Revitalizing
the Nation's Talent Pool in STEM

SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS

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NSF

THE URBAN
INSTITUTE

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Acknowledgments

Executive Summary

The Louis Stokes Alliances for Minority Participation (LSAMP) Program was established in 1991 by the National Science Foundation (NSF) to develop strategies to increase the quality and quantity of minority students who successfully complete baccalaureate degrees in science, technology, engineering, and mathematics (STEM), and who continue on to graduate studies in these fields. The Urban Institute was commissioned to conduct an evaluation of the LSAMP Program, an evaluation that would answer questions about the structure and implementation of LSAMP and its impact on students, participating institutions of higher education (IHEs), and the diversity of the STEM workforce. The information presented here comes from the Urban Institute's multiyear evaluation of the LSAMP Program.

The LSAMP Program began with grants to six multi-institution Alliances across the country. Today, 34 Alliances with more than 450 participating institutions have produced thousands of STEM bachelor's degrees. LSAMP provides financial assistance to many of its participants. Distinguishing it from traditional scholarship programs, LSAMP takes a multidisciplinary approach to student development and retention, creating partnerships among colleges, universities, national research laboratories, business and industry, and other federal agencies in order to accomplish its goals. Hands-on research experiences and mentoring to build student interest in STEM are LSAMP's other key characteristics.

The Urban Institute's evaluation of this program included both process and summative components, seeking to understand both the program's implementation and its success in meeting stated goals. The process component of the evaluation utilized qualitative methods to identify aspects of the LSAMP projects that promoted or inhibited the achievement of program goals. The analyses indicate that, at the institutional level, a supportive environment that includes adequate provision of resources and support of faculty and high-level administrators facilitated the achievement of program goals; at the Alliance level, collaborative activities among partner institutions that result in

the leveraging and sharing of both tangible and intangible resources were similarly important. Lack of financial resources and an adverse national, state, or institutional political climate were the most common challenges to program success. The process evaluation also revealed that, despite expected variation in practices among Alliances, a recognizable LSAMP model does emerge. That model can be understood as a merging of two prominent streams of research and theory: a model of student retention (the Tinto model), which emphasizes integration of students into the academic institution, and the notion of "disciplinary socialization," which is the process through which students become socialized into science as a profession.

In order to answer questions about the program's impact on participating institutions and to examine educational and career outcomes for participating students, the summative component of the evaluation utilized a combination of quantitative and qualitative methods. Institutional impacts were measured using interviews with program staff and Alliance site visits, while student outcomes were explored through a retrospective survey of funded LSAMP participants who graduated from the program between 1992 and 1997.

Institutional outcomes. Project staff members who were interviewed at participating IHEs believe that involvement in the program enables institutions to retain and graduate more STEM students by substantially expanding these institutions' capacity to develop and support STEM student talent. Staff members also believe that LSAMP had an impact on participating institutions by changing the institutional culture, policies, and practices to encourage the recruitment, retention, and graduation of underrepresented minorities (URMs)[1] in STEM majors.

Student outcomes. Analyses of survey data revealed that the vast majority of program graduates (close to 80 percent) sought additional education after obtaining a bachelor's degree, and two-thirds of participants later enrolled in graduate school, working towards a master's, doctoral, or professional degree. One in four LSAMP graduates had completed a STEM graduate degree by the time of the survey. Finally, the majority

of LSAMP graduates reported that the program had been helpful as they pursued bachelor's degrees in STEM and had influenced their decisions to attend graduate school. More than 90 percent reported that they either had recommended or would recommend LSAMP to others.

National comparison. In order to examine the difference between LSAMP student outcomes and those of STEM graduates nationally, LSAMP graduates' progress in the STEM pipeline was compared with that of nationally representative samples of underrepresented minorities and white and Asian students (using longitudinal data from NSF's National Survey of Recent College Graduates). Analyses revealed that LSAMP participants pursued post-bachelor's coursework, enrolled in graduate programs, and completed advanced degrees at greater rates than did national comparison groups. The difference in graduate school enrollment and completion is largely due to the significantly higher percentage of LSAMP students pursuing and completing degrees in STEM fields. In terms of the final phase in the STEM pipeline, LSAMP participants were observed joining the STEM workforce in proportions similar to those of national samples.

The information learned about the LSAMP program through the process and summative evaluations resulted in three main conclusions and five recommendations.

Conclusions

1. *LSAMP met its stated goal of increasing the quality and quantity of students who successfully complete LSAMP-supported STEM baccalaureate programs.* As the program expanded, the share of national URM undergraduate STEM degrees earned by LSAMP participants increased, coinciding with an increase nationally in the number of URM bachelor's degrees earned in STEM. On measures of undergraduate academic performance, LSAMP students were found to outperform national comparison samples.

2. *LSAMP exceeded its stated goal of increasing the number of students matriculating in programs of graduate study in STEM.* The LSAMP Program produced underrepresented minority students who enroll in and attain graduate degrees in STEM at a rate higher than that of both a national sample of underrepresented minority (URM) students and a national sample of white and Asian STEM baccalaureate degree recipients.

3. *LSAMP's strategies and approaches constitute a discrete and identifiable program model, grounded in research and theory, that can be tested and replicated.* The identification and description of this successful model signifies a critical advance in the knowledge base of intervention program models.

Recommendations

1. *Increase data collection efforts.* Areas of attention should include undergraduate retention/attrition information and up-to-date tracking and contact information for program graduates. Such information would allow for continued analyses of the program's impact.

2. *Strengthen the focus on community college students.* Community colleges enroll over half of all underrepresented minority students in postsecondary education, and thus provide a promising source of potential STEM students. In light of the program's success in retaining URM students who begin their degrees in community colleges, increased attention to this component is recommended.

3. *Expand the program to offer graduate school tuition and support to LSAMP graduates.* LSAMP graduates who did not continue taking courses after attaining a bachelor's degree were significantly more likely to cite financial reasons for not doing so than were URMs or white and Asian students in the comparison samples. Given LSAMP's success in preparing students to enter and complete graduate degrees, extending the program's offering to include financial incentives for these students to enter graduate STEM programs seems a worthwhile investment.[2]

4. *Emphasize successful factors in selecting sites to receive LSAMP awards.* In awarding LSAMP grants, the program should continue to consider three criteria: (1) evidence of institutional and faculty support, (2) history of, or plans for, a strong collaborative relationship among partners, and (3) well-defined plan and the capacity to provide the integrated services that comprise the LSAMP model.

5. *Replicate and expand the LSAMP program.* The LSAMP model, unlike most intervention efforts for increasing URM participation in STEM, encourages and supports the synergistic efforts of institutional partners, laying the foundation for systemic institutional change. Given LSAMP's demonstrated success, it is important that efforts to replicate and disseminate the model be increased.

Introduction

The U.S. science, technology, engineering, and mathematics (STEM) workforce continues to face the challenge of increasing the participation of women and minorities. While strides have been made to address this shortage, women and underrepresented minorities (URMs) are still not represented in the U.S. STEM workforce in parity with their percentages in the total workforce population. Recently, a confluence of trends has focused the spotlight on the nation's need to develop the talent of underrepresented groups in STEM. These trends include a surge in minorities among the college-age population; declines in science and engineering (S&E) graduate degrees earned by white students; declining enrollment of foreign students in S&E graduate programs; expectation of a high retirement rate in the S&E workforce; and rapid job growth in the S&E employment sector. These trends have led the National Science Board (NSB) to conclude that the "number of native-born S&E graduates entering the workforce is likely to decline unless the Nation intervenes to improve success in educating S&E students from all demographic groups, *especially those that have been underrepresented in S&E careers*" (NSB 2003, 1, emphasis added).

In 1991, the National Science Foundation (NSF)—responding to its charge from Congress to "undertake or support a comprehensive science and engineering education program to increase the participation of minorities in science and engineering" (42 U.S.C. 1885b)—designed the Louis Stokes Alliances for Minority Participation (LSAMP) Program. The main goal of LSAMP was to encourage and facilitate access to careers in STEM fields for underrepresented populations. The LSAMP Program's approach to fulfilling its goal addresses several of the often intractable barriers that inhibit minorities from pursuing careers in science and engineering.

Students from underrepresented minority groups[3] face obstacles at different points in the STEM pipeline that make it difficult for them to attain postsecondary degrees in STEM. First, many students fail to enter higher education due to inadequacies in their K–12 training. A second obstacle is attrition from the STEM pipeline at the college and university level. Underrepresented minorities are less likely than whites and Asians to complete baccalaureate degrees in a STEM major. Furthermore, those minority students who are successful in obtaining their baccalaureate science degrees often lack the laboratory research skills that make them competitive for graduate school admission. This juncture between undergraduate and graduate school is another point at which students leave the STEM education pipeline. Lastly, the high cost of tuition also serves as a barrier for minority students and affects their access to, and retention in, higher education. Tuition cost is one of the factors leading students to begin their college education at two-year institutions. And while community colleges enroll close to half of all students from groups traditionally underrepresented in STEM disciplines, only 26 percent of students at two-year colleges transfer to four-year institutions. The LSAMP program is designed as an intervention to help minority students overcome many of the problems and barriers they face as they transition into college and progress towards graduation.

In 2000, the National Science Foundation contracted with The Urban Institute to conduct a process and summative evaluation of the Louis Stokes Alliances for Minority Participation Program. Consisting of seven sections, this report summarizes key evaluation findings.[4] The first section, this introduction, is followed by a description of the LSAMP Program. The next section describes the evaluation design and methodology. Findings from the process component of the evaluation follow. Next is a detailed description of the elements that make up the LSAMP model and a discussion of the model's links to the existing theoretical and research literature. Findings of the summative component are then discussed. The report ends with the study conclusions and recommendations.

A Brief Description and Overview of LSAMP

The Louis Stokes Alliances for Minority Participation (LSAMP) Program was established in 1991. It was designed to develop comprehensive strategies intended to increase the quality and quantity of minority students who successfully complete baccalaureate degrees in STEM and who continue on to graduate studies in these fields. Originally named the Alliances for Minority Participation (AMP), the program was renamed in 1999 in honor of former Congressman Louis Stokes, who served in the U.S. House of Representatives for 30 years and was a leader and pioneer of congressional efforts to improve the education of minority health professionals, scientists, and engineers. LSAMP strives to nurture students' desire to pursue research in STEM fields, thus facilitating NSF's long-term goal of increasing the production of PhDs in STEM fields. The program's success will be measured by its ability to increase significantly the number of underrepresented minorities graduating with baccalaureate STEM degrees and persisting through to graduate study in a STEM field.

