in the following disciplines: biological and health sciences (686), physical and mathematical sciences (745), and engineering (760) (National Research Council 2011). Even though McNair Scholars at UAB were admitted to college with high ACT scores and maintained high university GPAs, students' initial GRE scores were not competitive for graduate school admission.

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Table 3.

Average Gains on Combined GRE Practice Test Scores (Verbal + Quantitative)

Cohort	Average Pre-Score	Average Post-Score	Average Gain
2007–08 Cohort 1	912.90	1012.90	100.0[a]
2008–09 Cohort 2	872.50	1008.50	136.0[a]
2009–10 Cohort 3	852.10	1009.30	157.1[a]
2010–11 Cohort 4	1000.00	1089.40	89.1[b]
2011–12 Cohort 5	961.10	1020.50	59.5[c]
Overall UAB Cohorts 1–5	943.02	1019.55	106.7[a]

[a] $p < 0.0001$
[b] $p < 0.0050$
[c] $p > 0.0500$

- Individual cohort averages based on UAB student practice test scores
- A cohort was based on students who began that year; second-year students' scores were included in the previous years' average. This was the reason the Cohort 5 gains were considerably lower: they did not include any second-year students.
- Based on individuals' earliest and latest practice test scores, even if across two or three years
- In 2007–08 and 2010–11, there were no third practice test scores; calculations were based on the second practice test.

Students benefited greatly from GRE preparation classes, as evidenced by increases in their GRE scores. (*See* Table 3.) Scholars' GRE score increases were statistically significant in every year except year five. Pre-GRE scores for years four and five were extremely high before attending GRE preparation classes, which could account for the smaller differences in pre- and post-GRE scores. Another plausible explanation for lower gains by cohort five as compared to previous cohorts is that it included only students who began the program in 2012, and the average did not include students who had participated for two years previously. Students who participated in the program for two (or three) years showed significantly greater gains on practice test scores than single-year student participants. Scholars who participated for one year averaged a gain of only 93.0 points whereas those who participated longer averaged a 132.3-point gain ($p<0.0001$).

Post-Baccalaureate Training Experiences

Evaluation data indicated that of the first four cohorts of scholars, 47 (66%) were accepted for graduate study. Students who participated in the McNair Scholars Program at UAB have pursued opportunities in the following STEM/research areas:

- 9 matriculated into M.S. programs in STEM disciplines,
- 19 matriculated into Ph.D. programs in STEM disciplines,
- 15 matriculated into medical school, and
- 17 completed programs in M.D., D.D.S., D.P.T., O.D., and Pharm.D.

DISCUSSION

Students who participated in the McNair Scholars program between 2007 and 2012 have achieved significant success in fulfilling the program's mission. These findings are particularly significant given the challenges faced by URMs in the STEM disciplines. As noted previously, STEM disciplines may have difficulty attracting and retaining a diverse pool of students given such students' lack of an appropriate support system (*e.g.*, mentoring, research experience, access); consequently, efforts by the United States to meet the demands of an increasingly competitive global economy may prove insufficient.

VALUE OF MENTORS AND ROLE MODELS

Faculty and peer support were hallmarks of the McNair Scholars Program at UAB. Scholars often commented that meeting with the principal investigator, program coordinator, peer mentors, and faculty mentors was helpful as they completed their research projects. Moreover, having positive role models enabled them to envision similar careers for themselves. This sentiment reflects the research findings of multiple studies in which role modeling/mentoring was identified as a key element in portraying the STEM fields as not merely acceptable but as normative for URMs (Burger *et al.* 2007; Fifolt and Abbott 2008; Frehill, Ketcham and Jeser-Cannavale 2005; Handelsman *et al.* 2005; Packard 2004–2005).

Scholars and program administrators also described the value of faculty mentorships and positive interac-

