UNDERSTANDING INTERVENTIONS

That Broaden Participation in Research Careers !

2009

EMBRACING A BREADTH OF PURPOSE

Volume II

Daryl E. Chubin, Anthony L. DePass, and Linda Blockus, Editors

INTERVENTIONS
RESEARCH
DIVERSITY

AAAS
ADVANCING SCIENCE, SERVING SOCIETY

UNDERSTANDING INTERVENTIONS
THAT BROADEN PARTICIPATION IN RESEARCH CAREERS

VOLUME III

Embracing a Breadth of Purpose !

SUMMARY OF A CONFERENCE
BETHESDA, MARYLAND, MAY 7–9, 2009

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We have labeled this report "Volume III" because it follows the 2007 and 2008 reports. The next in the series will be "Volume IV." Please go to www.UnderstandingInterventions.org for information regarding earlier reports and to request additional copies.

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PLANNING COMMITTEE FOR THE THIRD ANNUAL CONFERENCE ON UNDERSTANDING INTERVENTIONS THAT BROADEN PARTICIPATION IN RESEARCH CAREERS

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Preface

On May 7–9, 2009, the Minority Affairs Committee of the American Society for Cell Biology and the Center for Advancing Science & Engineering Capacity at the American Association for the Advancement of Science held the Third Annual Conference on Understanding Interventions that Broaden Participation in Research Careers. Three main groups were represented at the conference: directors and managers of programs designed to increase the number of undergraduate and graduate students pursuing science, technology, engineering, and mathematics (STEM) degrees; evaluators of these programs; and scholars who conduct empirical research that illuminates the constellation of issues around educating and developing a diverse STEM workforce. Many people at the conference could claim membership in more than one these groups, and the dividing lines between them are not always clear. Nevertheless, these groups remain sufficiently distinct that when their members have an opportunity to engage each other in conversation, the outcomes can be both unexpected and energizing.

The third conference on understanding interventions had some important differences from the conferences held in the previous two years. First, it was substantially larger. From 200 attendees in 2008, the 2009 conference attracted more than 300 attendees, even though the majority of attendees were first-time participants. In part, this reflects a broadening of scope beyond the biomedical and behavioral sciences that were the focus of the first conference in 2007. Attendees at the third conference had backgrounds in geology, physics, computer science, chemistry, engineering, mathematics, and many other fields. And while each field must address issues unique to its own history and traditions, the commonalities related to broadening participation in science-related careers are extensive.

In addition, the increased attendance at the third conference reflects a growing recognition of the importance of these issues. Presenters at the conference did not dwell on the data documenting the magnitude of the challenge (a compilation of these data by the Commission on Professionals in Science and Technology was made available to conference attendees; a selection of figures appears in Appendix A). Yet all were aware that increasing participation in science-related careers is more than a desirable goal. It has become a necessity for the long-term viability of the STEM professions.

The first interventions conference held in 2007 had four broad goals: to demonstrate the need for hypothesis-based approaches that would inform the design, implementation, and evaluation of programs; to enable biomedical scientists to tap the expertise of colleagues in the economic, social, and behavioral sciences; to equip participants with some of the methodologies and tools relevant to the design, implementation, and evaluation of programs; and to foster a community of scholars whose work and expertise could be used in such pursuits. (A summary of the workshop may be downloaded from http://www.nationalacademies.org/moreworkshop.) The 2008 conference added to these goals an explicit focus on the dissemination of research results to a broad audience of researchers and program practitioners. In addition, the second conference illustrated how research on minority students can inform and benefit research and interventions directed toward all underrepresented groups, including women, first-generation and low-income students, immigrants, and students with disabilities. (A summary of the second conference is available at http://www.understandinginterventions.org/wp-content/themes/simpla_widgetized/files/08Understanding_Interventions.pdf).

If the 2008 conference report aimed at demonstrating that the development of community is a work-in-progress, the 2009 conference unabashedly embraced a breadth of purpose. This was deemed appropriate by the conference planning committee, which opted in the conference to expand the range of activities and topics offered to participants. While the plenary sessions would frame major themes, workshops, concurrent sessions, and posters would illustrate effective strategies implemented in successful STEM programs, present results from hypothesis-based research studies, and develop approaches to translate research into practice. The conference schedule was designed to encourage interactions among practitioners, evaluators, and researchers and to develop multidisciplinary partnerships.

The 2009 conference sought not only to inform practice with research but also to inform research with practice. A particular goal was to engage graduate students seeking meaningful dissertation topics in the behavioral and social sciences and education. A poster section was twice as large as the previous year's and added a new feature: 12 exhibits on programs and institutions relevant to the concerns of attendees. Information from the posters and exhibits, along with PowerPoints from many of the presentations, is available on the conference's website: http://www.understandinginterventions.org.

This conference was constructed with "process" in mind. We sought to enlarge the circle of intervention researchers and practitioners, searching for core concerns and critical masses to explore those concerns. In this summary, we were challenged to shape 53 presentations, configured as a two-day sched-

ule, into a consumable collection for the reader to skim, probe, or otherwise build on. Our response to the challenge of intellectual pluralism is a report structured into five sections, some with subsections, organized around overarching themes that emerged in the months after the event through reviews of the draft contributions. Thus, this volume moves from "The Big Picture" of interests in context of systems to the testing of theoretical propositions in "Theory in Practice." The third section, "Pathway Programs," distinguishes performer, foci, and career stage (with an emphasis on faculty). Sections on "Data and Evaluation," a core concern of the interventions community, and "Technology," both a tool and a challenge to the community, round out the offerings.

In general, we have sequenced the sections to lead the reader to what is available. Plenary contributions lead most sections, introducing details for those who wish to "drill down" on a topic. We hope this "recombination" of materials will reveal some hypotheses, lessons, and hints with promise of informing future efforts. Just to be sure, for the ardently "thematic" reader we have provided a detailed index. Let us know how the report works for you.

A sampling of responses to a pre-conference survey reflects the wide range of expectations conference attendees brought with them. They suggest at least the following three categories of interests in interventions:

Student-centered

- Find new sites for undergraduate summer research
- Understand approaches that result in more students completing STEM programs
- Find ways to assess which students are more inclined to careers in research rather than medical/health practice

Networking

- Exchange contact information with potential collaborators
- Meet more people involved in training minorities in behavioral and social sciences
- Develop a small group of colleagues to keep in contact with and use as resources

Professional development

- Get invitations to speak and present research
- Learn new ways to promote programs
- Interact with federal grant program directors

According to post-conference surveys, participants benefited from the meeting in several ways. Most found new kindred spirits to discuss such topics as the minority postdoctoral experience, develop novel ideas about how to facilitate broader participation, or learn about ways to disseminate outcomes from programs they lead. Such motivations reflect a constant in the three intervention conferences: fostering the development of an interdisciplinary community of scholars who are interested in understanding how to study what makes for effective programs to increase participation, especially by

underrepresented students, in STEM careers. The constant is the need, typically ignored in scholarly conferences, to connect community development, research, and practice. As the conference organizing committee recognized, such connections must be made explicit and iterated throughout the event, since participants make choices on which breakouts and workshops to attend. The coherence seen in planning is not what is experienced by most at the actual event.

It is this "gap-filling" that helps a disparate array of experts and themes begin to cohere. What emerges is a set of characteristics of a community that need to be "served" by the in-person interaction that only a conference can supply, to wit:

- *Self identification.* Participants see their interests as fitting with community foci; they belong.
- *Ongoing interaction* (both in person and electronically). What is highlighted at the conference inspires subsequent contact and exchange; this is more than casual networking.
- *Sponsored support.* Evidence that sponsors value what one does is reason to persist.
- *Professional rewards.* Winning a grant and publishing results in professional journals feed career advancement; this is not "separate business" but rather "main business."
- *Specialized journals.* Communities create outlets for expression and wider dissemination.
- *Institutional transformation.* The community implicitly rejects the status quo of disciplines and professions; members envision creative alternatives in research and practice.
- *Systemic change.* Institutional change is a building block of bigger educational change—e.g., how to recruit, creating more effective professional socialization, enabling participation in a discipline.

These characteristics constitute an ambitious agenda for the groups represented at the conference. In many ways, practitioners, evaluators, and researchers still lack a common language with which they can effectively communicate and establish common goals. Practitioners can see research as sterile and not readily translated into real-world guidance. Researchers can see practitioners as so focused on program implementation that they do not engage in the broader issues necessary to generate and disseminate new knowledge. Yet all groups have interests in bridging the gap and building a community that integrates research and practice.

In an editorial published a few months before the conference in *Science*, editor-in-chief Bruce Alberts announced a new commitment at the journal to science education and the science of education. He wrote, "Some readers may therefore question whether the science of education deserves a prominent place in this prestigious journal. . . . We now recognize that we must look at

the 'art' of education through the critical lens of science if we are to survive."[1] The Third Annual Conference on Understanding Interventions that Broaden Participation in Research Careers provided a "critical lens of science" for one of the most important issues facing STEM communities today: the need to prepare a diverse and world-class workforce to carry the success of U.S. science, technology, engineering, and mathematics into the future.

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[1]Alberts, B. (2009). Making a science of education. *Science* 323:15.

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The Big Picture

Reaching Out

PUBLIC POLICY TO BROADEN PARTICIPATION IN RESEARCH CAREERS

Changing demographics pose major challenges to the U.S. educational system and demand new ideas, said Michael Nettles, senior vice president at the Educational Testing Service. Today, black and Hispanic students represent 40 percent of the U.S. population aged 5 to 17 years old. Yet as of 2004, only 12 percent of Blacks and 9 percent of Hispanics above the age of 25 had earned bachelor's degrees.

Fortunately, expectations of earning a bachelor's degree have risen appreciably among minorities in recent years. In 1980 just 40 percent of black tenth graders expected to earn a four-year college degree, compared with 77 percent in 2002. Among Hispanics, the percentage rose from 33 percent to 73 percent over the same 22 years. At the same time, the dropout rates for blacks and Hispanics dropped from more than 20 percent for blacks and more than 30 percent for Hispanics to less than 10 percent for blacks and less than 25 percent for Hispanics. But dropout rates for both these groups remain appreciably above those for whites.

Since 1992, more than 50 percent of black and Hispanic students who complete high school have enrolled in college the following fall. Furthermore, the total undergraduate enrollment increased 65 percent from 1976 to 2007 (to about 16 million), with much of that increase driven by greater numbers of minorities attending college. Bachelor's degrees increased 31 percent from 1994 to 2007, and minorities' bachelor's degrees rose faster than the total. Yet black, Hispanic, and Native American students remain underrepre-

sented at most colleges, and particularly at highly competitive colleges and universities.

Degree attainment rates have important consequences for the distribution of income in America. The differences in the annual earnings of U.S. adults have widened over time for those with higher levels of education. In 1988, a person with a bachelor's degree earned an average of 1.58 times that of someone with just a high school degree. By 2001, this factor had risen to 2.01. These earnings differences in turn can have a major impact on the net worth of families, which often is a strong determinant of the opportunities made available to a student. For example, median family net worth has increased substantially for white families since 1995 but has remained relatively constant for nonwhite families. Blacks and Hispanics with the same degrees also continue to earn less, on average, than whites.

These statistics demonstrate the vital necessity of increasing the quality of the preparation and resources available to minority students. Several programs have demonstrated great potential in closing these gaps. For example, the Developing High-Potential Youth (DHPY) program sponsored by the Goldman Foundation identifies underrepresented high-potential youth; provides them with high-quality academic preparation continuously through high school; helps them build their intellectual, social, and cultural capital; and builds higher aspirations. The students attend rigorous academic summer programs, engage in online courses, receive guidance and mentoring, and participate in internships and international learning experiences. More than 80 percent of the DHPY scholars participate in AP courses, compared with just a quarter of all high school students (and just 14 percent of Hispanic students and 7 percent of black students). Furthermore, the DHPY scholars achieve college admissions test scores that are within the range for selective colleges and universities, and three-quarters enroll in the most selective or highly selective colleges and universities.

Another program, Strengthening Instruction in Tennessee Elementary Schools: Focus on Mathematics (SITES-M), has established partnerships between historically black colleges and universities and nearby elementary schools where their graduates often teach. The goal of the program is to improve the knowledge of mathematics for teaching and improve the teaching of mathematics among K–4 teachers in the partner elementary schools, with an underlying goal of building mathematical education expertise among teachers so that they can sustain the project in outlying years. The program relies on a Summer Mathematics Institute to provide professional development for mathematics content and knowledge for teaching, replication of best practices in standards-based instruction, the use of formative assessments, standardized observation protocols, and a project-based website (http://www.tnstate.edu/sitesm).

As a final example, Nettles cited the Michigan Promise Zones Act, which uses tax-increment financing to fund college scholarships. Funding is generated by private donations for the first two years. After the second year of distributing privately funded scholarships, a certified Promise Zone can capture one-half of the growth in the state education tax.

ENTERING STEM FIELDS FROM COMMUNITY COLLEGES

Marie-Elena Reyes, a professor at the University of New Mexico, Taos, and the president and founder of the Frida Kahlo Institute for Women at the Borderlands, has focused on the transition between community colleges and universities for women of color in STEM. According to NSF statistics, 44 percent of science and engineering baccalaureate and master's degree recipients have attended community college. The majority of women and men of color enter higher education through community college. "There is a large and untapped pool of underrepresented students who are potential STEM recruits," Reyes said.

As part of an ongoing project, Reyes has been gathering the research literature on students of color who enter STEM fields through community colleges. She also has had an NSF-supported project on creating transition programs for women. She said that community colleges should be seen not only as sources of students of color but also as places to institute transition programs.

Students transferring from community colleges to university programs typically encounter a variety of obstacles. Learning styles may not match, pedagogy remains a big issue, and the competitive styles characteristic of these fields sometimes conflict with personal and cultural beliefs. In addition, members of some cultural communities, and especially women, are reluctant to move away from their families and communities. "Even though there may be great support within the family structure for women going and getting educations, there are other conflicting sorts of messages."

For women who have families, who are single mothers, who are divorced, or who are taking care of not only children but sometimes extended families, a large amount of time on campus is often not an option. They need to balance personal life and professional life, as well as deal with issues of ethnic isolation, racism, sexism, or ageism. They may have to work to pay tuition bills, support a family, and meet other financial needs. Often they are first-generation students coming from low-income families and communities to which they need to contribute.

Reyes' work has focused on identifying and addressing the needs of students transferring from community colleges to university programs. Among the important factors by students mentioned in both quantitative and qualitative research are community college opportunities, mentoring, and undergraduate research, all of which contribute to building self-efficacy and countering the isolation, racism, sexism, and ageism that occur on campuses. To take a specific example, leadership development is critical for these students, Reyes said. Students who come to STEM fields through community colleges often get messages about whether they really belong or are smart enough to do science. "Even if we end up with A's on our tests, we oftentimes wonder, 'Was there a quirk in the test, was I good enough, was that really my accomplishment?'" Addressing and overcoming these doubts is important for these students to become leaders in STEM fields, in universities, and in policy positions.

Parents, families, and communities have a major role in the education of students of color and women, and involving these groups can be an important way to address pipeline issues in STEM fields. For example, many Latino students are very reluctant to take on the debt involved with education. By communicating with families and communities about career possibilities and the relevance of the resulting work, families, communities, and students themselves might be more willing to take on debt to finance their educations.

Reyes pointed out that many students know nothing about research until they get to college. They may be interested in becoming a practitioner in a STEM field, but not until they were involved in an undergraduate research project did they start to think about becoming a researcher. Even while they are in community colleges, students can work on research projects through consortia or bridge programs.

There is a dearth of information on women of color, said Reyes, partly because available data have not been disaggregated. Yet this group at the intersections of race and gender is likely to experience a "double bind" with unique challenges, barriers, qualities, and strategies for success. "We need to understand what those needs, what those challenges, what those barriers are if we are going to influence success for those students." Such data also could help form communities and cultural connections for these students. There may be only two African American women in a class of 200 engineering students, and more needs to be known about the issues those students face to help those two students succeed, whether the students are African American, Hispanic, Asian, or international students.

OUTREACH TO A LOCAL SCHOOL SYSTEM

The Office of Outreach Programs at the University of Massachusetts Medical School (UMMS) has instituted several programs with local schools in Worcester, Massachusetts, that have led to major changes in the schools, according to Robert Layne, the director of the office at UMMS.

The mission of the largest program, the Worcester Pipeline Collaborative (WPC), is to encourage, educate, and challenge minority or disadvantaged students to achieve success in the health care and science professions. Established in 1996, the WPC is a partnership between UMMS and local educational, business, and community organizations that now involves more than 6,000 K–12 students in eleven schools. It includes mentoring, job shadowing, clinical and research internships, laboratory opportunities, after-school science programs, visiting scientist programs, summer science camps, a speakers' bureau, parent involvement workshops, and teacher professional development workshops. It encourages students to participate in rigorous K–12 mathematics and science curricula and develop the language skills that are required to enter competitive collegiate programs.

The University of Massachusetts Memorial Health Center provides an entire floor for the WPC, including offices and wet laboratory space in an inner city building. Job shadowing and internship provides middle school and high school students with opportunities to observe possible career choices that are available and obtainable. A variety of summer programs give students op-

portunities to interact with scientists, health care professionals, and medical students.

The WPC cooperated with the Worcester Public Schools and UMMS to secure funding for a new state-of-the-art North High School. Out of four high schools, North High School has the largest number of AP course offerings in the Worcester Public School system. North High School is also the first traditional high school in the city to successfully create three separate Small Learning Communities (SLC) within the school. One of these SLCs is the Health Science Academy (HSA), which enrolls more than 300 students who are interested in the health professions. These students, more than half of whom are black or Hispanic, participate in the health/science curriculum for the four years of high school.