The LSAMP Program is managed by NSF's Directorate for Education and Human Resources' Division of Human Resource Development (HRD). Awards are distributed in five-year phases, and the level of funding provided depends upon the scope of the proposal, with NSF's contribution to a project ranging between $300,000 and $1 million per year. Projects are selected based on the intellectual merit of their proposed activities and the excellence of their proposal's plan to broaden the participation of underrepresented minority groups. LSAMP encourages its awardees to create Alliances that forge partnerships among academic communities (both two- and four-year institutions) and encourages the inclusion of government agencies and laboratories, businesses and industries, and professional organizations. LSAMP awardees select strategies and approaches that are tailored to their institutional setting and are likely to result in the achievement of program goals.

The LSAMP Program began with grants to six Alliances producing fewer than 4,000 graduates from underrepresented minorities with baccalaureate degrees in STEM fields. Today there are 34 Alliances with more than 450 participating institutions that have produced thousands of STEM degrees. According to the LSAMP data-gathering system established by NSF, the program has also contributed to an increase in minority enrollment in STEM majors from 35,670 in 1991 to more than 205,000 in 2003. LSAMP attributes much of its success to the Alliance structure within which its awardees work. Alliance structures exist in different forms: citywide (e.g., New York City), statewide (e.g., California, North Carolina), and multistate (e.g., Florida-Georgia).

LSAMP awardees implement a variety of activities and services in order to accomplish program goals. These activities and services focus on strengthening academic skills and orienting students to STEM fields through student support, academic enrichment, and research skill development. Participants receive a stipend for engaging in LSAMP-sponsored activities. The program emphasizes activities designed to sustain minority student interest in STEM fields and graduate study through research experiences and interactions.

Evaluation Design

The evaluation consisted of two main components: a process component to identify elements of LSAMP programs that seemed to promote or inhibit the achievement of program goals and a summative component focusing on measurable student and institutional outcomes. The evaluation questions and methodology used in each of these components are as follows:

Questions

The *process component* of the evaluation focused on the implementation of LSAMP and asked the following questions:

- How are LSAMP programs being implemented?
- What components/strategies have accelerated the attainment of program goals?
- What factors have inhibited the attainment of program goals?
- Is there a recognizable LSAMP model?

The *summative component* of the evaluation sought to document the impact of LSAMP on:

- Participants
- Diversity of the STEM workforce
- Knowledge base of promoting diversity in STEM
- Participating institutions of higher education

Methodology

Process Evaluation. This component of the evaluation used qualitative methods to identify crucial components of LSAMP and factors that seemed to promote or inhibit the achievement of program goals. An important aspect of this component was to assess whether or not—in spite of expected variations in practices—the LSAMP alliances were operating according to a recognizable model, and whether that model could be traced to general theories of student retention and persistence in science that could inform future efforts to achieve and sustain diversity in the S&E workforce. Methods included a thorough review of LSAMP project documents; telephone interviews with project staff members of all Alliances; case study site visits to a sample of three Alliances[5]; and a literature review of research on effective strategies to increase diversity in STEM.

Summative Evaluation. The summative component of the evaluation required a combination of quantitative and qualitative methods. These included a review of project documents, telephone interviews with project staff, and the development and administration of a retrospective survey of past LSAMP participants. The goal of the survey, conducted several years after graduation, was to obtain education and employment information about participants and inquire about their experiences in the LSAMP programs in which they participated. Because the survey questionnaire was intended to examine program impact on participant outcomes, only the earlier LSAMP cohorts were included in the survey pool. More recent cohorts were excluded because it was expected that these graduates might not have had adequate time to pursue graduate studies and/or establish a career. The survey population, therefore, included all funded LSAMP participants who had graduated with a baccalaureate degree in a STEM major between 1992 and 1997. We obtained a 60 percent response rate on the LSAMP survey (843 completed surveys) and subsequent analyses indicate that no bias was introduced due to nonresponse. Data collected through the survey were analyzed and, when appropriate, compared with national data for S&E graduates from the National Survey of Recent College Graduates (NSRCG). Adjustments were made to account for the different sampling strategies used in the two data sets in order to obtain unbiased estimates and specifically unbiased standard errors needed to test for significance (i.e., errors that account for the complex design of the NSRCG data set and the weighted element sample of the LSAMP design). Differences reported here have a significance level of at least .05. More details regarding the methodology used are found in the full report.

Process Evaluation Findings

This section reports findings from the process component of the evaluation, which drew data from telephone interviews with staff at all Alliances and from case studies of three Alliances.

Project Components: How is LSAMP Being Implemented?

LSAMP projects collectively offer a wide range of activities and services. Data collected on the project components of the 27 Alliances included in the evaluation can be organized under the broad categories of pre-college development, student academic development, student professional development, faculty development, curriculum development, graduate studies development, and linkages with community colleges.[6] Figure 1 summarizes typical LSAMP components and shows the percentage of projects that offer them. When asked to identify their top five most important project components, Alliances most commonly cited student research (82%), "summer bridge"[7] (67%), mentoring (60%), stipend (48%), and tutoring (37%).[8]

Implementation Insights: What Did We Learn from the Case Studies?

Here we highlight some critical issues that emerged from a cross-case analysis of the three case study Alliances. Our analysis also drew additional support from the telephone interviews with project leads at all the Alliances.

An Integrated Approach

> "Partner institutions now approach STEM education as a holistic venture."
>
> —Project director (FGAMP)

An integrated intervention approach was found across the three case studies. All three case study Alliances provide student participants with financial, academic, social, and professional support. Though the exact nature of the project activities and services tends to vary somewhat across Alliances—and even across partner institutions within an Alliance—all three projects do offer support in these four critical areas. This extended assortment of offerings is important because it provides a broad net of services and opportunities with which to assist students, and targets those particular areas in which barriers are known to be especially problematic for underrepresented minority students. Additionally, data collected from the 27 Alliances reveal that approximately 60 percent of the projects involve summer bridge, stipends, and tutoring, in addition to faculty-mentored research. As demonstrated by responses from focus groups conducted with LSAMP students, the needs of these students vary. There is variation in what draws students to the project, as well as the services they consider most helpful.

A True Collaborative Effort

> "COAMP has helped transform the culture… and helped minority retention efforts to realize that we have far more to gain in helping each other because there are far more resources to be gotten if we do so."
>
> —Site coordinator

All three case study Alliances display a high level of collaboration on multiple levels. There appears to be much shared governance and collective decisionmaking taking place within the three projects. Although an Alliance's central office is generally responsible for coordinating and overseeing the overall project, much of how these three projects are implemented is determined by representatives from partner institutions. Two of the three case study Alliances had co-principal investigators who are not at the lead institution. In addition, each of the three projects includes several committees with membership drawn from institutions across the Alliance. Meetings of the steering committees, management teams, and so on enable high-level institutional administrators, faculty members, and

FIGURE 1. PERCENTAGE OF LSAMP PROJECTS OFFERING VARIOUS COMPONENTS

Pre-College to College Programs

Summer Bridge	85%
High School Outreach	67%
Career Awareness	22%

Student Academic Development

Scholarship/Stipend	100%
Tutoring	74%
Peer Study Groups	63%
Skills-Building Seminar	60%
Learning Center	52%
Academic Advising	22%
Summer Academic Enrichment	15%

Student Professional Development

Research Experience	89%
Mentorships	82%
Conferences	82%
Internships	59%
Career Awareness	44%

Types of Mentoring Programs

Faculty	78%
Peer	44%
Combo	44%
Other Type	22%

Faculty Development

Workshops on Teaching	26%
Professional Development	22%
Diversity Sensitivity Training	11%

Curriculum Development Activities

Course Reform	56%
New Course Development	30%
Curriculum Material Sharing	15%
Distance Learning Courses	11%

Graduate Studies Development

GRE Test Prep	59%
Graduate School Admissions Support	59%
Graduate Summer Bridge	15%

Community College Components

Articulation Agreements	74%
Community College Outreach/Links	59%
Research for Students	26%

project coordinators from across each Alliance to meet regularly to chart the course of their respective LSAMP projects. Case study data reveal that participants perceive these meetings as a vital mechanism of collaboration and as an important way to facilitate the mutual exchange of useful ideas and experiences.

Connections Made Outside of the Institution

"EXPO is inspiring because I see so many other minorities who are at the top of their game. The quality of presentations surprised me and now I am motivated to get a PhD."

—FGAMP student

"Last summer I conducted research at CSU because Fort Collins didn't have the equipment needed for the project. COAMP helped me to make the necessary connections at CSU."

—COAMP student

The LSAMP projects tend to differ from other intervention projects in that they not only foster student connections within the institution, but they facilitate connections made outside of the institution as well.[9] Like other similar campus-based programs, LSAMP promotes students' integration with the institution by facilitating student interaction with peers and faculty and involvement in institutionally sponsored activities and events. LSAMP, however, goes a step beyond by assisting students to form relationships outside of their institutions. LSAMP is able to do this because its Alliance structure is premised on institutional partnership. Partner institutions work together in bringing about shared events like Alliance- or region-wide conferences that allow students to network with peers and faculty from partner institutions and with representatives from industry and graduate schools. By emphasizing the involvement of community colleges, LSAMP facilitates contact between LSAMP staff and students at two- and four-year partner institutions. Nonetheless, some LSAMP participants at community colleges indicated that they would like more opportunities to interact and network with four-year institutions. Some Alliances do pursue such community college outreach efforts and have revitalized or refined

community college articulation agreements. For example, some partner institutions within COAMP and NYC LSAMP are currently developing better course coordination to smooth the transition between schools. Resource sharing also helps students to make connections across institutions as some partner schools have extended opportunities (e.g., summer research experience) to LSAMP students attending other partner institutions.

Institutional Support as Key to Project Implementation

"The President is extremely committed to the concept, and this leadership we see from the top has permeated throughout the campus."