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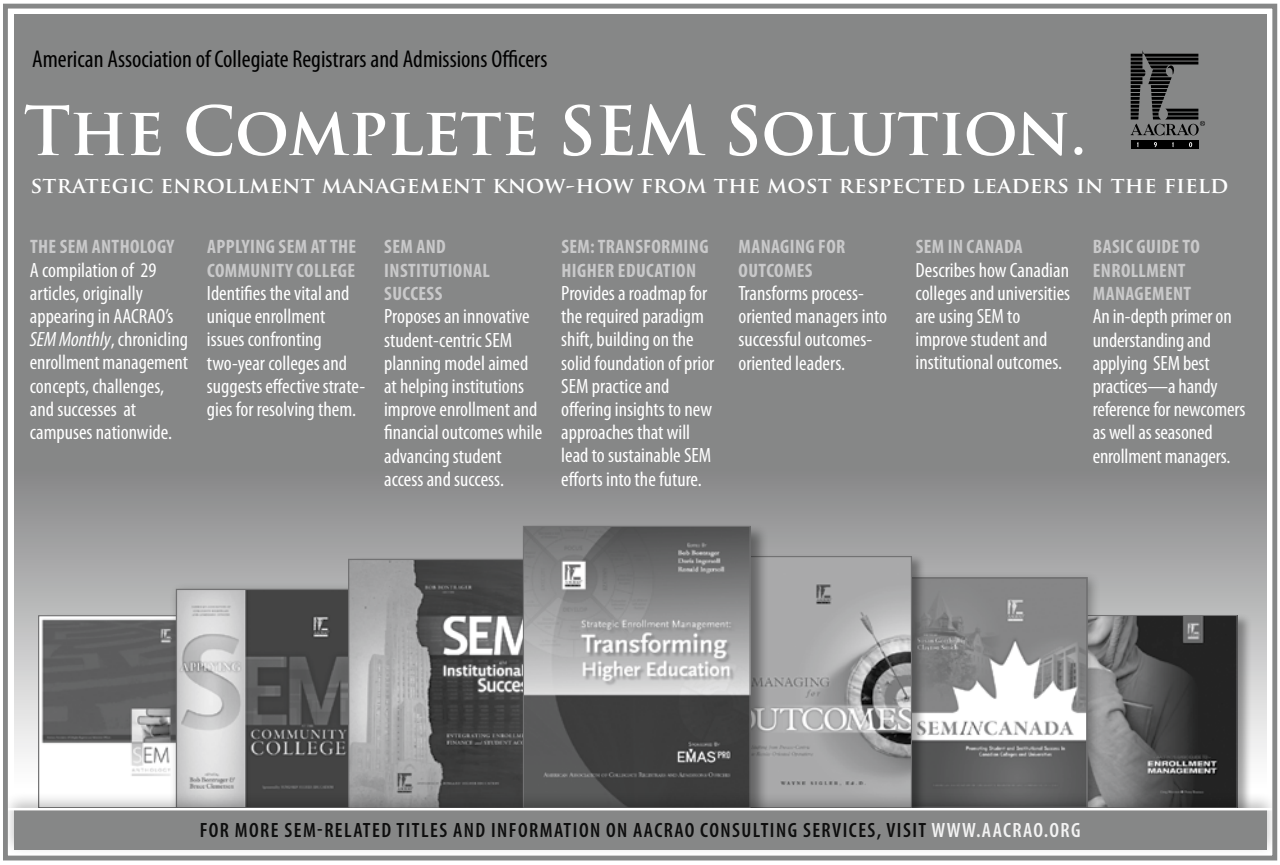
tions with others as key to the success of the program at UAB. In addition to providing hands-on learning experiences and opportunities for scholars to develop their technical skills, faculty mentors provided encouragement, guidance, access to resources, role modeling, advocacy, and friendship—all key elements of psychosocial support (Jacobi 1991; Kram 1983; Russell and Adams 1997). As Paglis, Green and Bauer (2006) note, "Psychosocial mentoring contributes to the protégé's (student's) sense of competence, confidence, and effectiveness in his or her role" (p. 457). The findings from the present study suggest that scholars perceived faculty mentoring as a value-added contribution in the critical areas of personal support, research experience, and skills and knowledge.

FACULTY MENTOR PREPARATION

Considering the potential influence of mentoring relationships as well as feedback from faculty mentors who participated in the McNair Scholars Program, additional training and support for future mentors may be critical. Zachary (2012) asserts that mentor preparation is about increasing an individual's level of readiness to assume the responsibilities of a mentor. Given the unique needs of URMs in the sciences as well as the "disproportionately small number of African American, Hispanic American, and Asian American faculty in most settings—particularly in the upper tenured ranks" (Johnson 2007, p. 166), engaging in cross-cultural competence and communication and establishing trust may be important topics for further research (Fifolt and Searby 2011).

SUMMARY

The McNair Scholars Program at UAB served as a catalyst for engaging URM students in research and scholarly activities. Further, program activities helped scholars transition from baccalaureate to graduate programs in the STEM disciplines. Key components of the McNair Scholars Program addressed students' specific needs in the areas of personal support, guidance, and encouragement; research experience; and skills and knowledge. Scholars



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benefited from their interactions with faculty mentors and enhanced their prospects for acceptance into graduate school through rigorous academic preparation. Given the important role faculty mentors play in supporting URMs, we recommend that additional consideration be given to preparing faculty mentors in the areas of cross-cultural competence, communication, and trust.

POSTSCRIPT

Between FY 2011 and FY 2012, the U.S. Congress reduced funding for the McNair Post-Baccalaureate Achievement Program by approximately 20 percent. This cut resulted in nearly one-fifth of all McNair Scholars Programs being defunded in fall 2012 (U.S. Department of Education 2013). The projected budget for FY 2013 included another 5 percent cut, indicating a continuing trend toward decreasing funding for the program. Despite the gains achieved nationally by the McNair Scholars Program over the past 27 years, recent cutbacks may have a powerful and negative impact on URMs' attraction to and retention in the STEM professions. In fact, the impact of these decisions may not be fully appreciated until organizations realize that the pool of diverse individuals who might serve as mentors and role models for a new generation of STEM students has all but disappeared (Collier 2007, Fields 2005, Higgins and Koucky 2000, McSherry 2005).

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