A five-year grant of $8 million from the Carnegie Institution funded the WPC to create Small Learning Communities in the other three high schools across the city. One of these high schools is Worcester Technical High School, which has an applied health program that helps students become certified nursing assistants, home health aides, emergency medical technicians, veterinary assistants, and medical office assistants. Worcester Technical High School now offers AP Biology for the first time in the history of the school. The class had 14 participants in 2008 and 17 participants in 2009.

North High School and Worcester Technical High School provide the state college entrance exam "AccuPlacer" to eleventh graders. This exam gives students a chance to improve their academic preparation during their senior year of high school.

At the middle school level, WPC staff helped to re-write the science curricula for the seventh grade at Worcester East Middle School. Due to the success of the curricula, they are currently being used in the other three middle schools in the city.

Layne and other program managers participate in Worcester Public Schools committees and advisory boards by:

- Sitting on committees to select new principals and admittance for all partnership programs.
- Participating in all AP parent awareness events at the sixth, seventh, and eighth grade levels.
- Participating in school accreditation interviews for the Department of Education.
- Participating on the diversity council for WPC.

Quinsigamond Community College now holds 10 spots for WPC students in its Allied Health program, which has a waiting list of two to three years. In addition, Quinsigamond Community College has its emergency medical technicians program taught at Worcester Technical High School. The course is valued at $2,500.00 and offers seven college credits. However, students from the high school are eligible to enroll in the program free of charge. This year 16 Worcester Technical High School students completed the program. Worcester Technical High School also has a donated ambulance and is the only high school in the county with a working ambulance.

WPC students are considered insiders on UMass job applications, and UMMS has provided summer jobs to five WPC students graduating and going to college. In addition, UMMS hosts and conducts six AP Biology labs for North High School students and additional labs for students from other city high schools. The National Youth Leadership Forum (NYLF) program visits UMMS four times during the summer and provides four full scholarships annually to WPC students.

The WPC has become a national model for educational partnerships that provide opportunities for students who are underrepresented in the biomedical, biotechnical, and health care professions. It encourages program participants to set high academic goals and helps them develop strategies to achieve those goals.

INSPIRING AND INSPIRED

Harvard professor Henry Louis "Skip" Gates once described himself as an "intellectual entrepreneur." Though he has received considerable criticism for tying his academic activities so closely to commercial interests, his engagement with the issues of the day must be taken seriously, said Frank Matthews, the publisher of the journal *Diverse Issues in Higher Education*.

Minority faculty members cannot afford to ignore their scholarly work, Dr. Matthews pointed out. Though promotion and tenure committees are more inclined to reward service now than in the past, many young minority professors fall into the trap of devoting too much time to service because of the many needs they perceive and the many demands they receive. "At George Mason in 1976, there were four black professors on campus; and I was one of them. I probably mentored all of the black kids on campus. That just kind of came with the territory. It was the black tax you paid."

Minority faculty members need to balance the many demands made of them. "You can do good and you can do well. I do not think that Skip necessarily had it wrong," said Matthews. "But do not be misled. You still have to get the respect of your peers and the publishing done."

The issues that call out for attention from minority scholars are well known and dire, Matthews said. Eighty percent of young children in Washington, D.C., are being raised by their mothers. Nationally, almost one out every three young black men will have an encounter with the criminal justice system, probably with incarceration, at some point in their lives. Among Hispanics, dropout rates are at a crisis level.

Yet sources of inspiration are equally common, Matthews insisted. Duke University historian John Hope Franklin, who died on March 25, 2009, was a stellar example of someone who became a first-rate scholar while remaining engaged with the community. George Washington Carver at Tuskegee was in many ways the "original ecologist," Matthews said. He traveled throughout Alabama, bringing the results of agricultural research to local farmers. "Think about what Dr. Carver could do if he had a computer and the Internet today."

Even though the world is changing very quickly, the principles exemplified by Franklin in the humanities and Carver in science provide valuable

guidance, said Matthews. The problems encountered in broadening participation in STEM fields remain severe, but "they are going to be resolved by the people sitting in this room."

Shaping Interests and Aspirations

PRECOLLEGE OUTREACH ACTIVITIES: TEACHER, PARENT, AND ROLE MODEL INFLUENCES

Despite the growing population of Hispanics in the U.S. population, their representation in the STEM workforce remains stubbornly low. "What is it that is precluding students from moving on after the freshman year, bridging the gap from the senior year to a master's student, bridging the gap from a master's student to a PhD student, and as a PhD student going on to faculty? What are those barriers and how can we best address them instead of just talking about them?" asked Gary Cruz, assistant director of programs for the Advancing Hispanic Excellence in Technology, Engineering, Math, and Science (AHETEMS) program.

AHETEMS is an effort to provide Hispanic students with the cultural, social, and intellectual capital they need to be successful college students in science and engineering. About 70 percent of its efforts are focused on the pre-college level, about 20 percent at the undergraduate level, and about 10 percent at the graduate level, according to Cruz.

The program has several basic objectives. It seeks to inform students and parents about the opportunities in STEM fields. It tries to demystify science, mathematics, and engineering so that students are not afraid of taking on challenges in those fields. And it seeks to create an environment that is culturally relevant for Hispanic students. Furthermore, program leaders make a particular effort to go into communities—to schools, churches, and community centers. They do not wait for students to come to the program; rather, they go out to engage with students.

AHETEMS manages a broad portfolio of programs. At the K–12 level, AHETEMS works with the Society for Hispanic Professional Hispanic Engineers (SHPE) on grassroots outreach with elementary schools, middle schools, and high schools. SHPE Junior Chapters, which are generally located in areas with Hispanic populations, provide access to a national organization, scholarship programs, symposiums, and even discounts for college entrance exam preparatory courses. Another program involves outreach to Hispanic communities during one week of Hispanic heritage month. Families attend with their children and have fun with science. "We make it engaging so that, again, we demystify science and bring it to them so that they can say this is exciting." Programs are bilingual, including a bilingual comic book on science and engineering.

Middle school students go to Huntsville, Alabama, to spend a week at space camp. The Academic Excellence Leadership Award provides rising high school seniors with college scholarship opportunities. "By the time the

student goes to college, he or she can have a scholarship package of at least $7,500 before entering university." Educators of the Year awards recognize teachers and faculty and provide them with a $5,000 teaching grant to use in their classrooms to work with Hispanic students in the community. A regional science bowl has expanded to nine events in 2009, involving 128 teams and 600 middle school and high school students throughout the United States.

The flagship program for AHETEMS is the Pre-College Symposium, which was held in Washington, D.C., in 2009. It is a three-day program for students and teachers across the United States and the largest precollege national conference for Hispanic students in STEM. The conference features science demonstrations, hands-on activities, and information sessions, and stipends are available to cover travel expenses.

At the undergraduate level, AHETEMS's goal is to integrate students into institutions through engagement in activities, internships, and scholarship programs while giving them a sense of belonging as a Hispanic student." Scholarship programs offer anywhere from a thousand to five thousand dollars. Internships with a variety of federal agencies expose undergraduates to the federal STEM workforce. Scholar-internships programs combine a scholarship with an internship. For example, the Motivating Undergraduates in Science and Technology (MUST) scholarship program provides up to 100 students with half their college tuition, up to $10,000 a year, along with an internship at a NASA facility during the summer.

A two-day "Grad Lab" gives undergraduates the tools they need to get ready for graduate school—how to find the right faculty members as mentors, how to write a personal statement, how to obtain letters of recommendation—"anything to help them become a competitive prospective graduate student." The overall goal, said Cruz, is to give students a sense that "I do belong at this institution, regardless if it's a predominantly white institution, an HBCU, or a Hispanic-serving institution. I have a right to be here."

At the graduate level, AHETEMS focuses on mentoring—"the most critical portion to help students succeed as a master's or PhD student," according to Cruz. A distinguished lecture series addresses topics that can help students get through their master's and PhD programs. A partnership with the GEM consortium provides a fellowship for a master's or doctoral student who is a member of the Society for Hispanic Professional Engineers. A two-day Grad Institute program brings together incoming grad students, mid-level grad students, and postdoctoral fellowship candidates and provides them with the soft skills they need to obtain the faculty or research careers in federal labs or the corporate world. "We help [students] understand what are the social and behavioral mechanisms of why students are persisting or are not persisting in science and engineering."

A GRADUATE COURSE THAT LINKS GRADUATE STUDENTS AND LOCAL HIGH SCHOOL STUDENTS

One extremely effective way to inform high school students about possible careers in science is to put them in touch with researchers and graduate students at medical schools, said Nicholas Ingoglia, professor in the Depart-

ment of Pharmacology and Physiology at the University of Medicine and Dentistry of New Jersey (UMDNJ) and director of the Sloan Minority to the PhD Program. At the Graduate School of Biomedical Sciences at UMDNJ, a master's degree program in the biomedical sciences has been offering its students opportunities to engage in teacher training internships with local schools. The internships are open to both master's and PhD students, are 60 or 90 hours long, provide two or three credits, and are pass/fail. Students are assigned to STEM teachers in three nearby high schools in Newark. "Sometimes they grade exams," said Ingoglia. "Sometimes they tutor, helping the students. . . . They also give supervised lectures on certain assigned topics."

At the end of the course, the students write a three- to five-page paper on what they did and meet with Ingoglia to talk about the experience, while the teachers send an e-mail attesting to the time the graduate students spent at the high school. "The whole point of this is to make this good for the student, good for the teacher, good for our graduate students, and as little work for the high school teacher as possible so they'll do it. And they have done it."

Outcome data for the program are sparse, according to Ingoglia, but enrollments in the program have gone from 2 students in 2006–07 to 20 in 2008–09. Students who have participated in the course are telling others that it is a good experience. Teachers have found the graduate students helpful, so that more teachers are accepting student interns. "This is a program that's working," said Ingoglia. "Maybe this is something that some of you should think about through your own schools."

The graduate students are just a few years older than the high school students, and many are minorities, so they make an immediate impression on high school students. As one teacher reported, "There was an instantaneous connection with [the intern's] youthfulness. For urban high school kids badly in need of a positive role model, this was a fortuitous meeting." Also, many of the graduate students give lectures on subjects they are studying, such as stem cell biology, which enables the teachers as well as their students to learn about cutting-edge science.

Approximately 90 percent of the graduate students report that their internships are a positive experience, and for some the experience is "transforming," Ingoglia said. As one student wrote, "it has sharpened my teaching skills and has warmed my heart into loving teaching. Surprisingly, I discovered that I have a passion for teaching."

The program has begun offering especially motivated high school students opportunities to come to campus and work in laboratories during the summer. The students are being trained in laboratory techniques and are paid a salary, which is important, said Ingoglia. They also will be mentored by the graduate students involved in the teaching internships, who also can encourage their faculty advisors to accept the students as summer research assistants.

The program has encountered several problems. The graduate students are most interested in working with the closest high school, not the ones that are several miles away. So far, only three high schools in the Newark system are participating in the program, though all of the high schools in the system were invited to participate. Some students would like to keep

working in the schools after the course is done, but they can only earn three credits maximum from the course, so they need to volunteer if they want to remain involved in the schools. Not all teachers in the high schools want to participate, and the graduate students sometimes criticize the quality of the teaching they see.

Nevertheless, said Ingoglia, the course serves as a valuable bridge among research faculty, graduate students, and urban high school students needing direction and role models. The graduate students get a much-needed teaching experience and a more personal view of the educational obstacles that confront urban high school students. And the course may help identify and encourage talented high school students to pursue science-related careers.

K–12 MINORITY OUTREACH FELLOWSHIP: BRIDGING GENERATIONS OF SCIENTISTS

The American Physiological Society (APS) has a similar program to foster communication and provide outreach opportunities for minority graduate students and postdoctoral students with minority middle and high school teachers and students. The objectives of the program are for fellows to improve their teaching skills, participate in outreach, and become more comfortable talking about careers in physiology in schools and at national meetings and conferences, said Brooke Bruthers, the minority programs coordinator for the APS. Launched in 2006, the program provides graduate students and postdoctoral fellows with opportunities to visit K–12 classrooms, help conduct teacher professional development workshops, and attend scientific meetings and conferences. APS does not provide a stipend for this fellowship, but travel to all the meetings and conferences is supported.

The program spans a full year to allow fellows to attend Experimental Biology (EB), the APS annual meeting, engage in outreach training, and participate in K–12 outreach activities. During the summer, the fellows participate for a week in a teacher professional development forum where they can model inquiry-based lessons, serve as content experts for teachers, and learn about student learning styles. They also learn about the challenges that the teachers face in the classroom, such as the required curriculum, standardized testing, and the importance of state standards. In the fall, the fellows perform their classroom visits in the schools. The APS provides planning tools for the fellows, but they also can organize their own classroom visits. In addition, fellows attend conferences to talk with students about summer research opportunities, fellowships, their own career paths, and careers in physiology.

At the end of their fellowship, the fellows attend the annual meeting again, but this time as trainers, instructors, and moderators for the K–12 events. At the Minority Travel Fellows luncheon, the Fellows are recognized for completing the fellowship. Once fellows complete the program, they are asked whether the fellowship changed their career aspirations or improved their teaching skills, with the responses being submitted to the APS Council for review.

Between 2006 and 2009, the APS received ten applications for the fellowship and accepted five applicants. Ninety percent of the applicants were African American, and 80 percent of the awardees were African

American. Ninety percent of the applicants and 100 percent of the awardees were female.

The initial evaluations from the fellows document very positive impacts. Many of the fellows thought the experience was personally and professionally rewarding. As one fellow wrote, "It allowed me to immerse myself in science outreach, network with educators all over the country, develop my own professional goals, and, most importantly, excite and inspire numerous students and teachers." Fellows also improved their teaching knowledge and skills, said Bruthers. "They felt that they would be a more effective teacher in their own programs."

So far, the fellows have met with more than 1,000 students at all grade levels in public schools, charter schools, and after-school learning centers. The visits ranged in size from ten students to 180 students who did hands-on activities in a gym. Fellows have facilitated demonstrations and hands-on activities on blood flow or oxygen delivery during rest and exercise. They have held question-and-answer sessions on careers in physiology and also on their own research. They have had the students do before-and-after draw-a-scientist tests. They have discussed the scientific method, nutrition and digestion, and "all kinds of relevant topics," according to Bruthers.

All the fellows so far have continued outreach efforts after the fellowship ended. One fellow, for example, is collaborating with institutions in the Research Triangle Park area of North Carolina to organize a summer research program for high school students. The fellows also have gained a new appreciation for the value of networking and mentoring. The program "really has increased their confidence in being a scientist and seeing themselves as role models," Bruthers said.

The program needs better evaluation measures, Bruthers acknowledged, in terms of both formative evaluations throughout the year and summative measures for overall impacts. The program is planning to track the fellows for five years after they finish the program to follow their career development and see if they continue their outreach efforts. The APS minority affairs website (http://www.the-aps.org/education/minority_prog) has information about the fellows and findings on how the fellowship influenced them. The APS also plans to increase promotion of the program to Hispanic, Latino, Native American, and male applicants.

A TRIAD OF INTERVENTIONS THAT ENGAGE AND RETAIN MINORITY FIFTH TO TWELFTH GRADE STUDENTS

A study of approximately 75 students at two middle schools and two charter high schools has revealed the importance of establishing an academic foundation that supports student success, said Garen Wolff, a recent master's graduate of Wayne State University School of Medicine and current fellow at the National Institutes of Health in Bethesda, Maryland. Wolff began with the assumption that the academic foundation begins to weaken for students in middle school. By fostering "academic longevity" in students beginning in middle school, students can use critical thinking to overcome the obstacles they encounter over the course of an academic trajectory.

Wolff compared achievement data for Detroit charter schools versus Detroit public schools and did not detect a significant difference. However, she found that proficiency levels for third through fifth grade students are higher than for sixth through eighth grade students. "If I were a parent, that would be extremely alarming to me," said Wolff. "Is there a lack of parental involvement from elementary to middle? Are students switching schools? Why does academic decline occur during this particular time frame? It was puzzling to me."

Wolff interviewed teachers and parents and provided surveys to students to see what they felt about mathematics and science. Students were asked whether they liked science and mathematics and how they perceived teaching styles in those subjects. She found that teachers were very influential in the way students thought about science and mathematics. Mathematics generated stronger feelings pro and con than science. Students reported much more exposure to popular culture than to important scientific ideas or discoveries. They also reported wanting more hands-on and interactive activities in science.

Parents, meanwhile, were often not aware of the topics students were studying in science or mathematics. They generally did not track tests or homework, and only 30 percent attended parent–teacher conferences. "When we ask ourselves why, we have to look at parental involvement. Parents must take some responsibility for their children's education."

Teachers suggested various rationales as to the cause of weak academic foundations in mathematics and science. Some cited unstable home environments as contributing to poor attendance, inconsistent homework, and re-taking classes. Others echoed the need of parental accountability. These factors, they surmised, led to further problems, such as reduced comprehension and retention. "One teacher expressed concern that many students were unfamiliar with scientific terms. It was as though she was starting from scratch all the time."

On the basis of these results, Wolff organized a three-pronged intervention focused on parental involvement, innovative teaching techniques, and academic preparedness to ensure academic longevity. Workshops at the beginning, middle, and end of the school year were designed to get parents involved with their students. "We thought of the idea as 'parent pods.' If you are familiar with weight loss programs, they always want you to have a buddy to help you. So maybe if parents were paired with another parent, they could dialogue about their student's success or dialogue about the different events that are happening in school." Incentives to get parents to participate include food and raffles, E-mail, monthly newsletters, and the school's website.