—Administrator at COAMP campus

"The commitment, dedication, and backing of presidents of partner institutions has been crucial to project implementation."

—FGAMP project manager

Spokespersons from all three projects noted the importance of receiving support from top institutional leaders at partner institutions. The push to pursue NSF funding for NYC LSAMP reportedly came about because the previous chancellor wanted to pull the various STEM intervention programs together into one coordinated effort. In the case of FGAMP, institutional support is perceived as a key factor in facilitating project implementation. Interviewees explained that endorsement by the president and other top officials often involves financial support and eases the way to securing faculty involvement. Similarly, in the case of COAMP, the support and commitment of top officials were cited as being critical to the project's success. The former president at the lead institution (who served concomitantly as a chancellor of the Colorado State University system) was described as being "extremely committed" to the project, and it is reported that people were very aware of this support from the top. The notable support that LSAMP projects receive from their host institutions likely results, in part, from shared goals. LSAMP institutions tend to have other ongoing efforts to enhance institutional diversity and increase the retention and graduation of STEM majors.

Importance of Project Staffing

> "FGAMP has remained active and vital because of the people who drive it."
>
> —Dean at a FGAMP campus

> "[The site coordinator is a] teacher, counselor, friend, tutor, and sometimes father figure."
>
> —COAMP student

Evidence from the case studies suggests an important relationship between project staffing and project success. Many LSAMP participants praised their project director for his or her strong leadership, and the central office staff for (1) its efficiency in running a smooth project and (2) its effectiveness in fostering teamwork among Alliance partners. Some interviewees spoke specifically about the importance of having a site/institutional coordinator with a high-level position and influence who can readily access resources and elicit the assistance of others. Such individuals, however, would also need to be very committed to the project given their busy schedules and other responsibilities. As the project director and manager of one Alliance noted, institutions need to recruit enthusiastic people who are already "working toward that end" rather than "just figureheads or people with big titles." This director explained that it is essential to start with "a small group of key people" who have "passion" and who really want to be involved, and then build from that. Academic/activity coordinators are commonly perceived as key staff members who work at the front lines with students. In many instances, these individuals know their LSAMP students intimately as they are approached with academic and nonacademic problems. In the case of NYC LSAMP, several of the academic/activity coordinators are former LSAMP participants. These people know the program well, have developed a deep loyalty to it, and can readily relate to the struggles of LSAMP students while serving as role models. One drawback, however, is the issue of continuous turnover, as such individuals are apt to leave for graduate studies.

Reported Effects on Students

> "They become more savvy about the whole culture of success…. they learn to access resources better."
>
> —COAMP professor

> "The drop-out statistics for engineering students are depressing, but COAMP energizes me because it lets me know that I have potential and instills a 'can do it' attitude in me."
>
> —COAMP student

Project staff members, professors, institutional administrators, and students spoke about the many ways that LSAMP positively affects students. A common perception is that LSAMP participation leads to increased student interest, commitment, and confidence in STEM; provides valuable academic support and professional development; fosters supportive relationships with faculty and peers; and facilitates academic progress and preparation for graduate studies. This wide range of effects is likely to be due to the myriad strategies that LSAMP projects employ within the program's integrated approach. Interestingly, case studies and telephone interview data reveal that while individual projects differ in the assortment of programmatic strategies they use in the pursuit of essentially the same goals, a great amount of commonality exists in the perceived project effects on students.

Reported Effects on Institutions

> "COAMP strives to build infrastructure within the institution so that it becomes a way of life, a way of doing things."
>
> —COAMP faculty member

LSAMP has benefited institutions in multiple ways, namely by enhancing institutional capacity for student talent development and by bringing about changes in institutional culture as well as institutional policies and practices. Through LSAMP services and support, institutions assist students in their efforts to continue through the STEM pipeline. All three case study Alliances, along with other Alliances, report increases in minority and nonminority STEM enrollment and STEM degree attainment. In all three of the case studies, interviewees observed a change in institutional culture. For example, some COAMP interviewees spoke about greater faculty awareness, understanding, and responsibility for diversity. In the case of FGAMP, some credited the project with increasing dialogue among faculty about effective teaching and learning

strategies and with the opening up of research labs to undergraduates. Similarly, some of the NYC LSAMP interviewees spoke about how more professors are now seeing research as an integral part of the undergraduate experience and how institutions are placing a greater focus on affirming the equal opportunity clause.

In addition, significant changes in practice and policies across the three case studies are attributed to LSAMP. For instance, projects such as the NYC LSAMP are heavily pursuing course restructuring; more than 18,000 students are reported to have enrolled in LSAMP restructured courses. Data drawn from the telephone interviews show that over half of the LSAMP projects are engaged in course reform efforts. The case study data also reveal the varying nature of LSAMP-inspired changes taking place across various partner sites, including new emphasis on student participation in research grant proposals, the pursuit of research expositions by individual schools, development of a school-wide research opportunity database, improvements in advisement procedures, creation of a standardized campus scholarship/funding procedure, and enhancement of community outreach and recruitment. Some participants noted that LSAMP serves as a "great recruitment tool" for schools and that the prestige and recognition it brings help participating institutions to secure funding to bring other intervention programs to campus.

Building on Past Experiences

All three case study Alliances are similar in that their projects build on past experiences with minority STEM programs at individual partner sites. Alliance leadership tends to be composed of individuals who have years of experience in working with pipeline programs. For example, in the case of NYC LSAMP, those involved in writing the original proposal were individuals who knew one another because of a shared interest and experience with administering minority STEM programs. Moreover, across Alliances it is reported that many of the participating institutions were invited to join the partnership precisely because of their track records in implementing similar initiatives and programs, though most of these were narrower in subject scope and at the campus level. In some cases, like that of FGAMP, the project came about as a natural next step following involvement with a "forerunner," such as NSF's Comprehensive Research Centers (CRC) program. Similarly, efforts to establish COAMP spring in part from the project director's own experience with

NSF's Research Careers for Minority Scholars (RCMS) grant. For all three case study Alliances, the LSAMP Program was a means to combine and scale up participating institutions' past and current STEM intervention efforts, allowing members to become part of either a systemwide or statewide pipeline program. The LSAMP Program has benefited from the accumulated experiences that various leaders and staff members bring to the projects. Telephone interview data confirm that the selection of project strategies is primarily determined by what is deemed effective based on past experience as well as the research literature.

Leveraging Resources

"Companies that are familiar with programs like COAMP are more willing to donate funds. They are also more open to having students intern at the corporation and to offer guest speakers."

—COAMP activity coordinator

The three case study Alliances appear to be engaged to a significant degree in resource leveraging. Across sites there are various instances of institutional resources being used to support LSAMP, including the institutionalization of coordinator positions, office space, support services of institutional personnel, and release time for some faculty members to work with the project. In some cases, tutoring for LSAMP students is now institutionalized—adopted and paid for by the institution rather than the project. Resource leveraging also takes the form of collaborating and sharing resources with other minority or STEM-based programs. For example, on the campuses of partner institutions LSAMP will commonly cosponsor activities such as workshops, tutoring, and student research conferences (or travel to conferences). LSAMP staff and coordinators of cosponsoring groups believe that this is a mutually beneficial relationship that strengthens both parties and that results in more student opportunities. In addition, this strategy leads to greater efficiency for institutions as it minimizes redundancy in effort. Moreover, some Alliances (or individual sites) are able to leverage their record of success and the LSAMP Program's prestige to secure additional funding from external sources. Concomitantly, partner schools can leverage the project's prestige and success in seeking funding for other related programs. The project director of NYC LSAMP explained it this way: "In the

case of some institutions, some of the funding that they achieved could not have been possible without AMP," because "unless you have some research activities going on, there's no kernel of growth." The project director of FGAMP noted that data on LSAMP student performance, retention, and graduation rates were a "big factor" in that Alliance's successful bid to secure yearly appropriations from the state legislature.

Tracking and Involving LSAMP Graduates

All case study Alliances offered indications that LSAMP graduates were a rich potential resource to continuously engage with, and contribute to, the projects. During site visits we had an opportunity to speak with some LSAMP graduates, who were generally very appreciative of LSAMP. A few are employed as activity coordinators for the NYC LSAMP and seemed happy to be able to give something back to the project through their own work. In addition, we heard about cases in which graduates return to campus as company recruiters to specifically interview LSAMP students, or attend LSAMP functions to show their support and to interact with students. Alliances such as COAMP recognize that their graduates constitute an important group that needs to be engaged; these Alliances therefore are currently setting up a system to maintain regular communication with graduates. Such contact with LSAMP graduates can also enable projects to collect data on long-term participant outcomes, develop a network of graduate mentors, tap into a potential source for fundraising, and so on. As results from the graduate survey illustrate, LSAMP graduates are satisfied with their LSAMP experience (over 90 percent of respondents said they would recommend the program to others), and about half remain in contact with a LSAMP peer, faculty member, or project coordinator.

LSAMP GRADUATES WERE A RICH POTENTIAL RESOURCE

Max, a graduate of FIU, returns regularly to his alma mater to speak to students about his experiences. As a freshman, Max had poor test scores and grades, and nearly dropped out of school. He credits FGAMP with providing him with the support and confidence to persist and persevere. Through FGAMP he received tutoring, summer enrichment, and research experience in a lab. Max went on to receive an undergraduate research award, two prestigious fellowships, and a PhD in theoretical quantum physics.

The LSAMP Model: Research and Theoretical Foundations

Is there a recognizable LSAMP model? If so, what research and theoretical bases have informed its approaches and strategies? What empirical evidence exists that these approaches and strategies are indeed effective for underrepresented minorities (URMs),[10] who are the program's targeted participants? Before we attempt to answer these questions, it is important to understand that the LSAMP model addresses dual goals: retention of participants through graduation with a baccalaureate degree *and* retention of participants in the STEM pipeline (which implies graduation with a STEM major and enrollment in a graduate STEM program). In terms of ensuring the retention of participants in a baccalaureate degree program, the LSAMP approach can be best explained by the Tinto Model of Student Retention. To explain the LSAMP approach to addressing the second goal—retaining students in the STEM pipeline through graduation and subsequent enrollment in graduate school—we draw on the concept of disciplinary socialization, the familiarization of novices with the process of "professional performance and discourse in the academic sciences" (Bowman and Stage 2002, 123).