Innovative teaching techniques encompass greater use of hands-on experiments and projects. Having students present mathematics or science concepts helps them learn those concepts. Most importantly, it builds research skills and gives the students a sense of ownership over their education.

Wolff developed a theory of categorization titled H.F.R.T, which stands for hard workers, followers, rebels, and turtles respectively. It is based on classroom observations and a crossword puzzle activity that illuminated

distinct peer interactions. Hard workers are fast and diligent. They are enthusiastic about their academics, are often classified as honors students, and serve as a resource for other students. Turtles are slow, but steady. They tend to work alone and are occasionally labeled with special needs. Rebels distract their peers and either hand in incomplete work or none at all. Wolff stipulates that this behavior is due to purposeful defiance, the inability to complete the work (again due to weak foundations), or both. Rebels are usually classified as troublemakers and sometimes, whether necessary or not, are placed in special education programs. The followers tend to adopt the behavioral patterns of students from the other groups, particularly the rebels. It is this theory that Wolff uses to explain differential academic achievement in the classroom. Recognizing these types of students can help teachers make sense of their classrooms and build the kind of academic longevity that will increase the numbers of underrepresented minorities in STEM fields.

POST-TRANSLATIONAL MODIFICATION OF A HIGH SCHOOL MENTORSHIP PROGRAM

Since 1992 the University of Mississippi Medical Center has been running a program called Base Pair, which is the name of both an overarching series of programs and one component of those programs. The Base Pair program began by pairing a student from a high school next to the medical center with a mentor in the medical center. The students commit one afternoon per schoolday for one or two years to work with their research mentors, and they get credit toward graduation for their participation. The program has since expanded to high schools across the state of Mississippi, said the Medical Center's Rob Rockhold.

In 1994, funding from the Howard Hughes Medical Institute helped expand the program. It now has a summer professional development activity for teachers at the medical center. These teachers in turn helped initiate several additional activities that have become part of the Base Pair program.

The Student Oriented Academic Research (SOAR) program, which began in 2001, links teachers with students who do several core science courses over two years, providing a continuity that does not always exist in high school. The teachers work with students to create research projects that are generally featured in science fairs. "It took me several years to realize that that was a valid outcome. What do science fairs get you as a high school student? Money and entry into college. I did not fully appreciate that when I started this program," Rockhold said.

The Rural Biomedical Initiative (RBI), which began in 2007, has many of the aspects of SOAR but also uses the Internet to identify mentors. RBI is now at three sites outside Jackson, from the southern border of the state to the eastern border and in the delta.

The teacher professional development program emphasizes motivating teachers to pursue grants for science-related activities. The program's teacher-initiated grants now have a 74 percent success rate, and the teachers have brought in more than a quarter million dollars of new funds for use in their classrooms.

Finally, the Muse of Fire program, made possible by a 2008 Howard Hughes Medical Institute grant, has created five lesson plans organized around the biology of the fire ant *Solenopsis invicta*. "We are now at five sites around the state, involving students in distributive science that plugs them in, in some cases, to global scientific research activities."

With the entering 2009 class, the Base Pair program is dealing directly with 155 students. Approximately 59 percent are African American, and 62 percent are women. Of the individuals in the original Base Pair program, three are paired with faculty members from pharmacology, two from physiology, two from microbiology, two from psychiatry and human behavior, and one each in anatomy, surgery, neurology, and the allied health or health-related professions programs.

The most important outcome of the program, according to Rockhold, "is whether or not we can create, within these individuals, an affinity for professional science careers." More than 99 percent of students in the program go on to a higher education experience. Of the 74 who have graduated from college so far, 17 have gone to medical school, 6 have gone into a science-related PhD program, 13 are in master's programs, 5 have gone into law, and 4 have pursued nursing.

THE CHOICES BLACK STEM STUDENTS MAKE: GRADUATE SCHOOL VERSUS INDUSTRY

Several years ago, Howard University participated in a longitudinal study of how students decide to become engineers. One remarkable conclusion from that study, said Lorraine Fleming, professor of civil engineering at Howard, is that some very accomplished students at Howard were not even considering going to graduate school. She therefore began collaborating with Dawn Williams, associate professor in the Department of Educational Administration and Policy, on an exploratory study of when and why high-achieving black undergraduates in science and engineering decided to enter STEM graduate schools, professional schools, or the workforce.

The High Achieving Black STEM Students (HABSS) study followed 51 high-achieving students for two years. It used surveys, semi-structured interviews, and focus groups and adopted social cognitive career theory as a theoretic framework for the study. The sample was 61 percent female and 39 percent male, with a mixture of African American, African, Afro-Caribbean, Indo-Caribbean, and other students. Sixty-nine percent of the students were pursuing degrees in the sciences or mathematics, with the remainder majoring in engineering fields.

When asked during their senior year, 45 percent of the students said that they intended to go to graduate or professional school. Forty percent intended to go into industry, and the other 15 percent were waiting to hear from either schools or companies about future options. When asked the following spring, 52 percent reported being employed in industry, with 48 percent in graduate or professional school.

More engineering students were in industry (67 percent to 33 percent) than science and mathematics students (46 percent to 54 percent). Of the stu-

dents who decided to pursue a graduate degree in STEM, 36 percent decided to do so during their senior year, 46 percent decided in their junior year, and 18 percent decided before college. The numbers were different for students who went into industry after graduation, with 70 percent deciding to do so during their senior year, 18 percent their junior year, and 12 percent before college. "This number is important for us," said Williams. "If we're going to provide them with interventions, we want to know when the interventions would be most effective."

Some students decided very early what they wanted to do and followed that course of action. Other students were influenced by experiences during their undergraduate years, especially research experiences. All of the students understood the value of eventually obtaining a graduate degree, said Williams. "Even if they did not pursue graduate school directly after their undergraduate careers, all of them said they were going to go, even the students who pursued industry, which were largely our engineering students." As one student wrote in a survey, a graduate degree "will make me competitive" and "help me move up the corporate ladder." According to another student, "along with the specialized knowledge, you will get qualified for more managerial positions with a graduate degree."

The most significant influences on the students' decisions were their academic programs, undergraduate research experiences, and mentoring, followed by internships and discussions with peers. The engineering majors often mentioned offers by industry to pay for further education or the desire to work for a company and then pursue a graduate degree.

Mentors included family members and research project mentors as well as professors in STEM departments. Sixty-three percent of the students said they had a mentor, and the science and mathematics students in particular reported that mentors improved their perceptions of the availability of supports in graduate or professional school. Talking to a mentor and hearing stories of resilience from faculty mentors helps students understand that they, too, can do this.

The science and mathematics students were more likely to have mentors, participate in research programs, have confidence in their ability to pursue a STEM graduate degree, and actually pursue such a degree. The engineering students, in contrast, reported less mentorship influence, lower coping efficacy, and greater influence by internship experiences.

Fleming and Williams posed several questions at the end of their presentation that deserve further study. What role does the academic climate within a program play in a student's choice? Are students choosing their career paths based on an inherent or intrinsic interest or solely from their experiences? Is this phenomenon seen in other minority-serving institutions, such as those serving Latino communities?

During the question-and-answer period, one participant in the session pointed out the importance of alumni in influencing post-baccalaureate decisions. Williams agreed. "Networking, community, and relationship building are huge at historically black colleges and universities." Another participant observed that the results would probably be somewhat different for different institutions, especially those that do and do not offer graduate degrees.

2

Theory in Practice

THEORETICAL PERSPECTIVES ON EFFICACY AND STUDENT SUCCESS

The social psychologist Kurt Lewin often said that there is nothing so practical as a good theory and nothing that so informs the development of a good theory as an understanding of practice. Martin M. Chemers of the University of California, Santa Cruz, used that advice to discuss the role of theory in the study of intervention programs. While intuition can be a valuable guide, he said, it cannot replace theory-based research. And a particularly useful way to approach this research is through the concept known as self-efficacy.

This concept holds that people are motivated to the degree that they believe that their effort will lead to the performance level and outcomes that are desired. They ask themselves the following questions: Can I do a particular task? If I do, will it lead to the outcomes that I expect? And how valuable are those outcomes to me? "This model of motivation provides a place to begin to understand why students choose programs, how hard they work in those programs, and why they leave programs," said Chemers.

Taking the questions in reverse order, there are many influences that determine whether a student values a particular set of outcomes. Among these are the values of the community where a student comes from, the importance of wealth in a career, the prestige of an occupation, family influences, a person's personality (such as the need for achievement), and the views of peers. Several of these factors revolve around the importance of community. For example, one of Chemers' graduate students, Jamie Franco-Zamudio, recently completed a study of perseverance among graduate students and found that every woman and minority student who was successful in graduate school

was a member of an organization that provided academic and career support for that group.

Many minority students have a heightened sense of responsibility to their communities. They recognize that many people are suffering in their communities, and they want to give back to that community. But students also should know that developing a cure for malaria will help a lot more people than a single medical practice, Chemers said. "That does not say that you want to dissuade someone from being a doctor. It is up to them, but . . . you can clarify those paths."

Two basic factors influence perceptions of the link between performance and outcomes. Many students do not know what a career in research is like. "Until they get into these programs, they cannot imagine what it is like to be a scientist." Second, many students ask whether society and the profession will reward them fairly for their efforts. "Obviously, for many underrepresented students, this is a valid question for them to be asking based on their experiences."

Finally, students ask themselves whether they will achieve a sufficient level of performance if they expend the efforts of which they are capable. In other words, "can they do it?" said Chemers. The answer to this question depends largely on their sense of self-efficacy. This self-efficacy does not necessarily reflect their actual ability. Rather, it reflects their beliefs about their ability.

The clinical psychologist Albert Bandura defined self-efficacy as "the belief in one's capabilities to organize and execute the courses of action required to produce given attainments."[1] Self-efficacy is domain-specific rather than a general function of self-esteem. "For example, someone could have high efficacy for research and low efficacy for golf," Chemers said. These efficacy beliefs can have a profound effect on personal choices. People choose to engage in activities where they think they will be successful. They try harder to do the things that they think they are capable of doing. Self-efficacy is thus related to perseverance and resilience in the face of challenges and failures. "Nobody goes through life without some setbacks," said Chemers. "When I sent my kids to college, I said, 'Just remember this, you never fail until you quit.'" When people believe that they can persevere in the face of failure, they do not give up. Instead, they try something else or work harder. "This is a very powerful contributor to success," Chemers said.

Efficacy beliefs can exert their effects through cognitive, motivational, and emotional channels. People who are efficacious in a particular domain have greater analytic complexity in that domain. They are able to think about more complex ideas and process more information. Students who have high efficacy for academic work also engage in a different kind of planning. Weak students tend to think about what they need to do for the next class, while highly efficacious students think about the whole course. "They start thinking about the paper they are going to write in the tenth week in the second week because they have a plan for where they are going." In addition, people

[1]Bandura, A. (1997). *Self Efficacy: The Exercise of Control.* New York: Freeman.

with high efficacy set higher goals, and people who set higher goals usually achieve higher levels of performance. This process of setting your own goals also leads to a process of self regulation in which people regulate their own performance. "They watch themselves. They observe how well they are doing. They imagine the trajectory that that level of performance will lead to and then they adjust. They work harder if they need to. That is the most powerful form of motivation you can get—much better than trying to have surveillance and push people." Finally, people with high efficacy tend to be calmer when they confront a difficult problem. They are more likely to see the problem as a challenge than as a threat.

These contributors to self-efficacy provide a rich source of hypotheses that can be investigated. For example, almost everyone believes that mentoring is a positive influence on students, but almost no one can define what good mentoring is. By having a theory of how students become efficacious, the pathways of mentoring that contribute to efficacy could be studied. In general, the important thing is to have a living theory that can be applied to the work being done, said Chemers. "Then, when you answer the question, 'Why did this happen?' you have an answer that allows you to go somewhere and replicate that program."

Chemers discussed several other sources of self-efficacy that are potential targets of research. For example, social comparison refers to the ways in which people judge their self-efficacy by looking at other people. Chemers recounted the story of a former student named Julio who was a gang member in Fresno before he came to UC–Santa Cruz. His counselor in high school told him that Santa Cruz was offering large scholarships for minority students, so he decided to attend. Halfway through his first quarter, he said to himself, "I am just as smart as these people. I think I am going to get a PhD and go back and be a counselor in the schools." That, said Chemers, is social comparison.

The social comparison process reveals why being the first in their family to go to college can be so important for students. Such students do not have an older brother or sister with whom to draw comparisons, so they have to draw comparisons with others whom they do not know as well.

Another source of self-efficacy is verbal persuasion that a student is smart and capable. "In my house there was not a question of whether you were going to college," Chemers said. "It was where are you going to college. There was a lot of support there." People who provide this verbal persuasion do not need to be of the same gender or ethnicity as a student. They simply have to be people with whom the student can relate. In particular, a mentor whom a student trusts and believes is competent can help a student build confidence.

Finally, affective states can be a sign of self-efficacy. When someone is happy doing something, that person tends to be good at what he or she is doing. "I never quite understood the whole idea of playing music in the lab, which a lot of natural scientists do—it's very rare in psychology," Chemers observed. "But then I realized that it is about emotions. It is about creating an atmosphere in the laboratory that makes it feel like fun, like home, like community."

How do students make attributions regarding their reasons for success or failure, Chemers asked. When a student gets an A on an exam, the student may ask whether the cause of that A was an internal attribute or an aspect of the situation. In that case, is the cause stable, or is it something that will change? A stable cause tells the student that he or she can succeed in the future, which has a powerful effect on motivation. In contrast, a poor grade also could be attributed to ability. Or a student can conclude that a poor grade resulted from a lack of effort. A mentor can ask a student about study habits and help students see that success is related to effort. "It is not a matter of them not having the capability, but this is a hard class and you cannot learn this stuff by osmosis. You really need to study."

Providing students with graduated challenges and a support structure that helps them meet those challenges increases the likelihood that they will be successful. "You do not do the work for them, but you create an environment in which they have a higher likelihood of succeeding. Then, at each level of success, you introduce them to a more difficult problem." In this way, students go through a graduated series of steps to build that sense of efficacy. "You want them to stretch; you do not want them to break."

Self-efficacy cannot completely trump preparation and talent. Students cannot become scientists just by thinking they are smart. But the problem is usually in the other direction. Students have the capability but doubt themselves. "When a society has been telling you over and over and over that you are too stupid to be in college, sometimes you need a little support to help you realize that you are not and that those results, that A on that test, is legitimate."

NAVIGATING THE LEGAL LANDSCAPE TO CHAMPION SUCCESSFUL PROGRAMS

In the 2003 cases of *Grutter v. Bollinger* and *Gratz v. Bollinger*, the U.S. Supreme Court addressed the question of whether, to what extent, and how race may be considered in admissions decisions by public colleges and universities that are subject to the Equal Protection Clause and by private institutions that accept federal funding and are made subject to the same principles through a congressional statute called Title VI. While these cases involved admissions, the principles articulated in the decisions also influence minority mentoring and funding programs, said Jamie Lewis Keith, vice president and general counsel for the University of Florida. During a luncheon address at the conference, Keith reviewed the legal context in which intervention programs in higher education are likely to be considered in the future.

The *Grutter* decision was "a great victory for higher education," said Keith. It affirmed that colleges and universities may take race into account in admissions decisions and that higher education has a First Amendment–protected right to exercise academic judgments in defining institutional missions and admitting students. These decisions must be made appropriately by considering race as one of many factors in a holistic, individualized assessment of each candidate. A university also must uniformly apply criteria to determine

the composition of the overall student body or graduate program that will best achieve the university's educational mission.

However, the *Gratz* decision, which struck down the University of Michigan's use of a points-based system in undergraduate admissions as unconstitutional, was in some senses a loss for diversity in higher education, according to Keith. This decision held that race may not be used in admissions to remedy general societal discrimination or to achieve racial balancing. In other words, race may not be used in admissions to ensure that the representation of racial groups in a college's student body approximates their representation in society at large.

These decisions hold that the Equal Protection Clause does not apply more to one race than another. They reject the notion that laws and programs aimed at including those who have historically been excluded should be looked at more favorably under the law than laws and programs which invidiously are aimed at excluding some groups. Unfortunately, said Keith, this "really puts blinders on why the Fourteenth Amendment was adopted in the first place."

Together these cases hold that strict judicial scrutiny applies in determining the propriety of taking race into account in admissions under the Equal Protection Clause. The burden of proof is on the institution of higher education to show that there is a compelling interest served by the use of race. The institution also must prove that the means of achieving that compelling interest are narrowly tailored. The institution must demonstrate that it is necessary to use race to achieve the compelling educational interest; that race is used only to the extent necessary and not more; that the approach of using race is not unduly burdensome on non-minorities; and that the use of race is time limited to the period in which there is no other alternative.

A similar standard applies to the use of gender under another federal statute called Title IX, which does not just apply to athletics but to broad programs within universities. However, the judicial review standard that applies to gender, while exacting, may not be quite as strict as the standard applying to race, where an important interest must be served and where there must be a substantial relationship between the means used and the interest served.

The *Gruder* decision pointed out that the educational benefits generated from a broadly diverse student body include undermining stereotypes, encouraging multicultural skills, and promoting social justice. These educational benefits constitute a compelling interest that justifies taking race into account in admissions. Writing for the majority, former Justice O'Connor also recognized the fundamental and central role of higher education in preparing future generations for citizenship and leadership and in contributing to a well-trained labor pool. Consequently, the Court endorsed a broadened diversity rationale by holding that an institution of higher education has a First Amendment–protected right to define its educational mission as not only educating all of its students but also serving the nation's and society's needs and providing access and opportunities to all citizens. To achieve that multi-pronged educational mission, an institution of higher education may determine that it has a compelling interest in fostering a broadly diverse student body. The richness of views, talents, and experiences in a broadly

diverse student body constitutes compelling educational interests, according to the court.

Broad diversity extends along dimensions of race, national origin, and gender but is not limited to these things. It also extends to talent, geographic and socioeconomic backgrounds, and many other attributes of individuals that contribute to broad diversity, Keith said. An academic institution may find, however, that it has achieved some aspects of broad diversity but has failed to achieve the racial diversity that it needs to achieve full diversity in its student body. It therefore may need more focused attention in that area and perhaps others.

Mentoring and funding programs also support the achievement of broad diversity in the student body or faculty because affordability and mentoring are critical aspects of access and of success. Under legal standards, for some consideration of race to be necessary and time limited—as required by strict scrutiny—there must not be any available workable race-neutral alternatives. Institutions also must periodically and seriously consider whether there are alternatives to the explicit use of race that would not change the character or quality of the institution or foreclose the exercise of academic judgment in assessing the strengths of candidates. Under strict judicial scrutiny, race can be used only to the extent necessary, and institutions generally must not use race-exclusive approaches such as racial quotas or assigning a specific numerical value to belonging to a particular race. The decisions do not mandate consideration of race in admissions or invalidate state laws that prohibit consideration of race in admissions and other undertakings.

Mentoring and funding programs take many forms across academia today. If the standards developed in the *Grutter* and *Gratz* cases apply to mentoring and funding programs, institutions must prove that race and possibly gender exclusivity is necessary if they desire to operate race- or gender-exclusive programs. They must be able to demonstrate that even if they spend more time and more money, merely taking race and gender into account along with other considerations will not achieve the compelling interests of increasing access. This is difficult to prove under prevailing standards, but it may be possible in limited situations with well-documented justification.

Former Justice O'Connor's opinion in the *Grutter* case admonishes U.S. higher education and all of society to solve the problem of continuing racial discrimination before too much more time ensues, "and of course she is right," Keith said. Whether because of political opposition or prohibitions in future court decisions, the current arsenal of tools available to fight the exclusion of racial minorities and women will not be available forever. Individuals and groups have successfully championed voter referenda that prohibit public institutions from considering race in admissions, employment, and contracting in California, Washington state, Nebraska, and, ironically, Michigan. Florida has an executive order that imposes essentially the same prohibition.

The *Grutter* and *Gratz* cases did not address faculty diversity, which is an even more challenging problem, according to Keith. The primary federal employment statute, Title VII, prohibits racial and gender discrimination in all aspects of employment by public and private employers. It also re-

quires an institution to be rectifying its own—not society's—discrimination or underutilization of women and minorities to justify race- and gender-conscious employment actions. The Department of Labor's Office of Federal Contract Compliance Programs (OFCCP) implements executive orders and requires reasonable goals to be established and actions to be taken by federal contractors to rectify underutilization. However, Title VII and OFCCP's regulations are not generally aimed at remedying pipeline problems in STEM fields. Thus, while there are some legal arguments to the contrary, current legislation does not necessarily provide a context in which race- and gender-conscious actions may be taken in employment. The key, said Keith, is to find the parameters of remedial action. "In other words, is the pipeline part of remedial action?" Proponents of greater participation need to argue that it is.

"The law does not chart an easy path," Keith acknowledged, "but I do not intend to leave you in despair. We can make progress if we are wise, creative, and determined in our STEM diversity efforts." First, institutions, leadership, and faculties must articulate and act on the compelling interest that each institution and the nation have in increasing access for minorities and women. Targeted outreach efforts should inform and encourage minorities and women to pursue education and ultimately careers in STEM fields. Of course, individuals of all races and genders should be encouraged to enter these fields, but particular efforts can be targeted at minorities and women when more general efforts have failed to attract them. In that respect, search committees must be knowledgeable and accountable for excellent outreach. In selecting participants for programs and in faculty job descriptions, multicultural experiences and skills can be articulated as selection criteria. In a society where race and gender still matter, focusing on a candidate's life experiences, the barriers he or she has overcome, and multicultural skills can yield a more broadly diverse student body and faculty and a more welcoming academy for minorities and women even without taking race or gender into consideration.

Approaches emphasizing both race and gender may not be enough for selective institutions to achieve diversity within a single race or gender. Consequently, in those jurisdictions and circumstances where it is legally permissible, selective institutions must also consider race and gender in a flexible, holistic, and individualized manner without quotas. Other selection criteria also can be designed flexibly to maintain quality while rejecting unnecessarily restrictive notions of qualification. The same criteria must be applied to all candidates, but these criteria can be as flexible and as broad as possible to analyze individual situations and consider less traditional backgrounds for highly capable students and faculty. Climate and the creation of community in institutions and in society at large also are critical factors.

The AAAS is leading a diversity law and policy project, with participation by the Association of American Universities (AAU), that has prepared a set of resource materials that can contribute to the educational mission of a college or university while also having the effect of increasing racial and gender diversity. The project is seeking to provide general counsels at colleges and universities with the tools to be positive partners in shaping effective and

sustainable programs, said Keith. "We must work together as policy and legal leaders, and we must be successful because the stakes are much too great."

On April 28–29, 2009, the project conducted its first workshop. The first day focused on an in-depth review of the law governing diversity efforts and the legal underpinnings of specific types of STEM diversity programs. General counsels of ten AAU research universities, the general counsel of the American Council on Education, and the deputy general counsel of NSF attended. On the second day, provosts and other academic leaders joined their legal colleagues. With guidance from the experts, these policy and legal partners focused intensively on specific program designs that are both highly effective and legally sustainable. In October, the project will conduct an all-AAU workshop, and it plans to work with other national organizations to make the project's resources available to colleges and universities across the country.

Wanda Ward, acting assistant director for education and human resources at NSF, offered follow-up comments to Keith's presentation. She said that she greatly appreciated the "foresight, stamina, and courage" needed to initiate engagements in a "complicated, barrier-laden, and hostile legal environments." A diverse academy in STEM fields is critical for many reasons, Ward said, including global economic competitiveness, quality of life, the movement of highly qualified people among countries, and historical exclusion and discrimination. Fostering this diversity will require creative, effective, and sustainable approaches to admissions, mentoring, and funding.

Legal questions are "the beginning and not the end of the conversation," said Ward. Considerations of leadership, culture, systemic change, and focus need to be addressed rather than relying on ill-informed assumptions. Whenever race, ethnicity, or gender preferences are involved, federal law requires strong evidentiary foundations and coherence.

The NSF has a long-standing track record in promoting diversity and broadening participation in the STEM enterprise, Ward said. This commitment is based on the fundamental tenet that intellectual diversity strengthens the STEM enterprise. In pursuing this goal, NSF has faced many legal challenges. "Designing and supporting legally defensible, forward-looking programs to promote diversity is, therefore, obviously a high priority for us."

Federal involvement is often indispensable in conducting such programs at institutional, local, and state levels. In addition, the collection, analysis, and dissemination of data disaggregated by race, ethnicity, and gender are critical. Such data are essential to measuring the progress over time of students and faculty along the entire STEM pathway. Small sample sizes, privacy, and confidentiality are all issues that can come into play. Yet access to high-quality data makes it possible to plan, develop, and sustain effective programs.

High-quality data also can reveal critical gap areas in the training of U.S. talent, and these gaps need to be addressed in legally viable and creative ways. For example, how can subgroups such as black and Hispanic males be engaged in a way that helps fulfill the educational missions of colleges and universities? NSF is increasingly supporting portfolio approaches, particularly in the Directorate for Education and Human Resources (EHR), that include integrative, synergistic efforts to help catalyze institutional transfor-

mation. For example, the "I-Cubed" Activity—innovation through institutional integration—challenges awardees supported by the EHR directorate to think synergistically about integrating research and education and transitioning across critical educational junctures to create a globally engaged workforce. "Based on what Jamie has shared with us today, I believe that such efforts are legally defensible," said Ward.

Integrated efforts must be built on strong core programs, including programs focused on underrepresented groups in STEM and programs in which such a focus is embedded as a critical component. Such programs also must provide quality learning opportunities, supportive environments, and high expectations to participants. For example, NSF's Advanced Technological Education program has been emphasizing accelerated learning opportunities that feature bridges from high school to community colleges to four-year institutions. All of these programs, said Ward, benefit substantially from an understanding of how best to navigate the legal landscape.

During the question-and-answer session following Ward's response, Rena Pasick from the University of California, San Francisco, emphasized the importance of extending diversity initiatives beyond STEM fields. She said that she is a public health social and behavioral researcher who works in poor and ethnically diverse communities, and the researchers who work on her projects should be from those communities. Yet when she brought her project to the university from a nonprofit research institute, she immediately ran afoul of legal provisions governing diversity programs in state-funded institutions. "I was fortunate that the lawyer who handled my case was very creative," Pasick said. "I was able to go on and reapply and be refunded, and my program is now in its tenth year. But I am constantly scared because that person could go away. The orientation of the counsel's office could change. I feel constantly at risk."

Keith observed that the materials developed for the AAAS diversity project apply "across the board." The part of the project focused on STEM fields is the collection of data to support the project. Daryl Chubin of the AAAS also said that colleges and universities are as interested in increasing diversity "in history and English as in engineering and mathematics." In fact, more broadly based programs are easy to justify. As Ward, said, "there is strength in numbers, and all kinds of sectors need to be participating and supporting this activity. If it is demonstrated as a broad groundswell among all stakeholders, that adds a considerable amount of strength and positions it for a longer lasting kind of activity."

In addition, Chubin pointed to the importance of data in providing support for such programs. "It is my conviction that there is an enormous research base available that has not been translated for legal scholars," he said, "Legal scholars are some of the most obsessive, compulsive people I have met—far worse than anybody who gets a PhD, frankly—and they constantly put this question to us. Where is the data? How do you know? It is very clear that our rhetoric as researchers outpaces our data. We think we have it in hand. But we do not have it in hand, or if we do have it in hand it is buried and oriented to a very specialist subdisciplinary audience."

Fae Korsmo of the National Science Foundation asked about the potential benefits to be gained by having government agencies partner with private foundations, which are less constrained by legal requirements. Keith noted that complementary but separate efforts might work better, because private institutions that are separate from publicly funded institutions have more leeway to act. Chubin advised that programs have a multiplicity of funders to ensure widespread ownership of a project, to spread costs, and to have many viewpoints represented in the implementation of a program. Sometimes private sponsors "do not want to share the limelight," said Chubin, which can require careful negotiations. But having many funders provides opportunities for interests to intersect.

PUTTING THEORY TO WORK: DEVELOPING CAREERS IN SCIENCE AND ENGINEERING

The understanding interventions conferences have sought to encourage cross-fertilization between life scientists and social scientists in understanding how to get more people to pursue science careers. This dialogue between disciplines creates an opportunity to talk about the theoretical frameworks that underpin career development concepts. Angela Byars-Winston, a vocational psychologist at the University of Wisconsin–Madison, presented some background on career development theory and explored the strengths and weaknesses of four specific theoretical frameworks.

Career development theory has a long and rich history. It has stimulated research across the life span in a wide variety of populations and with a large variety of occupations. Researchers, evaluators, and practitioners can use these theories to design programs, assess their effectiveness, and develop research studies that can lead to broadly applicable findings.

Byars-Winston began by introducing some of the terms associated with career development theory. An occupation is a set of defined tasks that are commonly performed for the purpose of making a particular product or performing a specific service. A job is the performance of an occupation in a specific place for a specific employer. "My occupation is as a counseling psychologist," Byars-Winston said. "But I have a job at the University of Wisconsin, Madison, and I previously have had jobs at the University of Maryland College Park, at San Diego State University, and at Arizona State University." A career, in contrast, is the combination of activities performed across the life span and incorporates all roles of life, including those of a worker. Thus, a career includes, for example, volunteer work.

Career development is the sequence of career-related choices and transitions across the life span. Career counseling is the process by which a professional counselor assists clients or individuals to make informed choices and transitions. Different types of professionals may intervene at different times; thus, a school counselor and a career development facilitator are both doing career development work. Career assistance is the process by which a career development facilitator provides support to clients, such as finding good career information or conducting a job search.

These distinctions play an important role in career-related interventions. An intervention may be focused on helping students understand themselves better, or it may be focused on giving people information so that they can make career choices. "Those are different types of tasks that require different types of constructs or theories," said Byars-Winston.

Vocational psychology is the psychology of human work behavior. When humans act willfully and purposefully to achieve a certain outcome, psychological factors are in play. "What are the motivating factors, for example, that would attract someone to aerospace engineering compared to biomedical engineering?" These psychological processes can include cognitive factors, behavioral factors, and affective or emotional factors. In turn, these psychological processes are antecedents to work-related processes like career interests and values, as well as to outcomes like career goals. Among the factors involved in this chain of causation are career-related choice, identity, consideration, exploration, attitudes, decision-making processes, values, occupational knowledge, job satisfaction, and job adjustment. Thus, interventions to encourage more students to pursue science careers can draw from a wide breadth of activities to intervene in various decision points.

Most people and programs focus on interventions that promote career development tasks. For example, with middle school populations, an intervention might help students understand who they are, what they are good at, what interests them, and what they like and dislike. In addition, the development of occupational awareness might include making students aware of the world of work. Given that the Department of Labor recognizes at least 20,000 different kinds of jobs, "this is a huge task, so occupational awareness tends to be a focus of the work that we do in terms of career development interventions," said Byars-Winston. Interventions also can center on how to search for a career, where to get information about available jobs, and making adjustments once choices are made.

The psychology of career development has been studied for more than a century. In 1909, Frank Parsons launched a civic service house in Boston, Massachusetts, designed to help young immigrant males find work in the Boston area. From that work, he developed a conceptual framework about how professionals could help young men find work. He developed a three-step process: people should know who they are; they should know about the world of work; and they should make reasonable choices to match the two. Parsons' 1909 book *Choosing a Vocation* launched a research program on how people's particular proclivities, orientations, and skills would direct them to a particular type of work.

At about the same time, Francis Galton in England and Alfred Benet in France were trying to assess individual differences by categorizing mental abilities. In the United States, Robert Yerkes at Yale was working on techniques to sort soldiers into categories, such as officers and infantrymen. This focus on individual differences and measurement of abilities led to a burgeoning interest in classifying people's career interests. By the end of World War II, for instance, the Veterans Administration and other federal agencies initiated formal educational programs to train professional counselors to help

transition former soldiers back into the workforce. This marked the formal establishment of counselors for vocational development.

Major emphases in career counseling today include addressing the need for diversity in the workforce, helping people navigate multiple career changes, and promoting understanding of the evolving meaning of work. In the past, many people were able to choose one job or occupation for a lifetime. "That is not the case for most people" currently, said Byars-Winston. "Given the multiple changes that people are having in the workplace, people are not necessarily going to be able to rely on an occupation or a particular employer to support their career development. Individuals have to be responsible for it now. That is a different way to think about the meaning of work."

In approaching career counseling, theory needs to precede or accompany empirical research, Byars-Winston said. A theoretical framework helps orient a particular body of knowledge as it is developing and evolving. Such a framework also can help answer specific questions. Does a theory help explain a particular behavior, such as career choice? Does it help control the particular phenomena being observed, in that it offers guidance into the tools or techniques that might be useful to enact a particular outcome? And does it help predict or understand and anticipate future events?

In addition, a theoretical framework provides a way to think about the variables and constructs that can be the objects of interventions. What do you intervene on? Should you focus on career information? Should you focus on coping skills? If it is coping skills, coping with what—people who are biased and are going to be working with you? How do you prepare somebody for an applicant-screening process, knowing that it might be biased? Theories can direct attention to the variables that can be changed and the ways in which those variables are linked to particular outcomes.

Five key tenets underlie different career development theories, and these tenets may or may not apply in different situations. First, many career theories assume individualism and autonomy, but choices are not always so free. "When I was doing therapy at the University of Maryland College Park, I had many clients, especially African American and some Asian Indian students, who were pursuing engineering because that is what they were encouraged to do. Many of them actually had family members who said, 'If you want me to pay for it, this is what you will study.' They came to the counseling center saying, basically, 'I am depressed. I am mad about it. I need you to help me deal with the depression.'" Identifying a choice that fits for the individual is not always the issue. Individuals' "freedom" to make a career choice might be better understood in the context of their relations to others and family support (or lack thereof) to pursue a given career path.

Also, every theory is culture bound, not just in terms of ethnicity and gender and but also in terms of socioeconomic setting, geographical constraints, historical trends, and so on. "For example, I grew up in San Diego. It was not uncommon to want to be a marine biologist. But that made sense—I lived next to an ocean. Now I live in Wisconsin, and not many people aspire to marine biology."

Second is the issue of having adequate resources. A student may want to pursue a particular course but not be able to afford it. Or even if a student

can afford a particular choice, he or she may have certain roles or financial contributions to make within a family that constrain choices.

Third, there is an assumption that everyone has equal opportunities, but that is clearly not the case. Nevertheless, many career interventions do not adequately recognize how students assess the lay of the land. "We can do many things in our interventions that make STEM careers attractive. Yet there is a larger backdrop against which our interventions are evolving that is very inequitable, and [this background] has implications for how students feel engaged and committed to pursuing those fields."

Fourth, work is central in the lives of many people, but people work for many different reasons. They may be seeking simply to survive, to gain social connections, to attain social power, to achieve economic self-sufficiency, to seek self fulfillment, and so on. The research used to support a given theory also may be representative of one population but not others. "We have to keep in mind whose experiences these theories were based upon," said Byars-Winston.