Academic and Social Integration: The Tinto Model of Student Retention

In attempting to determine the reasons why students leave undergraduate institutions, Tinto developed a theory of departure to explain the process that leads students to withdraw from college, drawing on Durkheim's theory of suicide to explain the process (Tinto 1993). According to Durkheim, one type of suicide occurs when an individual is unable to become integrated socially or intellectually into communities of society. Similarly, according to Tinto, withdrawal from college results partly from an individual's lack of integration into the academic community. Tinto argues that an individual's level of academic and social integration, which is the result of accumulated experiences and interactions within the institution, will determine whether or not that individual leaves the institution prematurely or remains to complete a degree.

The institution can, through its formal and informal structures, assist students' social and academic integration and thus encourage persistence in the system. These structures should function, among other activities, to smooth students' transitions into their new environment; encourage the building of learning communities with peers; foster interaction between students and faculty and staff; identify student needs and provide adequate support; and foster academic involvement and learning. In outlining his model, Tinto called for retention programs specifically tailored to the needs of different groups of students, such as older students, honor students, students of color, transfer students, and academically at-risk students. He also recognized the value of what he termed "breaking down the campus into smaller parts" (1993, 199), by which he meant forming smaller communities that are more manageable and less intimidating to students.

Much of the research on college student attrition has drawn on the Tinto model, particularly through examining the effects of academic and social integration on students' college persistence or withdrawal. A significant body of studies by various researchers offers support to the validity and usefulness of this theoretical model (Bers and Smith 1991; Braxton, Brier, and Hossler 1988; Cabrera et al. 1992; Cabrera, Nora, and Castaneda 1992; Nora, Attinasi, and Matonak 1990; Pascarella, Smart, and Ethington 1986; Pascarella, Terenzini, and Wolfe 1986; Stage 1989; Stoecker, Pascarella, and Wolfe 1988; Williamson and Creamer 1988). Among the few studies in this area that have conducted analyses on minority student populations, Stoecker, Pascarella, et al. (1988) found academic and social integration to be important determinants of persistence, while Nora (1987) found these factors did not significantly affect retention among Chicano community college students.

The LSAMP model utilizes strategies and approaches that focus on helping students achieve academic and social integration and, ultimately, graduation from college. These strategies include summer bridge, peer study groups, skills-building seminars, learning centers, academic advising, summer academic

THE LSAMP MODEL UTILIZES STRATEGIES AND APPROACHES THAT FOCUS ON HELPING STUDENTS ACHIEVE ACADEMIC AND SOCIAL INTEGRATION

enrichment, faculty workshops on teaching, diversity sensitivity training for faculty, new course development, and others listed in figure 3. Several of these strategies serve the purpose of academic and social integration with an emphasis on *integration in their science or engineering majors*. By what means does the LSAMP model attempt to ensure that students continue in the science or engineering pipeline and that they pursue a graduate degree in a STEM field?

Socialization into Science: The Professionalization of Scientists

In writing about the scientific community, Gaston (1989, 132) states:

> Scientists go through a process that socializes them to the conventional perspectives of their disciplines and specialties. In that indoctrination they learn the logic of inquiry and how to evaluate evidence. They become scientists during, and as a result of, this experience.

It is generally accepted that scientists *do* undergo a socialization process, yet very little has been written about this process. Delamont (1987, 165), in reviewing literature on the sociology of science over a 15-year period, identified research on the socialization of scientists as one of the three areas that had been neglected in this field. She comments on the "need for sociologists of science to examine normal science, the para-

digms inscribed in curricula, and the ways that scientists' tacit knowledge is reproduced through 'craft' apprenticeship." A more recent review of the sociology of science literature did not reveal subsequent studies of the type called for in her article.

"Disciplinary socialization" is the term Bowman and Stage (2002, 123) use to characterize the process "by which a student becomes familiar with the process of professional performance and discourse in the academic sciences." These researchers cite the need for students of science to participate actively in their fields in order to understand more easily the conventions of science. They recommend participation in undergraduate research as a means to prepare students for graduate programs in the sciences. Writing about professionalization, Dryburgh (1999) describes three aspects of this process as (1) adapting to the professional culture, (2) internalizing the professional identity, and (3) demonstrating solidarity with others in the profession.

It has been argued that some groups accumulate advantages important for socialization into science while others do not, with access for certain groups denied for reasons unrelated to their abilities but related to ascribed characteristics, such as race/ethnicity and sex (Merton 1973). For example, researchers find that African American, Hispanic, and American Indian students and women of all races/ethnicities are less likely than white or Asian males to be exposed to experiences and opportunities that are the precursors to membership in a scientific community (Dryburgh 1999; Mulkey and Ellis 1990). Interventions to expose these underrepresented groups to experiences and programs whose goal is to increase the participation of underrepresented groups in STEM fields must provide opportunities that are important for socialization into science. Strategies providing opportunities for undergraduate research experiences, mentoring, professional internships, and career awareness activities, along with opportunities to attend and present papers at scientific conferences and to publish scientific articles, are examples of these interventions. Included are efforts to prepare program participants to enter the culture of graduate education: GRE test preparation workshops, support with graduate school admissions, and graduate summer bridge programs.

The LSAMP Model

Figure 2 shows how the two research streams described above merge to form the LSAMP model. The graph depicts the relationship of the set of LSAMP strategies

FIGURE 2. LSAMP Model

FIGURE 2. LSAMP Model
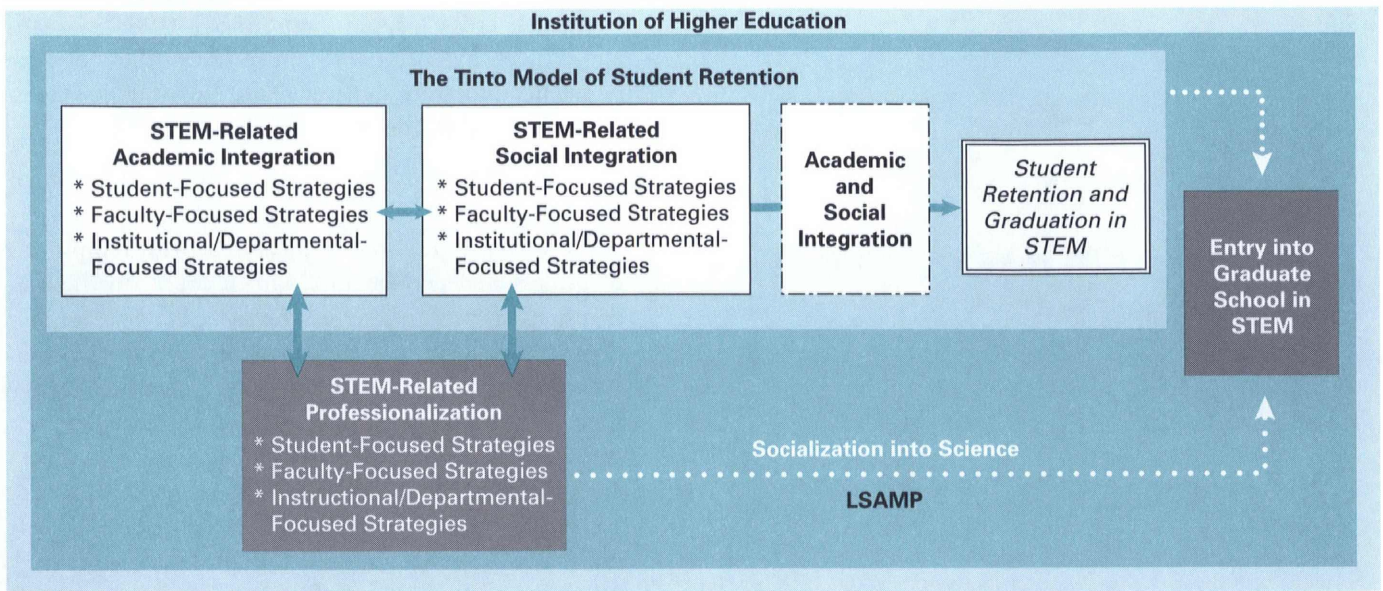
focused primarily on academic integration with those focused on social integration. Figure 3 lists the main strategies utilized by the LSAMP model, and identifies their contributions to the academic and social integration and professionalization of program participants. These individual strategies may serve more than one purpose, as is shown in figure 3.

Strategies and Approaches: Elements of the LSAMP Model

Strategies in figure 3 are the major approaches undertaken by the LSAMP Alliances as described earlier. These have been characterized as being student, faculty, and institutional/department centered. According to respondents (to the telephone interviews), these activities or approaches were chosen based on Alliance members' own experiences of what works, effective strategies identified in the research literature, and current or past efforts of partner institutions. A comprehensive review of the literature on strategies and approaches that increase the participation and persistence of URMs in STEM, conducted as part of this study and available in the full technical report of the evaluation, cites the support provided by empirical research for most of the LSAMP approaches and strategies that comprise the model.

FIGURE 3. Strategies and Approaches: Elements of the LSAMP Model

Focus/Activity	STEM Academic Integration	STEM Social Integration	STEM Professionalization
Student			
Summer Bridge	✓	✓	
Scholarship/Stipend	✓		
Peer Study Group	✓	✓	
Skills-Building Seminar	✓	✓	
Learning Centers	✓	✓	
Academic Advising	✓		
Summer Academic Enrichment	✓		
Tutoring	✓		
Research Experience	✓	✓	✓
Mentorships	✓	✓	✓
Conferences	✓		✓
Internships	✓	✓	✓
Career Awareness			✓
GRE Test Preparation	✓		✓
Graduate School Admissions Support			✓
Graduate Summer Bridge	✓	✓	✓
Faculty			
Workshop on Teaching	✓		
Diversity Sensitivity Training	✓	✓	
Faculty Research Program	✓		
Institutional/Departmental			
New Course Development	✓		
Curriculum Material Sharing	✓		
Distance Learning Courses	✓		
Changes in Institutional/ Departmental Policies and Practices	✓	✓	✓

Summative Evaluation Findings

The main objective of the summative evaluation was to assess the extent to which LSAMP has achieved its goals. As mentioned earlier, the LSAMP Program was designed as a comprehensive strategy intended to increase the quality and quantity of minority students who successfully complete baccalaureate degrees in science, technology, engineering, and mathematics (STEM) and who continue on to graduate studies in these fields. As it aims to make a positive impact on STEM fields, LSAMP's success may be measured by the program's ability to bring about a significant change in those areas targeted, such as the number of underrepresented minorities graduating with baccalaureate STEM degrees and persisting through to graduate study in STEM. This section of the report evaluates LSAMP's success in achieving these student-focused goals, and also reports on the effectiveness of the LSAMP model in increasing the participation of underrepresented minorities in STEM, and on participating institutions of higher education (IHEs).

Impact on Student Participants

The conclusions presented in this section are based mainly upon quantitative analyses of data collected via a survey of LSAMP participants who graduated from college between 1992 and 1997, and a national longitudinal survey of bachelor's degree recipients in STEM. Key findings are organized into three outcomes of interest—undergraduate performance, graduate school enrollment, and graduate school completion.

When appropriate, findings are compared with a nationally representative sample of STEM bachelor's degree recipients. This national sample was divided into a "white and Asian" sample and an "underrepresented minority" sample in order to provide two important comparisons—namely, LSAMP (all underrepresented minority) participants versus a national sample of underrepresented minorities, and LSAMP versus a national sample of white and Asian graduates.

Undergraduate Performance: Improving the Academic Success of Students in STEM

As measured by their undergraduate grade point averages (GPAs), LSAMP participants outperformed, on average, national comparative samples of underrepresented minority and (to a lesser extent) white and Asian students. A review of the distribution of GPAs among LSAMP students reveals that *half* of the LSAMP participants graduated with a high GPA (3.25 or above), and only a small percentage (< 10%) graduated with a rather low GPA (2.25 or below). Comparing the average GPA of LSAMP participants with that of a national sample of underrepresented minorities shows that LSAMP participants are significantly more likely to perform in the highest GPA categories, and significantly less likely to perform in the lower GPA categories. The analyses also show that LSAMP participants are as likely as whites and Asians (the two ethnicities that comprise the non-URM comparison group) to perform in the highest (3.75 and above) and lowest (2.24 or below) GPA categories, but more likely to perform in the second highest category (3.25–3.74) and less likely to find themselves in the second lowest performance stratum (2.25–3.24). *These findings suggest that, as measured by GPA, the average overall performance of LSAMP awardees, versus that of nationally representative samples of underrepresented minority and white and Asian students, is significantly higher.* It is important to note that some Alliances indicated that many (but not all) of their partner schools use GPA as a selection criterion, which would suggest that at those LSAMP schools, participants' GPAs would be above average. But this fact applies only to a limited number of institutions. More important is the fact that, across all institutions, participants are expected to maintain a minimum GPA level (which varies across institutions) in order to remain in the program. This requirement likely helps to encourage participants to perform well.

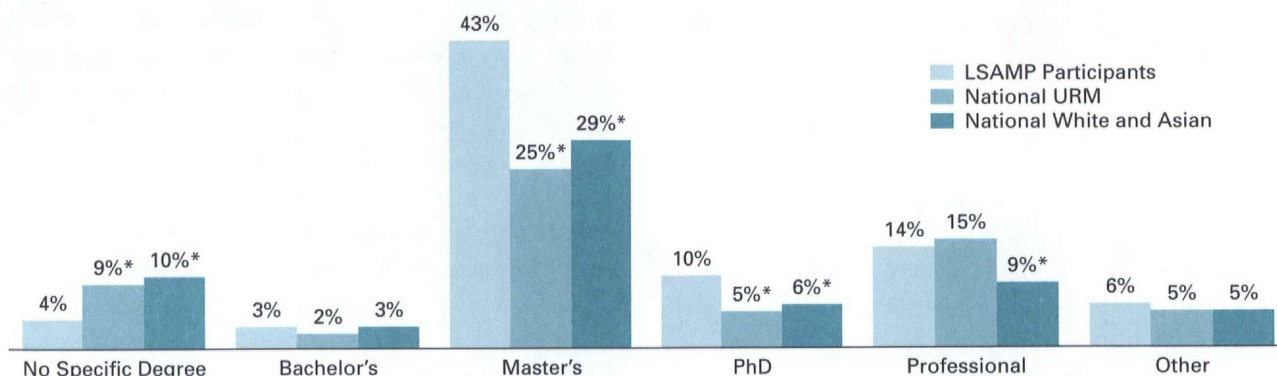## Graduate School Enrollment: Retaining URMs in the STEM Pipeline

LSAMP participants are significantly more likely to take additional post-BA coursework than are underrepresented minorities and whites and Asians nationally. At the time of the survey, almost 80 percent of former LSAMP participants had taken additional courses, compared with about 62 percent of both a national sample of underrepresented minorities and a national sample of white and Asian graduates. On average, then, LSAMP students are significantly more likely to have taken additional coursework after obtaining a bachelor's degree than are either URMs (non-LSAMP participants) or non-URM students.

LSAMP participants are significantly more likely to enroll in graduate programs and to pursue master's degrees and doctorates than either comparison group. As is true in the national population, LSAMP participants are most likely to pursue a master's degree, followed by professional degrees and doctorates. Analyses indicate that about 65 percent of LSAMP students pursued graduate degrees, compared with approximately 45 percent of the comparison samples. In addition, a significantly larger share of LSAMP participants pursued master's and doctoral programs than did those in either comparison group. Specifically, the data suggest that, as a share of the national samples, LSAMP participants are about 50 percent more likely to pursue an MA or a PhD than are those in either comparison group. Restricting this analysis only to participants who pursue graduate degrees also reveals that LSAMP graduates are more likely enroll in academic (master's and doctoral degrees) over professional programs than are their national URM peers. In so doing, their enrollment patterns mirror those of the white and Asian sample. Lastly, as a percentage of all LSAMP students, those seeking degrees were most likely to pursue a master's degree (43%), followed by professional degrees (14%) and doctorates (10%) (figure 4). This pattern is also true of the two national comparison groups.

LSAMP students are more likely to pursue graduate degrees in STEM. Thirty-eight percent of all LSAMP students pursued graduate degrees in STEM, compared with 20 to 22 percent among the comparison groups. This difference declines when restricting the comparison only to those who pursued graduate degrees in any field, but LSAMP students who go on to graduate studies are still more likely to enroll in STEM than are students in either comparison group (58% LSAMP versus 44 to 50% in the comparison groups). These and earlier results indicate that higher percentages of LSAMP participants have pursued graduate degrees—regardless of the STEM/non-STEM distinction—than have the national comparison groups, and that LSAMP participants are also more likely to pursue graduate degrees in STEM. These findings suggest that LSAMP had the desired effect of increasing minority representation in STEM graduate programs.

FIGURE 4. Degrees Sought: Post-Bachelor's Coursework

Legend: LSAMP Participants; National URM; National White and Asian

No Specific Degree: 4%, 9%*, 10%*
Bachelor's: 3%, 2%, 3%
Master's: 43%, 25%*, 29%*
PhD: 10%, 5%*, 6%*
Professional: 14%, 15%, 9%*
Other: 6%, 5%, 5%

* National comparison group statistic is significantly different from LSAMP.
Sources: UI LSAMP Graduate Survey, 2002. NSF NSRCG Longitudinal File 1993/95/97.
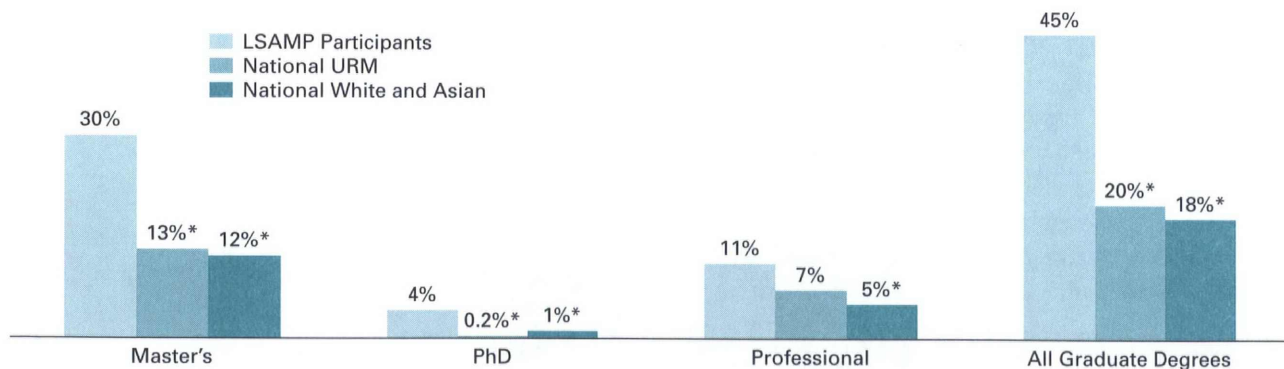
LSAMP students continuing in STEM tended to enroll in engineering or in life and related sciences, while the majority of those not enrolling in STEM fields (as defined by NSF) were in health sciences. The majority of students who remained in STEM at the graduate level pursued degrees in engineering (44%) or in life and related sciences (29%), while the majority in non-STEM fields pursued degrees in health, including medicine. Combining health studies with STEM yields a combined graduate school enrollment rate of 78 percent (among those pursuing post-undergraduate studies), *which means that 50 percent of all LSAMP participants went on to graduate studies in STEM or health sciences.*

Regardless of academic undergraduate performance, LSAMP participants were more likely than comparison underrepresented minorities and whites and Asians to pursue graduate studies. LSAMP participants were significantly more likely than national URMs and non-URMs to pursue graduate degrees, regardless of their GPAs. Across nearly all GPA categories, LSAMP participants display higher rates of graduate school attendance than do those in the two comparison groups.[11] This is important insofar as it suggests that LSAMP succeeds in encouraging not only high achievers but also more average students to pursue graduate studies and to seek to succeed in science. In other words, LSAMP is not biased towards promoting *only* those at the top of the achievement distribution, but instead appears to promote graduate studies among participants at all achievement levels.