The fifth key assumption is that career development is linear and rational. But clearly that is also not true, given the nonlinear and often irrational paths people take through their careers. Any model that tries to categorize any behavioral phenomenon runs the risk of being oversimplified. "Humans are the most complex organism on the face of the earth," said Byars-Winston. "If I could accurately predict today, on May 7, who and where you will be on May 7, 2014, I would be rich. There are so many intervening processes that happen between the current skills and abilities that people express or can have catalogued in an assessment test today and where they will be four or five years from now."

Byars-Winston briefly described four theories: trait/factor theory, developmental theory, social learning theory, and social cognitive career theory. Trait/factor theory grows directly out of Frank Parsons' work in Boston at the turn of the last century. It is called trait/factor theory because it involves looking at how people's individual traits, skills, or abilities match up with what the job requires. Trait/factor theory was extensively advanced by John Holland, who focused on how people choose careers and the choices they make. He assumed that career choices evolve out of six different personality types: enterprising, conventional, realistic, investigative, artistic, and social. He also said that people tend to flourish in careers where there is a good match between their personality type and what the job requires. The fit between an individual's personality type and a current or prospective work environment was termed congruence by Holland. Interventions that acknowledge congruence tend to focus on helping people get more knowledge about who they are and what they are good at. "Job shadowing, for example, is a wonderful way to get people more information and also to do reality testing of an occupation."

A strength of the theory is that it is practical and interpretable. "I could explain this to my mother or my sister. They get it. You do not have to be in psychology to understand this." The instruments are also user friendly. The Strong Interest Inventory and the Self-Directed Search measures yield a neat packet of information. Free websites are available to assess personal-

ity types, and books such as *What Color is Your Parachute?* produce similar information.

Several criticisms can be made of trait/factor theory. It focuses on what people choose as a career and not on how they choose a career. It assumes that a vocational counselor knows the right questions to ask and that an individual has appropriately expressed particular interests or abilities that can enable a match to be made for a particular career. It also has a strong potential to reinforce social stereotypes. Assessments tend to reflect whatever people said they were good at and the experiences they have had. The assessments reflect expressed interest, "but many of us have latent interests as well, things that have been career daydreams or aspirations that have been long since tucked away. These assessments are not as good at getting those types of latent interests as they are at getting expressed interests."

The second theory Byars-Winston described is developmental theory. In the 1950s, Donald Super emphasized the range and variety of factors affecting career decisions over time. Mark Savickas, one of his protégés and a senior faculty member at Northeastern Ohio Universities College of Medicine, says that while people are busy earning a living, they are also busy living a life. As Byars-Winston observed, many students face difficult decisions, such as how am I going to spend 12 hours in the lab when I want to have a family? "I can think back when I was on tenure track and I had my daughter," she said. "Things changed in terms of my priorities and my values. So as you add roles, the weight of work changes." Key concepts in developmental theory include people's perceptions of who they are; their self-concept, the life stage they are in, the tasks related to that life stage, and how mature they are about making appropriate career decisions.

Many environmental and social factors influence who we are, such as the quality of the schools we attend, family, community, the economy, and the labor market. At the same time, more individual factors such as personality, values, interests, aptitudes, and intelligence affect our decisions. Super argued that development through the life stages can be guided by helping people know what their abilities and interests are so they can test their self-concept against reality. "If you think you are good at being a veterinarian, let us test that out. Let us get some real information and understand how that might actually fit with the world of work."

Super also asserted that the process of career development is essentially the process of personal development. As a person gets to know who he or she is, that person can implement his or her occupational self-concepts more effectively. Super developed an approach for interventions that he called the thematic extrapolation method. It posits that the function of an intervention is to help people construct autobiographical understandings of who they are. For example, an intervention from a development perspective might ask people to think about their favorite songs, their favorite characters in movies, or their favorite superheroes. What would be the title of your autobiography? What would be the titles of the chapters? Themes in individuals' responses to such inquiry are helpful in uncovering their values and self-concepts that can inform their career development process.

A strength of the theory is that it helps people focus on career development beyond initial career entry. It also recognizes that life roles intersect with the work that people do. However, the theory is very hard to test, especially longitudinally. And there is little empirical support for the theory. "Are people appropriately doing the career development tasks that are relevant to where they are in life?"

The third theory Byars-Winston discussed is social learning theory, articulated for career development by Stanford University's John Krumboltz. The focus of the theory is how people's interests are learned and how career choices are made. The theory says that learning opportunities shape our understanding of who we are, our skills, and the types of careers that we choose to pursue. The theory has four key concepts. The first addresses the special abilities that we have. "There are some people who can do math in their head as soon as they are six years old." The second concept involves environmental conditions in terms of early learning experiences, especially before high school. The last two concepts are the most malleable and amenable to interventions. They are the types of learning experiences people have, and how they approach making decisions.

Instrumental learning relates to the simple reward and reinforcement principle. In terms of careers, people might pursue particular STEM fields because of the lifestyle it may give them, the respect they may earn, or other potential rewards—these are the instrumental ways in which people learn about the careers that may interest them. A second type of learning is associative—how do people affiliate or associate with particular models or types of people who do certain types of work? For example, a student may associate being a researcher with the stereotype that researchers do not have well-rounded social lives and never get out of the lab. This associative learning can be very powerful because people that we respect may become the cues for what type of work we believe is appropriate for and attractive to us. Many interventions involve exposing students to role models on the assumption that students will find them attractive role models for a particular type of work.

Krumboltz identified the skills that people need to make career decisions as learning how to define a goal, identifying alternatives, gathering information, and taking action. He created a seven-step model that lays out strategies to facilitate these decisions. "Many people are challenged in their career pursuits because they do not know how to make good decisions," said Byars-Winston. Interventions might focus on enhancing decision-making skills by helping people know what they want, what they are good at, and the occupations they might be interested in pursuing, thus establishing a sequence or pattern of behaviors that will help people achieve their goals.

As with the other theories, social learning theory has strengths and limitations. It focuses on modifiable skills. "If you can learn something one time, you can learn something new." It also focuses on opportunities. Krumboltz is known for having coined the term planned happenstance—"the idea that opportunity presents itself in the strangest ways," Byars-Winston said. "When a prepared person meets an unexpected opportunity, sometimes the greatest career opportunities evolve."

A limitation is that the theory does not account for career behavior after the initial entry. "If you are interested in talking about people after commitment to career, this theory may not be as useful." Also, because there are so many variables, this theory, too, is hard to test.

The final theory Byars-Winston discussed is social cognitive career theory, which is the theory she has used to articulate many of her research questions. It focuses on cognitive factors that play a role in a person's decision making. It assumes that people pursue tasks and behaviors that make them feel good and avoid those that do not make them feel good. "The basic idea is that all humans want to feel effective. People do not want to beat their head up against the wall and keep trying things that they are failing at. People want to experience success." Social cognitive career theory, which is an application of Albert Bandura's work at Stanford University, highlights the role of personal beliefs in people's decisions. These beliefs, which Bandura calls self-efficacy, are domain specific, so there can be self-efficacy for public speaking, tennis playing, lab work, or clinical research.

The theory acknowledges the importance of environment or contextual factors. However, it also recognizes that a person's level of motivation, actions, and affective states are based more on what they believe than what is objectively the case. At a deeper level, the theory is based on Bandura's model of triadic reciprocity among personal determinants, behavioral determinants, and environmental determinants, with self-efficacy functioning as the mediating factor among the three.

Bandura's theory identifies four ways in which people can learn what they are good at: personal performance accomplishments, vicarious learning, social persuasion, and physiological states and reactions. Each of these sources of self-efficacy can provide building blocks for an intervention. For example, social persuasion is particularly effective for African American students—"having somebody that they respect and believe say you can do it"—and is at the center of one of Byars-Winston's current research projects.

Byars-Winston has interpreted the model in terms of what she calls the three C's: contextual factors such as perceptions of the environment, cognitive factors such as confidence in the ability to succeed and outcome expectations, and cultural factors such as comfortably interacting with people outside one's own racial or ethnic group. By overlaying these three C's on the model, Byars-Winston aims to statistically and theoretically account for the relationships between particular interventions and particular outcomes.

The strengths of social cognitive career theory are that it supports predictive relationships among the constructs, it accounts for early and ongoing environmental influences, it offers paths for cultural influences on outcomes, and it suggests concrete interventions for modifying career outcomes through self-efficacy. The theory has strong empirical support and is valid with ethnically diverse men and women. Self-efficacy beliefs and outcome expectations consistently predict choice of STEM majors, STEM course intentions, STEM career interests, STEM persistence, and perceive STEM career options. Among its limitations are that it is unclear as to how outcome expectations develop and it does not fully articulate the contextual influences on self-efficacy.

As an example of the use of social cognitive career theory, Byars-Winston's colleague at the University of Wisconsin–Madison, Lori Bakken, briefly described a study of women's pursuit of clinical research careers. A one-day intervention directed at the four sources of self-efficacy was led by senior female role models and a counseling psychologist. It emphasized previous accomplishments, interviews with role models, collegiality, adaptive self-talk, and small group work.

The study looked at a female intervention group of 21 people, with a control group of 15 males and 22 females. The self-efficacy of those in the intervention increased significantly, and self-efficacy increased more for minority women than for white women. In part, said Bakken, this reflected a conscious effort to have a balanced group of presenters at the course so that minority students could hear from minority presenters. This is an example, said Bakken, "of how you can take a theory, put it into practice, design an intervention directed toward that theory, and actually measure an outcome."

RETAINING STUDENTS IN STEM FIELDS: A RESEARCH-BASED PERSPECTIVE

When Watson Scott Swail was doing his doctoral work at George Washington University in Washington, D.C., in the 1990s, he developed a framework that can be used to analyze retention issues for students of color. Today, as president and CEO of Educational Policy Institute, a nonprofit organization based in Virginia Beach that studies issues involving educational opportunity, Swail continues to work on retention issues for students underrepresented in STEM fields. Furthermore, he has also discovered that "if you put together the strategies that work for students of color, they generally work for everybody."

Retention of students in STEM majors and STEM careers is a very complex problem. It involves elementary and middle schools, high schools, colleges and universities, and graduate schools. The Educational Policy Institute supports a website that provides a variety of resources on retention issues (http://www.studentretention.org). The Institute also offers a variety of resources for downloading on its own website (http://www.educationalpolicy.org). One is a report, "Retaining Minority Students in Higher Education," written by Swail, Kenneth Redd, and Laura Perna, which extends the work Swail began in his dissertation (http://www.educationalpolicy.org/pdf/Swail_Retention_Book.pdf).

Student success in STEM fields can be defined in many different ways. It is not just graduation with a STEM degree, though policymakers may emphasize that endpoint as a specific metric they can use to judge success. Some institutions graduate large numbers of their STEM students, while others graduate relatively few. What is important, said Swail, is "to define what student success is for your college, institution, or department and have everyone come to some agreement."

Why is student retention in STEM fields important? "It is because we are really good at graduating 50 percent of the people who enter. Put another way, we are really good at losing half of them." Averaged over all of higher

education, retention rates have not changed greatly over time. According to a series of studies of postsecondary students, 29 percent of students who start end up with a bachelor's degree, 10 percent with an associate's degree, and 12 percent with a certificate. Overall, 65 percent of students are persisting. For most students, if they do not get a degree within six years after they start college, they are unlikely to get a degree thereafter.

At two-year institutions, one out of three students attains a degree, while at four-year institutions the number is close to 60 percent. Private colleges have a higher completion rate—around 75 percent. Whether those numbers are good or bad is a matter of judgment, though "I think we all agree they could be a lot better." The numbers reveal the great flexibility of American higher education. "We allow people to fail and then find their ways to success—sometimes." However, the cost of this flexibility can be enormous, both in terms of financial resources and personal hardship.

Based on a preliminary analysis of available data that Swail carried out for the conference, half of students who enter a four-year institution will earn a degree at that institution within six years. The rate is higher at private four-year institutions. The same data set shows that more than three-quarters of students borrow money to finance their education, with the amount they borrow and the percentage of students who borrow both rising in recent years. Furthermore, said Swail, 22 percent of borrowers default on their student loans. "To me, that is an amazing statistic." Graduation can bring great benefits, but students who drop out and default on their loans "have no credit card, no mortgage, and unemployment."

The Institute provides a tool on its website called the "retention calculator" that calculates the loss of revenues to an institution because of students who drop out. Even for a single department or small institution, "very quickly it is in the millions of dollars." The current business model for higher education is obviously poor, said Swail. "We need to do better at it."

Increasing student retention rates may sound like "administrivia," according to Swail, but that is far from the case. For example, the University of Nebraska, Lincoln, has increased its student retention rate by 1 percent for each of the past five years. As a result, each year 36 more students did not drop out, or more than 180 over that time period. Retention "is about individual students, their potential and ours."

There is only one way to increase retention rates by large amounts quickly: raising admission standards. But for many institutions that is not possible, whether because of the students they serve or their educational mission. Institutions also need to focus on the retention rates of particular subgroups. Success retaining one group may hide deficiencies in retaining other groups.

The conventional wisdom is that attrition is worst during the first year of higher education. But attrition rates also are quite high in the second, third, and even fourth years of four-year programs, often because of the financial burdens of an education. Some students transfer during those years to other institutions and earn degrees there, which can show up as attrition in statistics. But retention programs need to address the entire course of a student's college education. "If we have strategies for keeping students in the first year,

we need to have strategies for the second year, the third year, the fourth year." Furthermore, the strategies need to evolve to meet the needs of students at different points in their education.

Students coming into STEM fields have several obstacles to retention. The first is what Swail called college knowledge. Do they understand what it is they are getting into? Are they first generation? Are they familiar with the college culture? Much of this knowledge needs to be built up before college for students to succeed once they are there.

Many students have not received the career counseling that would help them know what they want to do once they leave college. Swail recounted the experiences of a friend who often asked students what they wanted to be when they grew up. He would receive responses like, I want to be an oceanographer but I don't like water. I want to be a teacher but I don't like kids. I want to be a doctor but I don't like blood. These were the humorous examples, but the problem of inadequate career counseling is widespread.

For many students, inadequate academic preparation is the "elephant in the room." Professors face the dilemma of whether to push students forward even though they do not have the skills or fail them because they cannot meet the requirements of a class. The question that must be asked in these situations, according to Swail, is what support strategies are in place. Where were your safety nets? If students were admitted, even to an open admissions institution, that institution has entered into at least a moral contract to help that student succeed.

College affordability affects whether a student goes to college, what kind of institution a student enters, and whether a student remains in college. "Affordability is a massive issue that, trust me, is not going to get any easier than it is now. It is a spiraling out-of-control issue, and we are doing nothing to change it." The costs of two-year and four-year institutions have essentially doubled in real terms over the past 25 years, and fewer resources are available to students to pay those costs.

Finally, cultural barriers keep people from succeeding. These cultural issues are not necessarily associated with race or ethnicity. If a student was born in a rural area and attends an urban institution, the cultural adjustments can be substantial and can contribute to a decision not to continue in higher education.

Bad teaching can be a factor in retention. "I apologize in advance for any offense, but a lot of our STEM teachers are not the best teachers around," said Swail. "We give them very few skills. . . . We have some brilliant minds that are not always good at transferring information."

Structural barriers also can make it difficult for people to succeed. Bus schedules are an example, or how courses are scheduled. Students may need to wait a year to take a course, by which time it is more difficult for them to do so.

From a theoretical perspective, the factors that affect retention can be placed into three categories: cognitive, social, and institutional. Cognitive factors encompass their prior academic rigor, quality of learning, content knowledge, critical thinking ability, technological ability, study skills, learn-

ing skills, and time management. These are critically important factors for students and have a major impact on retention.

Social factors include financial support, educational legacy, religious background, maturity, cultural values, goal commitment, family influence, and peer influence. It is possible to get information on these factors from students. "The challenge is that we have to treat a student as an individual to do it." Colleges and universities often treat students in a wholesale rather than retail fashion. But if tuition and fees can be collected on an individual basis, then those institutions can construct learning plans for individual students as well.

Colleges need to put early warning systems in place for students so that they can address issues before they become crises. "If you wait until mid-semester to check on a student, you have lost. It is too late. Only some of the exceptional students who have a really hard start-up can pull themselves back together and academically get back on track."

Plans to increase retention can be viewed as having four stages. The pre-planning stage involves collecting data to identify what the problems are. What is the challenge? Are there groups to target? What is being done on campus now? What is the effectiveness of current strategies?

Stage Two involves using that information to plan what needs to be done. One critically important step in this phase is getting buy-in from others on a campus. "You are not going to have consensus on everything," said Swail, "but you have to decide what you are going to do and how you are going to do it."

The third phase is implementing the plan.

The fourth phase is monitoring what is being done. Differences need to be identified and causal links established. Surveys of students and teachers can provide valuable information. An instrument called the Institutional Student Potential Assessment (ISPA), which is free on the Institute's website, can help with student audits.

"Retention is our job as instructional faculty, retention is our job. That is what we are here to do." Get to know your students, Swail recommended. Tell them how they are doing. Nothing is lost by being personal, and there is much to gain. Develop your skills as professionals, which means that your institution must allow you to develop your skills. A book by George Kuh and his colleagues, *Student Success in College*, contains much valuable advice. Institutions that do well at student retention have an unshakable focus on student learning. Students have a clearly marked pathway to success. Faculty and staff need clearly marked pathways to student success, too. "They need to know what it is for students to succeed."

DEVELOPING THE IDENTITY OF A SCIENTIST: LEARNING THEORY AS A FRAMEWORK

The Computing Alliance for Hispanic-Serving Institutions (CAHSI), which consists of seven Hispanic-serving institutions that have received a Broadening Participation in Computing grant from the National Science Foundation, has undertaken four specific interventions to recruit, retain, and

advance students in computing. An introductory computing course gets students engaged in computational thinking. A Peer-Led Team Learning initiative lets undergraduates lead hands-on activities designed to explain course concepts to beginning students. Use of the Affinity Research Group (ARG) model builds communities of computer science research practice. And development workshops offer practical, professional, and technical content to undergraduates, graduates, and early professionals in academia and industry.

In 2007, CAHSI institutions graduated 204 computer science and computer engineering degrees at the bachelor's level. Of these students, 92 were Hispanic U.S. citizens and others were Hispanic international students. Several research teams collected data on the experiences of students involved in the interventions. Sarah Hug and Heather Thiry from the University of Colorado, Boulder, presented results from this research, with a particular focus on the effects of ARGs among students.

The learning theory that informs the ARG model is Situated Learning Theory, Hug said. As described by Lave and Wenger, Situated Learning Theory offers a complex and holistic view of what it means to learn.[2] In essence, to learn is to become a member of a practicing community. Learning takes place through meaningful, authentic activities. And the work of each individual makes both a local contribution and a global contribution to the community.

In a community, expert participants serve as models of professional practice for novices, imparting the community's values, language, skills, and tools through everyday work and interaction. In essence, a community assumes that learners are becoming certain kinds of people. For this to happen, communities adapt a structure that allows for apprenticeship.

In the context of education, the ARG model provides an orientation to integrate new students into a research group. Defined deliverables are assigned to ensure individual accountability and progress toward goals. By defining and producing defined deliverables, each member—even novice members—creates a meaningful, tangible contribution to the work of the research group. Through this process, students have the opportunity to become engaged in professional scientific habits of mind. And through regular interaction with scientists at multiple levels of expertise, students have the opportunity to take on the role of expert scientists.

"Students need to feel that they're making a contribution to the research group," said Thiry, "and they need to know how their work fits into the larger work of the research group. They also need to be making a contribution to the field in general. . . . We call that the local contribution to the group itself and the global contribution to the body of knowledge and the discipline as a whole."

Surveys conducted with approximately 100 of the ARG students at six of the CAHSI institutions revealed many instances of students working on authentic, challenging, but achievable tasks as part of a research experience. As an example of a local contribution to a research group, one student reported

[2]Lave, J., and E. Wenger. (1991). *Situated Learning: Legitimate Peripheral Participation.* Cambridge, UK: Cambridge University Press.

in the survey, "I helped build the first front-end node on a cluster that the group is building this semester." As an example of contributing to the body of knowledge in computer science, another student wrote, "This year I felt that I was able to contribute to the solution of a real-world problem."

Through learning as practice, students were able to extend their classroom learning into research. Another student wrote, "I was able to apply what I learned as an undergraduate to the problem I was working on. I realized that the knowledge I gained from school is only part of the equation. The real world experience I gained helped me grow."

In the ARG model, students are not left on their own to flounder in the research experience. They have support and guidance. They develop an identity as a researcher through collaborative learning and being part of a community of practice.

Among the students surveyed, half cited research as the most important factor in their decision to apply to graduate school. "This was more important than any course work that they had taken," said Thiry. "It was also more important than the influence of a professor and more important than the influence of a family member." Three-quarters said that participating in the Affinity Research Group increased the likelihood that they would attend graduate school. The ARG experience is especially important for students from underrepresented groups, since research often introduces them to the idea of going to graduate school. "They don't necessarily have those models in the lives of family members or peers," said Thiry. Engaging in research "gives them the confidence that, yes, I can do this work."

Among students who participated in an Affinity Research Group, 65 percent attended a professional conference. Thirty-eight percent of them presented a poster at a professional conference. Eighteen percent authored or co-authored a paper in a peer-reviewed journal. And 10 percent presented a paper at a professional conference. "These rates of participation are quite high—the highest that we've seen in our other projects involving undergraduates in research experiences," Thiry observed. Typically, rates of participation in the scholarly community would be "maybe 10 to 20 percent on any of these measures."

The take-home message, said Thiry, is that research experiences are critical for fostering research identities and for the most positive student outcomes. Students learn that "I belong to this group, I'm helping the group, I'm making a contribution, I'm valued in this group."

THE AFFINITY RESEARCH GROUP MODEL: CREATING AND MAINTAINING EFFECTIVE RESEARCH TEAMS

In 1995 the University of Texas, El Paso (UTEP), created an intervention called the Affinity Research Group (ARG) model designed to increase student retention in the sciences through undergraduate research experiences.[3] Today

[3]Teller, P., and A.Q. Gates. (2001). Using the Affinity Research Group model to involve undergraduate students in computer science. *Journal of Engineering Education* (October):549–555.

the model is being used intensively at the seven-institution Computing Alliance for Hispanic-Serving Institutions (CAHSI) consortium and is being adopted at other institutions across the country. "We work on the development of skills to get students oriented toward success," said UTEP's Ann Gates. "UTEP is 80 percent Hispanic and consists largely of students who commute to classes, so the ARG model was originally created as a way to build community among students. The model provided an opportunity for faculty–student interaction outside the classroom and placed an emphasis on helping students clarify and maintain goals, which are both important to persistence in a challenging program of study," said Gates.

The ARG model brings together several documented best practices for others to adopt.[4] The model provides mentoring and creates role models within a research group and focuses on the development of technical, communication, and team skills that are critical during the conduct of research. It also is built around cooperative teams that are nonhierarchical, in the sense that undergraduates and graduate students work together with each member of a group bringing particular skills to the group. It engages students in the deliberate building of skills. "We don't assume the students come with the skills needed. We work with them on developing the skills needed to be successful in research."

The affinity model was designed to involve students in research who might not be otherwise. It structures in positive interdependence—"all for one and one for all." Students work together to reach a goal, and students are openly acknowledged when they are doing well. The model teaches both social and professional skills, and students are accountable for their part within a project. The model also teaches students to be reflective. "On a regular basis, you're looking at what's working, what's not working, and how the functioning of the team can be improved."

Each year all of the students involved with the program undergo an orientation to assimilate new members and increase the ownership of returning students in the program. Students divide into groups to discuss such topics as proposal writing or constructive critiques. During a session known as competing concerns, students and faculty members divide into separate groups, and students discuss the question, What are your concerns about being involved in a research group, while faculty discuss the question, What are your concerns about involving undergraduates in research? Then the groups come together and share their responses. "This is really important because we have found that a lot of students have reservations about being in the group, which are often similar to faculty concerns, and these need to be addressed openly."

The program leaders have come to recognize the importance of faculty members articulating to students the mission and goals of a research project. Then, as students receive tasks, it is important to match the tasks to goals and

[4]Kephart, K., E. Villa, A. Gates, and S. Roach. (2008). The Affinity Research Group model: Creating and maintaining dynamic, productive and inclusive research groups. *Council on Undergraduate Research Quarterly* (Summer):13–24.

talk about the dependency of a task on another task. In this way, students begin to understand the steps needed to complete a project, and they learn the skills needed to carry out those tasks. "This makes it much more concrete for the students." It also helps students set goals and balance the demands on their time.

Particular deliverables are defined for each project, and students receive explicit instruction about providing constructive critique of a deliverable. For example, a deliverable might be a presentation, critical review, or literature summary, and students might then develop critiques of the deliverable, which are then examined. "This is where students begin to develop the domain expertise—the technical and communication skills—that are needed to be successful in research."

The Affinity Group has two types of meetings: small-group meetings that occur weekly or every two weeks, and large-group meetings that occur less frequently. The small-group meetings feature such activities as presentations, constructive critiques, and problem reporting. Students are encouraged to challenge others' ideas, including those of professors. "We want students to understand that questioning is important in research." The large group meetings can involve teaching particular skills or recognizing students who have achieved particular milestones or awards. For example, said Gates, a recent large-group meeting talked about setting goals and objectives with a mixed group of environmental scientists, geologists, computer scientists, and mathematicians. "We pulled out a lot of different goals and objectives that are published on the web from different groups and had them reflect on the differences among those articulations of goals and objectives."

The core component of the ARG model is the development of student connectedness and the deliberate practice of skills. "Institutions that survive for long periods typically have a strong set of core values," said Gates. These values can be difficult to develop. They address such questions as: Why are you doing the research that you're doing? Why are you involving students from underrepresented groups? What do you want those students to achieve?

The ARG model has been formatively evaluated using a series of surveys, individual and focus group interviews, and participant observations since its inception. In terms of outcomes, it has increased the number of students who have pursued graduate studies. Students also have demonstrated gains in identifying as a scientist, competence, interest in computer science, interest in attending graduate school, and technical and professional skills.

SOCIAL AND CULTURAL CAPITAL: HELPING MINORITY STUDENTS EXCEL

At the University of California, Riverside, Robert Ream and a group of colleagues—James Lewis, Begoña Echeverria, and Reba Page—have been investigating sociological and psychological factors that affect underrepresented minorities' career paths through the sciences. Their study attempts to account for the dialectic between relationships and motivation as they affect student performance in undergraduate science education. The researchers

have been using a theoretical framework based on social capital, which Ream defined as "the actual and potential resources embedded in social networks that may be converted, via social exchange, into other kinds of resources (including valuable dispositions as well as insider information) for use by individuals or groups."[5]

The researchers asked whether college science majors' *formal* relationships (their perceptions of the trustworthiness of faculty mentors) as well as their *informal* friendships (students' perceptions of their friends' studiousness) affect motivation and other educational outcomes, including college grades and aspirations to become a research scientist. In particular, the researchers designed their study around three questions:

1. Is social capital educationally useful?
2. Is achievement motivation educationally useful?
3. Is the educational utility of social capital mediated by achievement motivation?

The research is quasi-experimental, drawing from a longitudinal study of students over a number of years. It also is evaluative in drawing from assessments of specific government programs. The dependent variables in the study are students' reported grades in science, their aspirations to attend graduate school, and their plans to become research scientists. Using these variables, the study sought to assess how interventions (which the researchers referred to as "The Program") affect the accumulation of social capital and its impact on motivation. More colloquially, said Ream, "does who you hang out with impact how motivated you are?"

The conceptual framework links two specific forms of social capital—having a trustworthy mentor and science-oriented friends—to a student's motivation and to the three outcome measures. Obfuscating the nature of the trust relationship is the common failure among researchers to specify the trustee. By asking science majors to first identify various institutional agents "who have helped you most in college life" and then asking which one of these agents "has been the MOST helpful in your college life" (usually a mentor but not always), the researchers sought to address this oversight. Trust reflects the degree to which a student perceives this "most helpful" person as being professionally competent, benevolent, and a person of integrity. "We're very interested in measuring trust and its implications for science career trajectories," said Ream. Having "science-oriented friends" represents the degree to which students perceive their friends as attending classes regularly, considering science important, getting together in informal study groups, sharing a major field of study, and believing that pursuing a science degree is worthwhile. Internalized motivation is a measure of the degree to which students pursue learning as its own reward and not primarily for extrinsic rewards, such as a job or recognition. In surveying the literature on "intrin-

[5]Ream, Robert K. (2005). Toward understanding how social capital mediates the impact of student mobility on Mexican American achievement. *Social Forces* 84:201–224.

sic motivation,"[6] the authors grappled with what is external to individuals versus what is "in" them. Drawing on theory that develops a dialectical relationship between social-contextual conditions and individual agency,[7] they push back on the "intrinsic" label to avoid re-inscribing the notion that motivation is self produced, *sui generis*. Thus, they model what they refer to as internalized motivation.

The data come from a longitudinal sample of 161 undergraduate science majors who either were or were not engaged in interventions at 16 four-year colleges and universities. The vast majority of students engaged in interventions were underrepresented minorities. They were less likely to grow up in two-parent households than majority students and had a lower average socioeconomic status. However, they were highly motivated, had high grades, and had high aspirations.

Analysis of the data showed that having a trustworthy mentor is positively correlated with internalized motivation. But having science-oriented friends is not directly associated with motivation. These findings suggest, said Ream, "that institutional agents are very important to your motivational disposition but your friends, maybe not so much." One reason may be that the zero-sum nature of competitive undergraduate science curricula makes students less likely to be motivated by their friends, but that remains unknown. "The idea is to think about the structured conditions that impact people's motivations," said Ream. "Different forms of social networks matter differently for different groups of people. And trust really seems to matter to undergraduate science majors. The importance of trust, however, is largely ignored in program design, practices, and evaluation."

The data also show that internalized motivation positively influences grades, the intention to become a research scientist, and the intention to attend graduate school. "And we can infer from the path analytic models that if trust impacts motivation, and motivation impacts the outcomes, then trust is being mediated by motivation," Ream said.

Evaluation of the programs revealed that students in the interventions had a greater propensity to develop trust in a mentor than students not in a program. But being in an intervention does not appear to influence students' perceptions of the science orientation of their friends. Interventions also tended not to have an immediate impact on motivation, but by the end of the second year the direct effects of interventions on motivation are starting to appear. Also, being in an intervention increases the rate of growth in trust and motivation above an already higher base level. "Trust not only begets trust—trust begets motivation and the will that drives students toward becoming research scientists."

Nevertheless, according to Ream, "It must also be recognized that this structured development of trust is clearly out of the ordinary. Growing and

[6]Ryan, Richard, and Edward Deci. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist* 55:68–78.

[7]Ortner, Sherry B. (2006). *Anthropology and Social Theory: Culture, Power, and the Acting Subject.* Durham, NC: Duke University Press.

perhaps especially maintaining trust is a tall order for anyone—not least for traditionally underserved college science majors for whom feelings of racial tension and historically embedded distrust of science institutions can pose obstacles to taking chances with powerfully positioned institutional agents whose profiles differ so markedly from their own." Yet there is no trust without risk-taking.[8] "Thus, the important question is not so much whether trust in institutional agents matters to science majors who are minorities but whether underrepresented minorities can perceive it as *rational* to take the kinds of risks and seek the kinds of help that make trust possible in the first place."

By explicitly illuminating how they have measured trust, Ream emphasized that their findings about its beneficial consequences suggest an important—and measurable—benchmark for evaluating college science programs and rewarding faculty advising.

PREPARING THE NEXT GENERATION OF STEM PROFESSIONALS THROUGH INTERNATIONAL RESEARCH EXPERIENCES

"We live on a very small planet with some very big problems," said Carol Bender, the director of the Undergraduate Biology Research Program at the University of Arizona (UA). Controlling climate change, developing renewable sources of energy, reducing the dependence on fossil fuels, and producing food for a growing population are "problems without passports," as Kofi Annan says.[9] Solving these problems requires "scientifically trained people who have cultural competence to work together across nations."

A major way to develop this cross-cultural competence is to study abroad as an undergraduate or graduate student. Yet according to the annual *Open Doors* report from the Institute for International Education, only 16 percent of the U.S. students who study abroad are STEM majors.[10] Only about 11 percent of underrepresented minority students in U.S. colleges and universities have an international experience while they are in college.[11]

STEM students follow a very structured curriculum, and taking time to study abroad for a semester can put them behind as much as a year. Also, many underrepresented minority students and many majority students do not have the resources to afford an international experience.

The University of Arizona has developed several ways of supporting STEM students, including underrepresented minorities, to gain international experience. One means is through the Biomedical Research Abroad Vistas

[8]Rousseau, Denise M., S. Sitkin, R. Burt, and C. Camerer. (1998). Introduction to special topic forum: Not so different after all: A cross-discipline view of trust. *The Academy of Management Review* 23:393–404.

[9]Boren, David. (2008). *A Letter to America.* Norman, OK: University of Oklahoma Press, p. 20.

[10]Institute of International Education. (2008). Open Doors Report. http://opendoors.iienetwork.org/?p=131559.

[11]Ibid. http://opendoors.iienetwork.org/?p=131562.

Open (BRAVO!) program, which Bender directs.[12] The target audience is students who have at least six months of research experience before applying. They go from a University of Arizona research group to a research group abroad to do work related to what they have done in the past.

The university has many international visitors who come to the campus every year to do research, where they often find themselves working with undergraduate researchers. These common scientific interests can develop into personal relationships. "Capitalizing on that, when we have an international visitor who is doing something that would be of interest to the undergraduate students, I invite them to speak to my students, and they always do."

A distinctive feature of the program is that it is a research experience, not a traditional study abroad experience. The students' expenses are paid, and because many students cannot afford to lose a summer without making money, they can apply for a stipend in addition to their living expenses. They also receive supplemental health insurance during the time they are out of the country and funds for research supplies if the foreign site is in a developing country. BRAVO! is funded by grants to the University of Arizona from the Howard Hughes Medical Institute and the NIH National Center on Minority Health and Health Disparities.

Since 1992 the university has sent 179 students as "scientific and cultural ambassadors," said Bender. "We impress upon them how very important that role is. They all take it very seriously."

To get involved in BRAVO!, students approach their mentors and ask if they think they are ready for the experience. If the mentor agrees, the mentor contacts a colleague in another country about sending the student. If the mentor thinks the student is not ready, she or he provides advice about how to become better prepared. Accepted students then write proposals for the work to be done abroad, which "is great preparation for this experience because we want them to feel solid with the science before they go into a situation where everything else is new." Students are interviewed and have to defend their proposals before a group of faculty members who are from different disciplines. "Ninety-nine percent of the time they are approved because getting ready for that interview really does get them ready to go."