Graduate School Completion: Promoting Completion of STEM Graduate Degrees

LSAMP participants exceeded the national rate of graduate degree completion for both URM and non-URM national samples, and are more likely to complete a graduate degree in a STEM than in a non-STEM field. At the time of the survey, over 40 percent of LSAMP participants had completed a graduate degree,[12] compared with approximately 20 percent of individuals in the national comparison groups. *LSAMP participants have thus far exceeded the national rate of graduate degree completion for both URMs and whites and Asians* (figure 5). In addition, as a percentage of all respondents, LSAMP participants were more likely to complete a degree in STEM (25% did) than is true among either comparison group (9% of URMs and white and Asian graduates). Restricting this comparison to those respondents who completed a degree shows that LSAMP students are still more likely to have completed a graduate degree in STEM (57%) than are comparison URMs (43%) or whites and Asians (51%). Also important is the finding that LSAMP students in general were slightly more likely to complete a degree in STEM (25% of all LSAMP participants) than in a non-STEM field (19% of all LSAMP). Almost 70 percent of completed master's degrees were in a STEM field, as were nearly 90 percent of completed PhDs. As expected, given the NSF definition of STEM,[13] the exception to this trend was professional degrees; over 80 percent of completed professional degrees were awarded in a non-STEM field.

FIGURE 5. Degrees Completed at Time of Survey

Legend:
- LSAMP Participants
- National URM
- National White and Asian

Master's: 30%, 13%*, 12%*
PhD: 4%, 0.2%*, 1%*
Professional: 11%, 7%, 5%*
All Graduate Degrees: 45%, 20%*, 18%*

* National comparison group statistic is significantly different from LSAMP.
Sources: UI LSAMP Graduate Survey, 2002. NSF NSRCG Longitudinal File 1993/95/97.

Engineering, followed by health and life sciences, was the most common field of study among LSAMP participants who completed graduate degrees. Overall, the top three fields of completed graduate degrees for LSAMP participants were engineering (25%), health professions (23%), and life and related sciences (17%). These were followed by business (9%), physical and related sciences (9%), and computer and math sciences (7%). Degrees in non-STEM fields other than medicine or business make up only 10 percent of the graduate degrees completed by LSAMP participants.

A very large share of LSAMP participants seeking post-undergraduate degrees are in the graduate school pipeline, either as graduates (60%) or enrolled students (20%). The status of those who indicated they were seeking—but had not yet completed—a graduate degree at the time of the survey is an important complement to this discussion, as it relates to URM persistence in higher education. As reported above, about 60 percent of those LSAMP participants pursuing master's degrees, 75 percent of those pursuing professional degrees, and 36 percent of those pursuing doctorates had completed them at the time of the survey, between 5 and 10 years after participants' graduation with a BA in STEM. These figures rise significantly, however, if we add those who have not yet completed their graduate studies, but are still taking courses—i.e., are still in the pipeline. This is particularly true for doctoral students, which is natural given that doctoral programs take longer to complete than either master's or professional degrees.

The issue of "time elapsed" is critical here, and helps explain both the greater rate of completion of master's and professional degrees, as well as the greater share of doctoral students (compared with master's and professional degree students) who are still taking courses. For the majority of LSAMP survey respondents, between 5 and 6 years passed between the time of undergraduate graduation and the survey, which is plenty of time to complete a short program, but is generally not long enough to apply to, enroll in, and complete a doctoral program. Overall, 60 percent of LSAMP participants seeking graduate degrees had completed the highest degree they were seeking and about 20 percent continued to take courses at the time of the survey. The remaining 20 percent indicated that they were not enrolled in or taking courses at the time of the survey, which might be an overestimate of those *not* in the pipeline, as doctoral candidates could be working towards completion of their dissertation.

To summarize, this analysis suggests that a very large share of LSAMP participants have gone on to graduate school, with at least 80 percent of them likely still in the graduate-level pipeline, either as graduates or enrolled students.

The most frequently cited reasons by LSAMP participants for not taking post-BA courses align with those cited in national samples. LSAMP graduates are, however, more likely than the national comparison groups to cite financial burdens. At the time of the survey, only 20 percent of the LSAMP sample had taken no courses since their STEM bachelor's degree, compared with nearly 40 percent of the national comparison groups.[14] The main reasons cited by LSAMP graduates who had not taken courses were that they had a job or needed to work (76%); had achieved their educational goals, at least for the time being (58%); faced other financial burdens (48%); and needed a break or were tired of going to school (45%). This ranking of most-frequently cited reasons is largely the same as that of a national group of STEM graduates who had also *not* taken courses since obtaining an undergraduate degree.[15] Nonetheless, LSAMP graduates are significantly more likely than either comparison group (underrepresented minorities and whites and Asians) to report financial concerns as a reason preventing them from returning to school. More specifically, over 75 percent of LSAMP graduates not taking additional courses (versus about 60% of comparison group students) cited the need to work, while almost 50 percent of LSAMP graduates (versus about 30% of national URMs and whites and Asians) mentioned "other financial burdens." Also possibly alluding to financial burdens, LSAMP respondents were significantly more likely than national whites and Asians to cite family responsibilities as a reason for failing to pursue additional studies.

Key Student Outcomes: Graduate School Enrollment and Degree Completion

Figure 6 presents the most critical student-level outcomes measured, and clearly conveys the differences in the "pipeline" progression of LSAMP participants versus participants in comparative URM and white and Asian samples.

The data show that about 80 percent of LSAMP students took further coursework after completing their bachelor's degree, compared with about 60 percent of comparison URM and white and Asian students. Similarly, a larger proportion of LSAMP participants

FIGURE 6. Graduate Coursework, Degrees Pursued, and Degrees Complete

LSAMP Participants
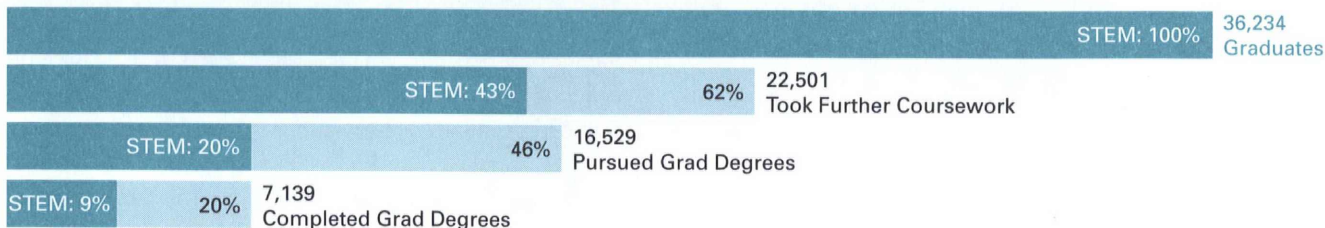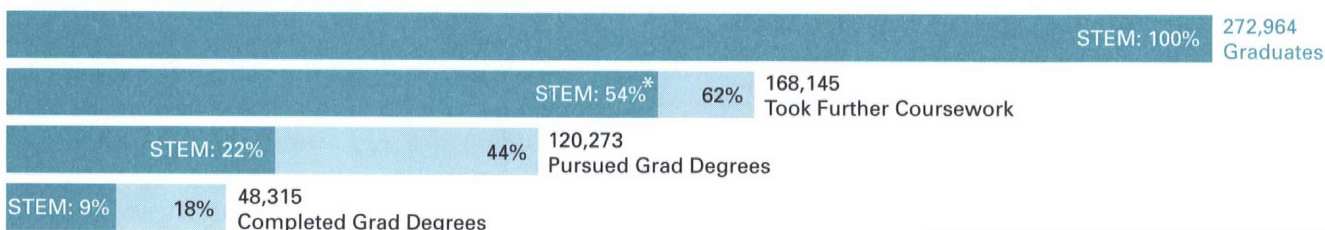
STEM: 100%	1,426 Graduates
STEM: 58% · 79%	1,122 Took Further Coursework
STEM: 38% · 66%	937 Pursued Grad Degrees
STEM: 25% · 45%	635 Completed Grad Degrees
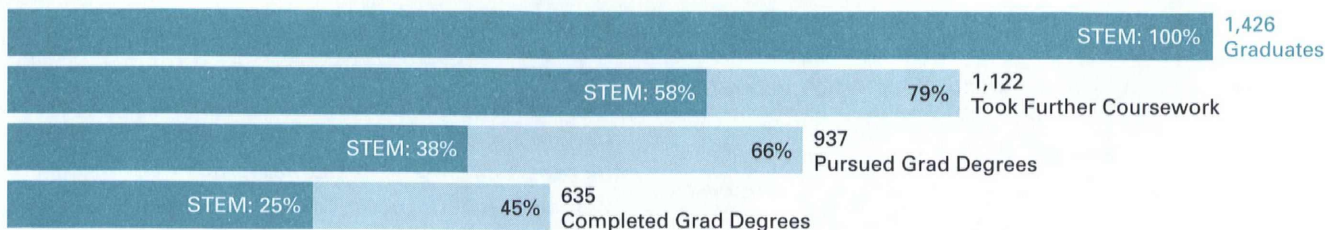
National Underrepresented Minority

STEM: 100%	36,234 Graduates
STEM: 43% · 62%	22,501 Took Further Coursework
STEM: 20% · 46%	16,529 Pursued Grad Degrees
STEM: 9% · 20%	7,139 Completed Grad Degrees

National White and Asian

STEM: 100%	272,964 Graduates
STEM: 54%* · 62%	168,145 Took Further Coursework
STEM: 22% · 44%	120,273 Pursued Grad Degrees
STEM: 9% · 18%	48,315 Completed Grad Degrees

Sources: UI LSAMP Graduate Survey and NSF NSRCG Longitudinal File.
*National comparison group statistic is not significantly different from LSAMP.

pursued graduate degrees (66%) than is true among the comparison groups (45%). Lastly, about 45 percent of LSAMP students completed graduate degrees, while this was true of about 20 percent of national URM and white and Asian bachelor's degree holders.

Analyses of these same data by field of studies shows that LSAMP participants, while as likely as whites and Asians to pursue further coursework in STEM, outperform this comparison group as well as URMs in terms of graduate degree enrollment and completion in STEM. Thirty-eight percent of LSAMP participants enrolled in STEM graduate degrees, compared to about 20 percent of comparison groups. In addition, 25 percent of former LSAMP students completed graduate degrees in STEM, versus about 9 percent of graduates in comparison groups.