Once approved, students participate in a two-evening cultural orientation. Foreign nationals from the countries where they are going meet with the students to "give them the inside story on the country." This takes place over food representative of where they will be going. "We talk specifically about homesickness, because everybody gets it, and we talk about strategies for dealing with other kinds of problems." Bender works with them with visas and immunizations, and the students' university mentors help them secure approvals they may need to work with human or animal subjects or collect samples.

[12]Bender, Carol. (2004). Biomedical Research Abroad: Vistas Open (BRAVO!): A program to internationalize the undergraduate science curriculum. In: *Reinvigorating the Undergraduate Experience: Successful Models Supported by NSF's AIRE/RAIRE Program*, J. Stocks and L. Kauffman (Eds.). Washington, DC: Council on Undergraduate Research.

When the students return, they speak to both on-campus and off-campus groups. Many have returned to their high schools, but some have spoken at churches, retirement centers, and to youth groups.

So far students have gone to 34 countries on six continents and have worked in 89 foreign institutions. More than 100 scientific publications and more than 130 presentations at scientific conferences have included their work. Most of the students in the program have gone on to do PhD programs, along with a substantial number who have done MD-PhD programs. "They come back different people. They are much more self-confident. They understand that they can make a contribution and that they can navigate in a foreign culture independently."

The disadvantages are that coordinating the program is labor intensive and time intensive. But it is worthwhile, said Bender, even if it is more expensive than offering an enriched experience on campus.

The university has also taken advantage of its proximity to the Mexican border. Ten years ago it started a program called the Ambos Nogales Revegetation Project to abate air pollution near the border. Students who are not able to go to an overseas site can have a research experience in another country by working on the project. "It is a wonderful alternative for our students who cannot readily leave their families."

The University of Arizona honors program provides small research grants that students can use either domestically or internationally. In addition, students can apply for a wide range of external grants such as Fulbright scholarships. "We make students aware of [these grants] and then coach them as they apply for these opportunities to try to help them put together the most competitive applications they can."

"My parting challenge," said Bender, "is just do it. Figure out a way. . . . One of our responsibilities as educators is to provide students with a global perspective. It is simply something that they must have to function appropriately in the 21st century."

3

Pathway Programs

Sponsors and Performers

AN NSF PROGRAM ON THE SCIENCE OF BROADENING PARTICIPATION

In 2004 the congressionally appointed Committee on Equal Opportunities in Science and Engineering recommended that "the National Science Foundation should sponsor additional social science research that will advance understanding of the causes and effects of progress and barriers to broadening participation in science, technology, engineering and math at all levels." This recommendation provides a strong justification for a research program on the science of broadening participation, said NSF's Kellina Craig-Henderson. At the time of the conference, such a program was being strongly considered within the Social, Behavioral, and Economic Sciences Directorate at NSF. Many intervention programs continue to be driven "by intuition and gut instincts but lack empirical support," said Craig-Henderson. There remains a great need for "careful, evidence-based findings that underlie effective programs."

Research on interventions in other areas has sometimes produced unexpected findings, Craig-Henderson observed. For example, women often do not negotiate as effectively for themselves as men do on such issues as salaries. One response to this finding has been a well-meaning effort to get women to be more assertive. Yet when women attend assertiveness training programs that cultivate negotiating skills, follow-up studies have shown that the programs do not necessarily lead to better success for women in negotiations. Instead, "when women do negotiate in ways that are similar to men, people do not like them," Craig-Henderson said. "They are evaluated more

poorly and are deemed to be less likable and less employable. So there is clearly a reason why women do not march into the office negotiating in the same way men do."

Another counterintuitive finding involves training programs designed to diversify the ranks of management. Empirical work by sociologist Frank Dobbin, supported by the NSF, has shown that diversity training programs do not work to increase the ranks of underrepresented minorities in management. What works are multi-pronged approaches that include mentoring, a point person in the organization who is committed to diversity, and a variety of other strategies. "My point here is just to show you that some of what we think of as being instinctive and intuitive does not actually result in the outcomes we would like when we employ evidenced-based approaches and the scientific method."

The NSF has supported considerable research over the years that can inform efforts at broadening participation in STEM. In particular, Craig-Henderson called attention to the work NSF has funded on stereotype vulnerability or stereotype threat. This research has shown that when individuals are in groups associated with negative and well-known stereotypes, they sometimes fall prey to that stereotype when performing in a context where the stereotype is relevant. An example would be underrepresented minorities or women as undergraduates in certain academic fields. "It does not matter how smart you are coming into the university," said Craig-Henderson. "To the extent to which you become aware of and sensitive to those negative stereotypes, it does impact your ability to perform well." This effect has been demonstrated across a wide range of populations, and the literature on stereotype vulnerability is today extensive.

As these examples demonstrate, many research findings that could be useful in efforts to broaden participation can be found outside the disciplines of education and psychology. Fields like political science, economics, and sociology also have much to contribute. For example, sociological research has been demonstrating the value in diversity in organizations both internally and with regard to external objectives. "We do not read across one another's literatures so you might be studying this as a social psychologist and have not a clue about the fact that somebody in sociology or economics is asking a similar question," said Craig-Henderson.

The research program being considered by NSF would draw from across the social sciences and behavioral sciences, with additional cross-linkages among NSF directorates. It would develop a coherent set of scientific questions about what works and what does not work. The results of this research would constitute a literature that would be both available and centralized for people who are trying to develop effective intervention programs. "We would have something akin to a clearinghouse of effective findings that could effectively inform approaches to broadening participation."

To date, planning to establish a program on the Science of Broadening Participation has included a workshop in June 2008 that brought together experts from across the social, behavioral, and economic sciences whose work informs the SBP. More recently, the Social, Behavioral, and Economic Sciences Directorate compiled a survey of awards made throughout the directorate

in the Science of Broadening Participation, with the results revealing that a substantial amount of research in this area has been supported within the last three years. In addition, a working group has been developing a "Dear Colleague Letter" to be disseminated throughout the social, behavioral, and economics research communities as an initial invitation for proposals focusing on the Science of Broadening Participation.

INCREASING INTEREST IN COMPUTER SCIENCE

The field of computer science, which is often neglected in considerations of the overall STEM enterprise, faces serious problems of recruiting and retaining students, said Janice Cuny of the National Science Foundation. Since the year 2000, the number of college-bound high school students who say they are intending to major in computer science is down 70 percent overall and 80 percent for women. Furthermore, minorities "participate very rarely in computer science," Cuny said. Even in 2000 the field was not producing the number of degrees it is projected to need, so computer science is facing a "big problem."

One barrier to getting more students involved in computer science, said Cuny, is the field's image. Students tend to think that the field centers on calculating and keyboarding, whereas the field actually centers on exciting scientific questions. It is a multidisciplinary, team-oriented discipline organized around exciting problems. "We do not communicate what we call the magic of computing to students," said Cuny. "They think it is word processing or e-mail. Well, that is not what computer science is." Especially in high-poverty schools, students tend to think of computer science as vocational education. When students use computers, it is often to learn keyboarding skills.

An additional problem is that women and minorities tend to come into computer science wondering if they belong, and the messages they get from others in the field do not necessarily allay those concerns. If minority or women students "get a low test score or they have trouble with something, . . . they are much more likely to think it is their fault and they should get out. We have all had the experience of giving a test that is too hard, and the guys come in and argue with what a stupid test that was and the women come in and say they have to drop the course. This is pretty standard across all of the sciences." Everyone involved in computer science needs to take steps to fix this problem. "We need to make sure that the education that we have is much more inclusive and open and less discouraging."

Students also tend not to see the social impact that their work in computer science can have. But computer science will underlie many future discoveries in many fields of science, Cuny said, and "has something to add to almost any academic endeavor."

Cuny runs a program at NSF designed to broaden participation in computer science from middle school through early faculty positions among underrepresented groups, including African Americans, Hispanics, Native Americans, other indigenous people, persons with disabilities, and women. "That is 70 percent of the population, so it is a huge target group," she said. The program provides two kinds of awards. Alliances are regional or national

programs designed to deal with multiple target groups and multiple stages of the pipeline. In addition, smaller demonstration projects are designed to demonstrate novel interventions that, if successful, could be scaled up and implemented across an alliance. "President Obama said last week that he challenged scientists to think about new and creative ways to engage young people in science and engineering," said Cuny. "Well, my principal investigators have been doing that."

The program has experimented with many different approaches. It has applied information technology to journalism, art, the media, gaming, and cultural preservation to get students excited about computer science. It has provided students with multidisciplinary and multi-institutional research experiences. It has joined students into communities through workshops, conferences, social networks, residential life programs, and community service projects. It has supported peer mentoring, STEP mentoring, and faculty mentoring.

"But, if you ask me whether we were done and whether this was going to be good enough, I think the answer is no," said Cuny. "We are still stuck in the same model." Programs tend to be isolated from each other. While individual programs can be spectacular, not enough assessment is done to identify critical components of a program and reproduce those components elsewhere. "We would never behave like this in a research community," Cuny observed. A research community is much more knit together, much more following each other's results, much more of a community effort."

To address the siloing of intervention programs, Cuny and her colleagues at NSF have instituted a third category of awards focused on leveraging, scaling, and adapting successful approaches so that they can become larger and more widespread. In part by having the alliances work together more often, they are seeking to build a national community. Ongoing workshops are looking at such issues as evaluations, building leadership in the disability community, and K–12 education. A newsletter and a special interest group in the Association for Computing Machinery are additional ways of building community.

Cuny pointed out that in families where the parents did not go to college, there is much less information on how to pick a college, how to fill out an application, and how to apply for financial aid. "Not all students have the kind of driven, in-touch families that some of us have had. So outreach goes beyond just the schools and to the parents."

People in STEM fields can be trained to deliver productive messages. For example, the message that education in STEM disciplines is hard is counterproductive. "It is not hard," said Cuny. "It is fun, and it requires work like anything else."

Cuny described the "program in a box" developed by the National Center for Women in Information Technology. It lets computer scientists know what they need to be effective in a classroom. It describes the relationship needed with the teacher, the preparation that is necessary, the things to bring to the classrooms, and activities to lead. Many people from industry want to help in classrooms, she observed, but "they need to be told what to do. You cannot just walk into a classroom and expect a teacher to hand you her classroom and not care what you do. You need to build a relationship with that

teacher and you are going to have to work what you say into a meaningful place in the curriculum to have it matter."

Many of her projects also include service learning opportunities for students in college. When college students reach out to community colleges and high schools, they are more likely to stay in school. "It makes them happier about what they are doing," said Cuny. "It makes them feel a more valuable part of the computer community." The programs train students to do this outreach, which can be much more meaningful for younger students. "We could do a much better job of training people to do meaningful things in the school and working with the high schools and the middle schools to make sure that what they do is meaningful and fits into the rest of the curriculum."

One great difficulty with reforming K–12 education, Cuny acknowledged, is its decentralization. "If we come up with a dazzling computer science curriculum, we basically have to go sell it school district by school district by school district, which is totally impossible," since there are many thousands of school districts in the country. Instead, she and her colleagues are working with the College Board and International Baccalaureate Program to construct "the perfect computer science course." By fashioning a course that is engaging, exciting, accessible, inspiring, and rigorous, they hope to interest even low-income schools in offering such a course.

"It has become clear to me if we do not fix high school, we are dead in the water." Unless an interest in computer science is built in high school, not enough students in college will be interested in the subject. Cuny has recently started a project to redo the high school curriculum in computer science and get 10,000 teachers prepared to teach it in 10,000 high schools by 2015. "If any of you have suggestions on how I might actually accomplish that, I would love to hear from you."

Changes in state standards may be necessary in states where computer science is defined as vocational education. In addition, teachers need to be certified. But "the computer science academic and professional communities have gotten behind this effort and are interested in figuring out how to do this." The computer science community is intent on going state by state to change certification requirements and train teachers, to work with the College Board, and to get a new AP course in place. "Now is a really good time to do this," said Cuny. "You cannot look at Houston and say that we are happy with 60 percent of our students not graduating. Clearly there are things that are dramatically wrong. No Child Left Behind, for all its faults, has let us see that there are definitely things that are going awry, and I think that we have a President who cares about education, who is committed to spending money in science and education, and who talked last week about bringing a Sputnik-like excitement back to science. Maybe now is exactly the right time to try to fix high school."

THE CHICKEN OR THE EGG: WHAT COMES FIRST IN INSTITUTIONALIZING PROGRAMS?

The Undergraduate Research Opportunity Program (UROP) at the University of Michigan began in 1989 with 14 underrepresented minorities in a single college. The focus was on first- and second-year students and on

research activities that took place during the academic year. Since then the program has been expanded to include women, all minority students, and then the entire campus, with more than a thousand undergraduates currently participating. According to Cinda-Sue Davis, the program's director, the program's growth has been based on dedicated staff who are compensated for their efforts, peer advising groups, research seminars, skill-building seminars, research symposia, and a multicultural focus.

The program has undergone both quantitative and qualitative evaluations through surveys, retention studies, focus groups, and interviews. The key to these evaluations, said Davis, has been to collect "data, data, data." For example, data collected early in the program's history on retention and academic success issues provided critical support for the program. Subsequent retention studies with matched controls showed that the program was having positive effects and led to peer-reviewed journal articles.

Other important factors in the program's success have been leadership for diversity efforts at the highest levels, a good alignment of the program with the mission of the institution, and leveraged outside support through federal awards, foundation grants, and private gifts. Meanwhile, the program continues to evolve. Questions currently being examined include what is the impact of the program on the faculty, what can freshmen do in mathematics or physics, should the program have a high school component, and should it be linked with a graduate student or postdoctoral training component.

INSTITUTIONALIZATION OF THE MEYERHOFF SCHOLARSHIP PROGRAM: INCLUSIVE CHANGE

In the late 1980s the University of Maryland, Baltimore County (UMBC), a medium-sized research university, was troubled by yearly student sit-ins by African American students, who, along with African American faculty members, perceived the campus as "cold" toward minorities and "racist." Efforts initiated in the late 1980s to change this negative climate were spearheaded by Freeman Hrabowski, who began working at UMBC in spring 1987 as vice-provost and since 1992 has been the university's president.

As part of his efforts to enhance and transform the campus, Dr. Hrabowski initiated:

- an ongoing dialogue within the campus community on issues related to race;
- data-based reviews of student achievement, including the achievement of African American students;
- a strengths-based rather than deficits-based view of minority students;
- recruitment efforts to admit better-prepared students, including African Americans, and to increase the number of minority faculty.

As a central part of Hrabowski's efforts, the Meyerhoff Scholarship Program was founded in 1988 as a multifaceted initiative to enhance the achievement of African American students in STEM fields. Key components

of the program include scholarships contingent on maintaining a B-average in STEM majors, an intensive six-week summer bridge program, a family-like program community, an emphasis on achieving at the highest levels, personal advising and counseling from program staff, summer research internships in national and some cases international labs, science mentors from the Baltimore and Washington, D.C., areas, and support from both administrators and faculty.

The Meyerhoff Program has achieved dramatic success, said UMBC's Kenneth Maton, who has been conducting research on the program for more than a decade. For example, as a result of their high achievement levels and research accomplishments, 51 percent (88 of 172) of African American Meyerhoff students entering the program between 1996 and 2003 attended STEM PhD and MD/PhD programs. An additional 40 percent entered master's programs, particularly in technical fields, or medical school. The program is widely viewed as a national model.

More generally, dramatic improvements have occurred over the years in the overall campus climate, Maton observed. One indicator is that in 2002 UMBC was named by Kaplan/Newsweek as a "hot campus" in the diversity arena. In 2009 the campus was named one of the nation's "best value" public universities by the Princeton Review. "It has come a long way," said Maton.

In reviewing the diversity initiatives literature in higher education, Williams, Berger, and McClendon propose an Inclusive Excellence Change Model that simultaneously embraces the diversity of students and promotes academic excellence for all students.[13] Drawing in large part on their model, the successful diversity change effort on the UMBC campus—including the development and institutionalization of the Meyerhoff Program—appears due to a number of key features, including

- modifications in the culture of the university, including its vision, values, and norms related to inclusive excellence;
- change in multiple dimensions of organizational behavior, including the structural, collegial, and symbolic;
- ongoing assessment, monitoring, and evaluation research;
- a strategic change strategy that includes senior leadership, institutional vision and buy-in, enhancement of organizational capacity, and leveraging resources;
- successful management of key external and internal challenges.

The presence of a critical mass of highly talented African American students on campus, the large amounts of external funding received, and substantially enhanced regional and national recognition resulted in an altered campus culture, one that deeply incorporates awareness of and commitment

[13]Williams, D.A., J. B. Berger, and S. A. McClendon. (2005). Toward a model of inclusive excellence and change in postsecondary institutions. In: *Making Inclusive Excellence: Preparing Students and Campuses for an Era of Greater Expectations*. Washington, DC: Association of American Colleges and Universities.

to inclusive excellence. For example, science faculty attitudes towards African American students underwent a dramatic transformation as these students achieved at the highest levels in the most difficult science courses and in many cases became valued research team members in faculty labs.

The inclusive excellence change process at UMBC has influenced the structural, collegial, and symbolic dimensions of the university. Within the structural dimension, inclusive excellence has been instituted as a campus priority. Efforts to enhance minority student success have become routine, reflected in both the institutionalization of the Meyerhoff Program—the program was placed within the mainstream budget process—and the periodic addition of new related programs focused on the achievement of minority students, and also women, in STEM fields, at the undergraduate, graduate, and faculty levels.

At the collegial level, building successful coalitions with key science department chairs and faculty was critical. Without such coalitions, it is unlikely institutional change would have followed. For example, the chair of the biology department and a Howard Hughes Medical Institute professor became key members of the inclusive excellence leadership on campus.