These results reveal a striking difference in the progression of LSAMP participants versus national URMs and whites and Asians going through the STEM pipeline. This difference, in favor of LSAMP, is perceived at each step—in pursuit of post-undergraduate coursework, in enrollment in graduate programs, and in completion of graduate degrees, overall and in STEM fields.

Impact on the Knowledge Base: The LSAMP Model

The main goal of this evaluation, as required by NSF, was to evaluate the success of the LSAMP program in increasing the quality and quantity of minority students who successfully complete baccalaureate degrees in science, technology, engineering, and mathematics (STEM), and who continue on to graduate studies in these fields. In carrying out the work necessary to conduct this assessment, we identified a set of practices that converge to form a distinct program model. Above, we discussed this model and its links to the existing literature in STEM. In this section we take this work further and explore the model's effects empirically. Using the data collected through the survey of LSAMP participants, and national data from the NSRCG, we study the relative success of different components of the LSAMP model in producing the outcomes presented in earlier sections of this report.

An important caveat is warranted here. The LSAMP model as defined in this work is not one that can easily be teased apart into discrete components to see the relative impact of each. Instead, it is a model

whose success is likely dependent on the presence of all the factors (in statistical terms, there are both fixed and interaction effects associated with the model components). While one could envision setting out to test these factors in a multivariate model, such an exercise would not provide useful information because the categories are too interrelated, making the construction of discrete variables measuring relevant constructs impossible (see figure 3). To the extent that we felt we could reasonably tease out components that could be interpreted in a standard way throughout institutions, we did so. The findings from these analyses are presented below.

The data were analyzed, by targeted outcome, by separating LSAMP strategies or activities. The goal of this analysis was to find out if there is a positive relationship between participation in different activities and desired outcomes. For this purpose, and for each outcome of interest, we divided the LSAMP sample according to whether respondents achieved the desired outcome or not, and proceeded to compare the rates of participation in different activities.

Three activities or program components stand out as having a positive relationship with desired outcomes (such as enrollment in and completion of graduate programs)—namely, research with faculty, internships (i.e., research activities), and summer bridge (i.e., academic preparation).[16] The results show that LSAMP participants who participated in research with faculty were more likely to pursue and complete graduate degrees, both overall and in STEM. In addition, students who participated in research internships were more likely to have enrolled in graduate degrees (in general and in STEM) and to complete a STEM graduate degree. Participants pursuing graduate degrees, and completing graduate degrees (both in general and in STEM) were also more likely to have attended summer bridge activities. These findings align nicely with those obtained through interviews with the Alliances. As reported in the process component of this evaluation, the top three project components cited by Alliances as being most important were, in order of importance, research experience, summer bridge, and mentoring. The first two are the same listed by survey respondents (all LSAMP participants); the last one is likely associated with doing research with faculty. *To summarize, this analysis suggests that there are three activities or program components that stand out as having a significant positive relationship with desired outcomes—namely, research with faculty, internships, and summer bridge. These components represent research and academic preparation, which corre-*

spond, respectively, to the professionalization and academic elements of the model.

LSAMP students who pursued graduate degrees and who completed graduate degrees (in general and in STEM in particular) tended, on average, to participate in more activities and to spend more time in the program. Two other factors studied were number of LSAMP activities in which students participated and number of years of participation in LSAMP. The mean of each was constructed for two groups—students who achieved the targeted outcome (e.g., enrollment in graduate school, enrollment in STEM, etc.) and those who did not. The results show that LSAMP students who pursued graduate degrees and who completed graduate degrees (in general and in STEM, in particular) tended, on average, to participate in more activities and to spend more time in the program.

Although there are some demographic differences between LSAMP participants who began their studies at a community college and those who did not, no differences between these two groups are found in program outcomes. Another distinguishing component of the LSAMP program was its initial emphasis on community college students. Community colleges enroll close to half of all students from groups traditionally underrepresented in STEM disciplines. Only 26 percent of all students at two-year colleges, however, transfer to four-year institutions. By targeting these students, LSAMP may have aided in the transition to a four-year college and helped preserve students already in the STEM pipeline.

Close to 10 percent of LSAMP participants began their studies at a community college. Community college starters were demographically different from those who did not attend community college across three dimensions: gender, race, and socio-economic status. They were significantly more likely than students who did not begin at community college to be male (63% versus 49%), Hispanic (54% versus 36%), and to have a mother who had not completed high school (25% versus 15%).

Despite these demographic differences, program outcomes for community college starters mirrored those of students whose entire degree was completed at a four-year institution. There were no significant differences in distribution of undergraduate grade point average, the enrollment in STEM graduate studies, or the completion of a STEM graduate degree between these two groups. Based upon these data, we conclude that regardless of initial demographic differences, par-

ticipation in LSAMP is associated with similar outcomes for both groups of students.

Impact on Participating IHEs

Greater retention of students in STEM. Evidence gathered from the telephone interviews with project staff and the case study site visits provides insight into the ways in which the LSAMP Program has affected participating colleges and universities. Foremost is the belief that involvement in LSAMP has enabled institutions to retain and graduate more STEM students by substantially expanding their capabilities to develop and support STEM student talent. The overwhelming majority of LSAMP projects reported that the major outcome of their project is a positive impact on student retention and degree attainment in STEM (in particular, among underrepresented minority students). The process evaluation data show how institutional capability to boost STEM student productivity is seemingly enhanced by LSAMP's work in providing a wider and more targeted array of services and supports that often includes increased access to undergraduate research, participation in summer bridge, tutoring and peer study groups, attendance and presentation at scientific conferences, and internships. While each of these services and supports may be effective alone, the fact that they form components of an integrated and comprehensive program seems to strengthen their collective efficacy. Furthermore, as pointed out by some, this enhanced institutional ability, coupled with the LSAMP Program's growing reputation, bestows indirect benefits and advantages to the schools, such as greater institutional prestige, increased ability to recruit URM STEM prospective undergraduates, and an improved chance to procure subsequent funding for other STEM-related intervention programs.

Change in institutional culture. LSAMP is also said to have affected participating institutions by influencing a change in institutional culture. For example, STEM faculty members are reported to have developed greater awareness, understanding, and responsibility for diversity; become more open-minded about how undergraduates can contribute in the laboratory; become more engaged in advising at various levels, including in more informal ways; and become more reflective about effective teaching and learning strategies. Moreover, some schools reported that the LSAMP minority retention approach is inspiring non-STEM disciplinary fields on campus to follow suit (e.g., by expanding undergraduate research opportunities, and providing students with more personal attention). In addition, LSAMP's emphasis on connecting students to institutional services is reportedly helping to bring together faculty and student support staff. LSAMP is also said to be impacting student culture at participating schools through community building, which enables LSAMP students to become part of a supportive social network. For example, senior LSAMP participants commonly tutor and mentor junior participants, and serve as role models. LSAMP helps to fend off student isolation by promoting student interaction and camaraderie through such vehicles as student clubs, LSAMP learning centers, and a range of activities and events, which take place at the school and Alliance levels.

Changes in policies and practices. LSAMP has also affected policies, procedures, and practices at participating schools. Examples include LSAMP's influence on changing aspects of academic advisement, institutional admissions recruitment, scholarship applications, advertisement of science research internships and assistantships, course registration, and faculty research proposals. Some schools have experienced infrastructure change through the enhancement of diversity support systems, such as the addition of LSAMP-sponsored advising and tutoring services, and the creation of learning centers or LSAMP space for students to come together. More than half of the Alliances reported that some of their partner schools have undertaken efforts in the area of STEM curriculum development (often involving gatekeeping courses), which includes reforming existing courses, developing new ones, sharing course materials with partner schools, and introducing distance learning courses. Finally, LSAMP participation has also enabled institutions to engage in greater collaboration, networking, and resource and information sharing with other schools. This practice occurs among the four-year institutions as well as between the four- and two-year institutions (e.g., refinement or development of articulation agreements; assistance with the transfer and adjustment of LSAMP community college students to four-year institutions). Collaborations within the Alliance take place at multiple levels as LSAMP expands opportunities for institutional leaders, project staff, students, and faculty on one campus to work with and form supportive relationships with counterparts at partner schools.

Conclusions and Recommendations

This section summarizes the main conclusions that emerge from our evaluation of the LSAMP Program and provides a set of recommendations for its future implementation and replication.

Conclusions

1. *The LSAMP Program has met its stated goals of increasing the quality and quantity of students successfully completing LSAMP-supported STEM baccalaureate programs, and increasing the number of students matriculating into programs of graduate study in STEM.*[17]

LSAMP graduates make up a growing percentage of underrepresented minorities (URMs) who obtain baccalaureate degrees in STEM fields. From 1994 to 1997, the LSAMP share of URM undergraduate STEM degrees increased fourfold as LSAMP participants progressed to graduation and the number of LSAMP Alliances increased (NSF 2002).[18] This increase coincided with a steady rise in the number of underrepresented minorities obtaining bachelor's degrees in STEM nationwide (NSF 2002). Most importantly, former LSAMP participants are significantly more likely to enroll in graduate programs in general, and in STEM in particular, than are members of national samples of whites and Asians, and underrepresented minorities.

Our comparison of LSAMP participants' graduating GPAs with those of national samples of underrepresented minority (URM) and Asian and white student baccalaureate recipients in STEM majors reveals that LSAMP students are significantly more likely to perform in the highest GPA categories and significantly less likely to be in the lowest GPA categories. This suggests that, as measured by GPA, the overall performance of LSAMP graduates is higher than that of nationally representative samples of minority and nonminority students.

2. *The LSAMP Program has exceeded its goals by producing underrepresented minority students who attain graduate degrees in STEM at a rate not only higher than that of the national population of underrepresented minorities (URM) but also higher than that of white and Asian STEM baccalaureate degree recipients.*

LSAMP students have attained STEM graduate degrees at significantly higher rates than URMs or whites and Asians in comparison samples. Moreover, former LSAMP participants are also more likely to complete a graduate degree in STEM than in a non-STEM field than are graduates in the other two comparison groups.[19]

3. *LSAMP's strategies and approaches constitute a discrete, identifiable program model, grounded in research and theory, that can be tested and replicated.*

The mixed-methods approach used in this evaluation enabled us to study the LSAMP model in a number of settings. This allowed us to observe the program playing out in Alliances and institutional sites across the country, with common strategies and approaches forming an identifiable intervention model to increase access to, and success in, STEM fields for URMs. The model represents an integrated approach to increasing minority student success in STEM. More importantly, the LSAMP model, grounded in theory as well as empirical research, has been tested and demonstrated to be successful based on data collected as part of this evaluation. The identification, description, and empirical investigation of this model signifies a critical advance in the existing knowledge base of intervention program models.

Recommendations

1. *Increase data collection efforts.* LSAMP Alliances should collect the following additional data on Level I participants:

- Undergraduate retention and attrition information about participants so that the program's success in retaining participants may be assessed.

- Tracking information that may be used to follow up on participants in order to ascertain whether or not they remain in the STEM career track by enrolling in a STEM graduate program and/or entering the S&E workforce.

2. *Strengthen the focus on community college students.* In light of the program's success in retaining in the STEM

pipeline underrepresented minority students who begin their college education in community colleges, LSAMP should place added emphasis on strengthening and expanding the program's community college component. Community colleges enroll more than half of all underrepresented minority students in postsecondary education, thus providing a promising source of potential STEM students.

3. *Expand the program to offer graduate school tuition and support to LSAMP graduates.* LSAMP graduates who did not continue taking courses after completing a bachelor's degree cited financially related factors as reasons for not doing so. The need to work and other financial burdens figured prominently among the most important barriers to LSAMP students' enrollment in graduate education and these factors were cited by a significantly higher percentage of LSAMP graduates than their peers in both comparison groups. Given LSAMP's success in preparing participants to enter and complete graduate degrees, extending the program's offerings to include financial

incentives to encourage these students to enter graduate STEM programs seems a worthwhile investment.[20]

4. *Emphasize successful factors in selecting sites to receive LSAMP awards.* In awarding LSAMP grants, the program should continue to consider three criteria of utmost importance in identifying potentially successful applicants: (1) evidence of institutional and faculty support;[21] (2) a history of, or plans for, a strong collaborative relationship among partners;[22] and (3) a well-defined plan and the capacity to provide the integrative services that comprise the LSAMP model.[23]

5. *Replicate and expand the LSAMP program.* Given LSAMP's proven success, it is important that efforts to replicate and disseminate the model be increased. The LSAMP model, unlike most intervention efforts for increasing URM participation in STEM, lays the foundation for systemic institutional change. It does so, in large part, by synergistic efforts of institutional partners who can collaborate and share resources, information, and experiences.

The LSAMP

Program

has met its

stated goals

Notes

1. 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.

2. NSF recently initiated a program, Bridge to the Doctorate, to provide graduate school tuition and support to LSAMP graduates.

3. Includes African Americans, Hispanics, and American Indians. For more details, see note 1.

4. The full evaluation report is available on the web at http://www.urban.org.

5. Three Alliances were selected through a stratified random sampling design described in the full report: the Colorado Alliance (COAMP), the Florida/Georgia Alliance (FGAMP), and the New York City Alliance (NYC LSAMP).

6. These were the Alliances that had received funding at the time the evaluation began.

7. Typically a 4–6 week pre-freshman program that entails intensive academic enrichment and other strategies to facilitate students' transition and adjustment to college.

8. These can be compared with the "keys to success" identified in an earlier report on LSAMP (Sharp, Kleiner, and Frechtling 2000): summer bridge program, research experience, mentoring, drop-in center, caring staff, and alliance structure.

9. A few other programs such as NIH's Minority Access Research Career (MARC) and Minority Biomedical Research Support (MBRS) programs also adopt this approach.

10. Includes African Americans, Hispanics, and American Indians. For more details, see note 1.

11. The only exception is the lowest GPA category (less than 2.24), where no differences across groups are found.

12. Graduate degree is defined as a doctoral, master's, or professional degree.

13. Recall that the NSF definition of STEM excludes medicine and technicians in various fields, including computer and information technology. These degrees make up the largest part of the non-STEM professional degrees attained by LSAMP students.

14. The original proposal question asked about those who had not "gone on to graduate school." Because of different skip patterns used in the three NSRCG surveys, relevant data were collected only from those who had taken *no courses at all*. It should be kept in mind, therefore, that this analysis does not include information for the 13 percent of LSAMP, 27 percent of national URMs, and 28 percent of national whites and Asians who had taken additional coursework since graduation, but were *not* working towards a master's degree, professional degree, or doctorate.

15. The one exception is that white and Asian graduates were more likely than either minority group to indicate, as a reason for not taking additional courses after obtaining a BA, that they had achieved their educational goals, at least temporarily.

16. Findings regarding graduate school support, although significant, are not reported due to the low number of records on which they are based and concerns over selection bias.

17. LSAMP participants, graduates, or students referred to in this study include only Level I participants, since these were the focus of our study. Level I students are those who are funded by the program and who typically participate in a basic set of LSAMP-sponsored activities. LSAMP might have shown a larger impact on the numbers of URMs graduating in STEM if *all* students who participated in the program had been included.

18. Data from NSF show that degrees awarded to URMs from 1994 to 1997 increased steadily, with LSAMP contributing an increasing share (1% in 1994–95, rising to 4% in 1997–98).

19. It is conceivable that the completion rates for the two comparison groups may increase with time, thus narrowing the gap with LSAMP. The findings, nevertheless, suggest that LSAMP may have had an effect on accelerating time to degree.

20. See note 2.

21. Institutions whose goals are aligned with those of LSAMP and that have a history of prior involvement in diversity-focused efforts are more likely to be supportive.

22. Proposed partnerships should have a plan for facilitating collaboration among partners and choose a structure and rationale that encourage collaboration.

23. This plan should include provisions for advancing the knowledge base by tracking effectiveness of efforts.

References

Bers, T.H., and Smith, K.E. 1991. "Persistence of Community College Students: The Influence of Student Intent and Academic and Social Integration." *Research in Higher Education* 32: 539–56.

Bowman, M.H., and Stage, F.K. 2002. "Personalizing the Goals of Undergraduate Research." *Journal of College Science Teaching* 32(2): 120–25.

Braxton, J.M., Brier, E.M., and Hossler, D. 1988. "The Influence of Student Problems on Student Withdrawal Decisions: An Autopsy on 'Autopsy' Studies." *Research in Higher Education* 28: 241–53.

Cabrera, A.F., Castaneda, M.B., Nora, A., and Hengstler, D. (1992). "The Convergence between Two Theories of College Persistence." *Journal of Higher Education* 63: 143–64.

Cabrera, A.F., Nora, A., and Castaneda, M.B. 1992. "The Role of Finances in the Persistence Process: A Structural Model." *Research in Higher Education* 33: 571–93.

Delamont, S. 1987. "Three Blind Spots? A Comment on the Sociology of Science by a Puzzled Outsider." *Social Studies of Science* 17(1): 163–70.

Dryburgh, H. 1999. "Work Hard, Play Hard: Women and Professionalization in Engineering—Adapting to the Culture." *Gender and Society* 13(5): 664–82.

Gaston, J. 1989. "The Benefits of Black Participation in Science." In *Blacks, Science, and American Education,* edited by W. Pearson and H.K. Bechtel (123–36). New Brunswick: Rutgers University Press.

Merton, R. 1973. *The Sociology of Science.* Chicago: The University of Chicago Press.

Mulkey, L.M., and Ellis, R.S. 1990. "Social Stratification and Science Education: A Longitudinal Analysis, 1981–1986, of Minorities' Integration into the Scientific Talent Pool." *Journal of Research in Science and Teaching* 27(3): 205–17.

National Science Board. 2003. *The Science and Engineering Workforce: Realizing America's Potential.* (No. NSB 03-69). Arlington, VA: Author.

National Science Foundation, Division of Science Resources Statistics. 2002. *Science and Engineering Degrees, by Race/Ethnicity of Recipients.* (Report No. NSF 02-329). Arlington, VA: Author.

National Science Foundation. 2001. "National Survey of Recent College College Graduates (NSRCG) Longitudinal Data File (1993, 1995, 1997)."Prepared by WESTAT for the National Science Foundation.

Nora, A. 1987. "Determinants of Retention among Chicano College Students: A Structural Model." *Research in Higher Education* 26: 31–59.

Nora, A., Attinasi, L.C., and Matonak, A. 1990. "Testing Qualitative Indicators of Pre-college Factors in Tinto's Attrition Model: A Community College Student Population." *Review of Higher Education* 13: 337–56.

Pascarella, E.T., Smart, J.C., and Ethington, C.A. 1986. "Long-term Persistence of Two-year College Students." *Research in Higher Education* 24: 47–71.

Pascarella, E.T., Terenzini, P.T., and Wolfe, L.M. 1986. "Orientation to College and Freshman Year Persistence/Withdrawal Decisions." *Journal of Higher Education* 57: 155–75.

Sharp, L., Kleiner, B., and Frechtling, J. 2000. *A Description and Analysis of Best Practice Findings of Programs Promoting Participation of Underrepresented Undergraduate Students in Science, Mathematics, Engineering, and Technology Fields.* (Report No. NSF 01-31). Arlington, VA: National Science Foundation.

Stage, F.K. 1989. "Motivation, Academic and Social Integration, and the Early Dropout." *American Educational Research Journal* 26: 385–402.

Stoecker, J., Pascarella, E.T., and Wolfe, L.M. 1988. "Persistence in Higher Education: A Nine-year Test of a Theoretical Model." *Journal of College Student Development* 29: 196–209.

Tinto, V. 1993. *Leaving College: Rethinking Causes and Cures of Student Attrition,* 2nd ed. Chicago: University of Chicago Press.

Urban Institute. 2002. "Urban Institute's Louis Stokes Alliance for Minority Participation (LSAMP) Graduate Survey." Washington, DC: The Urban Institute.

Williamson, D.R., and Creamer, D.G. 1988. "Student Attrition in Two- and Four-year Colleges: Application of a Theoretical Model."