Finally, at the symbolic level, the selection in 1992 of Freeman Hrabowski, the African American founder of the Meyerhoff Program, as university president, was critical.

The diversity initiative at UMBC has effectively used institutional data related to access and equity of STEM student performance to initiate and monitor diversity-related change. Furthermore, external funding has been regularly obtained to allow systematic, ongoing study of the program that incorporates quantitative and qualitative methods. The evaluation findings have proved critical in helping to (1) establish the program as a national model, thus directly contributing to the positive institutional changes noted above, and (2) provide useful feedback to staff in their support of students.

There have been various external and internal challenges that the program and the university have faced over the years. For example, in the mid-1990s there was a growing anti–affirmative action climate in the country, and an appellate court decision supported a landmark lawsuit challenging the Banneker Scholarship Program at the University of Maryland, College Park, a program targeted exclusively to minority students. This led to the strategic decision to open the Meyerhoff Program to students of all races as long as the applicant could demonstrate an interest in the advancement of racial and ethnic minorities in STEM fields.

Within the campus, from the start there was resistance to the program among some faculty and students, who criticized channeling resources to minority students in science rather than to all students in science or to all disciplines. The university has responded by engaging in dialogue about the issue and ensuring that various university resources are directed to the larger goal of inclusive excellence. For example, university monies have been earmarked since 1996 to support scholarships for nonminority students in the Meyerhoff Program, to develop prestigious scholarship programs in non-STEM fields, and to effect curricular changes that would benefit all students. The latter include revamping intro biology and chemistry courses using "ac-

tive pedagogy," "discovery learning," and "inquiry-based" elements to make them more accessible and engaging.

In summary, a number of factors help explain why the Meyerhoff Scholarship Program has been successfully institutionalized at UMBC:

1. The program has been an integral part of a larger, inclusive excellence change effort.
2. Indicators of success emerged early on and were highly visible on campus.
3. The program contributed substantially to modifications in campus culture.
4. Key structural, collegial, and symbolic changes in organizational behavior occurred.
5. State-of-the-art program evaluation data were collected and widely disseminated.
6. Key elements of a strategic change process were employed, including senior administrators' initial and continuing support, buy-in from faculty in key science departments, leveraging of resources, and capacity building of departments and systems on campus.
7. The program has continually enhanced UMBC's status, reputation, and resources.
8. Campus leadership successfully addressed challenges as they emerged.
9. MSP was well matched to the needs, strengths, culture, and mission of the campus.

Undergraduate Focus

THE BIOLOGY SCHOLARS PROGRAM AT THE UNIVERSITY OF CALIFORNIA, BERKELEY

From its inception, many of the initiatives undertaken by the Biology Scholars Program (BSP) at the University of California, Berkeley, have been informed by an "intuitive" as opposed to a research-based assessment of what students need to succeed as undergraduate biology majors, said the program's director John Matsui. Yet the BSP has become a model program that has been widely emulated elsewhere.[14] Matsui provided a brief history of the program and addressed three questions: has the program been effective, what has been learned from the program, and how will the program change in the future.

The goal of the BSP has been to enlarge and diversify the pool of students who succeed in biology majors and careers, not just to skim those students who are already on a successful track. Program funding has come from the

[14]Koenig, R. (2009). Minority retention rates in science are sore spot for most universities. *Science* 324:1386–1387.

Howard Hughes Medical Institute for the past sixteen years and from the Gordon and Betty Moore Foundation for the past five years.

From 1992 to the present, more than 2,000 undergraduates have participated. About 60 percent of the students have been underrepresented minorities, 70 percent have been women, and 80 percent have been low-income and first-generation students. "This is not the typical profile of those who succeed in science at Berkeley," said Matsui.

The program has sought to provide students with the skills, the information, and opportunities to become and remain successful as biology students. There is no lower cutoff in terms of grade point averages or SAT scores for participants. Students must have an interest in a biology-related career. They also must have a demonstrated commitment to service, which is most often directed toward underserved and underresourced communities, which are the communities where the majority of the students came from. About 25 percent of the students come from community colleges. BSP students typically need to work and hold down one or more jobs while attending classes. Compared with their classmates, they have lower test scores and fewer advance placement courses and so are less well prepared to meet the expectations of the university. "Many of my colleagues question whether they are Berkeley material," Matsui said.

Many of the features of the BSP are shared among diversity programs elsewhere in the country. It is an academically centered and discipline-based program rather than being situated within the student services aspect of the campus. The program has high academic expectations, and communities are formed within an academic context. At the same time, the program tries to recognize the needs of students, offering comprehensive and integrated support and mentoring from culturally sensitive faculty and staff. Resources are front-loaded toward the beginning of a student's time in college, since many adjustment issues confront students entering colleges, especially when they are the first in their families to attend college. "Students when they are seventeen or eighteen are very different than when they are twenty-two years old and ready to graduate," said Matsui. There also is a continuum of resources to address critical transitions. "The issues do not stop once a student gets on campus. There is declaring a major, getting into a research lab, and choosing a career."

In some cases, students need more services than the program can provide. Students can be under considerable stress during critical junctures of their lives, and they may need help beyond the scope of the BSP. Matsui and the other program staff are cognizant of the limits of their expertise and refer students to other campus services, such as financial aid, academic counseling, and psychological services.

Over time, Matsui has become more aware of the less measurable and quantifiable influences on student success. Factors such as potential, readiness, and resilience are qualities that may not necessarily be reflected in the scores. Also, what students want is not necessarily what they need. "A student may say to you I want a tutor 24/7 available in math. Well, of course, that is not what the student really needs. Time management and many other

things are really what the student needs, and so I have learned to make that discrimination."

Matsui recognizes the importance of learning the life stories of students applying to the program, especially those whose applications are less polished. "Rather than looking at the end product, I look at each student's path, the distance they've traveled . . . . It is remarkable that some of them are still standing." An interview can reveal a lot about a student that numbers cannot really reveal. "It is the story behind the numbers. I had a student, for example, who scored a total on the old SAT of 700, verbal and math combined. She is now working for Proctor and Gamble. She got her PhD in infectious diseases and has done really well. All she needed was the right environment."

Matsui has come to appreciate that the program provides students with assistance tailored to each individual's life history and circumstances that may not be available elsewhere in the university. "The program mediates the interaction between students and the institution rather than fixing the student," he says. "I think that is a very important distinction."

The program recognizes that failure can be an important lesson for students. BSP helps students gain the ability to learn from their failures and to develop rationales for making future choices. It does not give them a prescription and say that they should simply follow instructions. "Information, opportunities, and student choice versus prescriptions are very important in terms of program design. It is important to provide students with accurate, good, timely information and opportunities and the ability to make choices versus saying, 'Just do this and come back to me when you are successful or if you fail.'"

In this way, the program strives to foster independence, not dependence. "I want my students to be full citizens rather than visitors in the academy," said Matsui. Success may take different forms for different individuals depending upon where they start and where they want to go. But students should develop self-advocacy and self-determination. "I want them to be capable of producing their own infrastructure once they leave." When they go to medical school or graduate school, "they should be able to garner the resources and to create their own program. . . . I want them to be able to manage their environment rather than be subject to the whims and vagaries of the environment.

An evaluation of the program has demonstrated its effectiveness. A 2003 study compared underrepresented minority BSP students with majority students outside the program.[15] It looked at the grade point averages and SAT scores of incoming students and took as its major measures of success graduating with a biology degree and college grade point averages. The study found that underrepresented minority students in BSP entered Berkeley with lower high school GPAs and total SAT scores, yet they graduated with percentages of biology degrees and final college GPAs equivalent to those of biology majors in general.

[15]Matsui, J., R. Liu, and C. Kane. (2003). Evaluating a science diversity program at UCBerkeley: More questions than answers. *Cell Biology Education* 2:117–121.

BSP students also have met with success after graduation. At Berkeley, about 55 percent of medical school applicants are accepted. The average for BSP students applying to medical school has been about 85 percent over the program's duration. In the fall of 2008, 100 percent of the program's underrepresented students got into medical school. In terms of graduate school, over the sixteen years, 88 percent who have applied have gotten into PhD programs.

Matsui observed that for people interested in implementing an interventions program, the message received from others may be just to do what they are doing. "That's as helpful as saying if you want to run a four-minute mile, watch me as I do it. Simply put one foot in front of the other really quickly." Nevertheless, he has drawn several important lessons from the program's success. Among the factors critical to student success are academic and financial support, mentoring and early research experiences, the formation of academic communities, and academic advising, especially when advisors can provide guidance in course taking and an academic plan.

However, Matsui emphasizes, "beyond the 'list,' the devil is in the implementation." For example, the conventional wisdom is that students should get into laboratories as soon as possible to do research. But for many BSP students who are trying to succeed in their classes while adjusting to the demands of college, engaging in research too early would be disastrous. "Research experiences are critical, but they should be quality research experiences at the right time, when the student is ready to contribute to the lab and also benefit from the experience." In those cases, the student could have a good experience and receive a strong letter of recommendation, rather than simply serving as a technician or going through the protocols without understanding what the research question is. Readiness for research varies from student to student. At the same point that some students may be ready to participate in research, others may have no idea of what research is.

Especially for first-generation and low-income students, learning the rules of the game and developing "system smarts" are critical. These students need both quantitative and qualitative information. For example, they need "a reality check in terms of what their grade means. Can you really get into medical school with a 2.2 GPA? What do you have to do to compensate for that early poor performance in your lower division courses?" Program managers have learned to listen to students and what they have to say. "We observe and we listen. We look for trends and patterns."

Finally, a program should provide a college or university with an opportunity to understand its weaknesses. The students in the program do not lack motivation or drive. They are simply underprepared. Given the right environment, they can succeed, but the university needs to recognize that fact if it is to become an accessible institution. Intervention programs are experiments that provide data. These data provide a way to replicate the program in other disciplines, other institutions, and ultimately throughout a university.

As such, the future challenge for the Biology Scholars Program is to replicate its success in other science and non-science disciplines at Berkeley and elsewhere, Matsui said. The program also wants to increase the participation of males in the program, since 70 percent of the students in the program cur-

rently are women. The program also needs to mitigate the negative impact of finances on low-income students. "I am sure all of us in this room are cognizant of that problem."

More research is still needed to determine if the success of BSP students is in some way a function of the selection process versus how students are treated. Another question is which interventions work for which students under which conditions. Finally, what aspects of the model are replicable and scalable at other sites with other students and with other staff and faculty?

THE STARS ALLIANCE AT FLORIDA A&M UNIVERSITY: BROADENING PARTICIPATION IN COMPUTING

The Students and Technology in Academia, Research, and Service (STARS) alliance is a partnership of institutions in the southeastern United States focused on broadening participation in computer science and information technology. It was funded by an initial three-year, $2 million grant that recently has been extended for an additional three years. Master's students Sabrina Fontaine, JeRone Gant, and Maynard Yates and Jason T. Black from the Department of Computer and Information Sciences at Florida A&M University described components of the program and pointed to particular ways in which it is effective.

The alliance began with 11 colleges and universities and more than 50 partners, including companies, professional organizations, and K–12 schools, and now has 20 colleges and universities and more than 80 partners. Its goal has been to recruit women, minorities, people with disabilities, and other underrepresented groups into computing and information technology fields. According to Department of Labor statistics, 140,000 new jobs are available yearly in computer science while only about 40,000 bachelor's degrees and 15,000 master's degrees are being granted in those fields each year. "Simple math would tell you 40 thousand plus 15 thousand does not equal 140 thousand," said Yates. "That's why STARS was formed—to try to get more people recruited and for students to see that there are opportunities in this field."

A variety of colleges and universities are involved in the alliance, which means that the alliance includes schools with very different needs and ideas. For example, Florida A&M has worked hard on recruitment while other institutions may be more interested in student research. "If they wanted to be more involved in recruitment, then they can help us out by helping us with research and we can help them out by helping them with recruitment," Yates said.

The alliance's website—www.starsalliance.org—has been used to market the program. In addition, the alliance has conducted a variety of demonstration projects to promote and expand the program. Every year begins and ends with a STARS celebration in which everyone involved in the alliance comes together at a specific member institution. The celebrations inform participants of the national need for computing professionals and provide opportunities to reinforce the STARS values.

A centerpiece of the program is the STARS leadership course, which is a repeatable one-year program open to both undergraduate and graduate stu-

dents. Through the course, more than 300 students have participated in the STARS leadership corps (SLC). Graduate students receive a stipend of $1,000 a year for their participation and undergraduate students receive $500 per year. SLC students are responsible for participating in at least three projects per semester drawn from outreach, service learning, research, recruitment, or seminars. Students keep online journals, attend monthly SLC meetings, and attend the annual STARS celebrations.

The major focuses of the alliance's programs at Florida A&M University have been community outreach, service learning projects, research, recruitment, and retention. Community projects have included mentoring at local boys and girls clubs and community centers and serving as instructors at an after-school program for underprivileged minority students. For example, SLC students developed and implemented a series of day-long workshops designed to introduce freshmen and transfer students, along with some high school students, to computing departments and topics.

Another major program at Florida A&M has been the African-American Women in Computer Science (AWCS) program, which seeks to encourage women minorities to pursue computer science. Scholarships made as part of the program are based on need and go to students majoring in mathematics, computer engineering, or computer sciences, with stipends ranging from $2,000 to $5,000 per semester. AWCS recipients are also STARS associates. "We're all basically doing the same thing and trying to reach the same goals," said Fontaine.

A recruitment and retention program run by the university, by Seminole Community College, and by Florida Community College at Jacksonville is called the Tri-Regional Information Technology (Tri-IT) program. Its goal is to engage underrepresented women in ninth to eleventh grades to engage in computer science and information technology projects. SLC students instruct Tri-IT girls at four local schools in 80 hours of after-school workshops. The girls also can receive $50 for going to a week-long summer camp. "We want to show them the different paths that they have" available to them, said Fontaine.

Another demonstration project, which is being implemented at the middle school level, uses what is known as Culturally Situated Design Tools (CSDT). The program is designed to attract the interest of middle school girls before they start to lose interest in mathematics and science. It uses concepts they can relate to, such as the braiding of hair or graffiti, to entice them into learning about mathematical or scientific concepts. As with Tri-IT, SLC students instruct the middle schoolers. "They relate to us more because we're not 'adult' in their eyes," according to Fontaine.

STARS will continue to implement research and retention projects to diversify the computer science and information technology fields. A monthly SLC newsletter introduces people in other departments or other schools to the program. Regular talks by professors and collaborations with other SLC chapters will further advance the program's aims. The field "may not seem welcoming," said Fontaine, "but it is welcoming and we do appreciate diverse people in our field."

In evaluations of the SLC program, about 85 percent of students said that participating in the program has increased their commitment to pursue computing majors. About the same amount said that participation in the projects allowed them to develop better skills and knowledge of their field. And more than 90 percent said that computing faculty members within their departments care about diversity.

BROADENING PARTICIPATION IN UNDERGRADUATE RESEARCH

At about the same time as the conference, the Council on Undergraduate Research published a book on broadening participation in undergraduate research, scholarship, and creative activity among students of color, students with disabilities, and low-income students.[16] Jodi Wesemann, who coedited the book with Mary Boyd, used the book as a jumping-off point for a discussion of how colleges and universities can build or strengthen their undergraduate research programs.

The book had several goals. One was to make the case for broadening participation in research, scholarship, and creative activity involving undergraduate students not only in the sciences but across all disciplines. Another was to share a range of strategies that people have used to pursue this goal. A third was to share case studies and personal examples, "because that really inspires many of our colleagues."

There is no one right way to broaden participation, said Wesemann, but the book provides guidance on what to do and how to do it. It includes a set of program design principles based on those identified by a working group under the public–private partnership Building Engineering and Science Talent (BEST):[17]

- institutional leadership
- targeted recruitment
- engaged faculty
- personal attention
- peer support
- enriched research experience
- bridging to the next level
- continuous evaluation
- comprehensive financial assistance
- evidence-based approaches

These principles, as a set, address the "what" question, Wesemann pointed out. But they do not necessarily address the "how" question. For example, an

[16]Boyd, Mary K., and Jodi L. Wesemann. (2009). *Broadening Participation in Undergraduate Research: Fostering Excellence and Enhancing the Impact.* Washington, DC: Council on Undergraduate Research.

[17]Building Engineering and Science Talent. (2004). *A Bridge for All: Higher Education Design Principles to Broaden Participation in Science, Technology, Engineering, and Mathematics.* San Diego: BEST.

enriched research experience often involves activities that take place outside the classroom. But such an experience also can take place within the classroom. "The design principles are really principles," said Wesemann. They are not a "cookie-cutter" prescription.

Participants in the session worked in small groups to identify ways in which the design principles have (or have not) been implemented in their institutions and explore strategies to implement or strengthen the principles. Factors that either enhance or impede the implementation of the principles were then discussed. Wesemann compiled a list of the factors shared by participants. They include:

- faculty rewards and recognition
- time commitments
- financial compensation
- students' perceptions about the value of undergraduate research
- availability of research opportunities across entire institution
- connection of students with research opportunities (within and outside of the institution)
- peer and near-peer mentoring
- cultural sensitivity

Addressing these and other factors to advance the design principles requires strategies that can move institutional programs forward. Wesemann emphasized three strategies in particular. The first is assessing past and current contexts. "You need to think about your institutional context—the students, the culture of the student body, the faculty, what they were brought in to do," she said. Examining the context enhances not only self-reflection but also benchmarking with other institutions. "Know what's happening out there."

The second strategy involves organizing change efforts. The process needs to be managed, said Wesemann. "You have to think strategically about who you're bringing to the table, what they're saying, and how they can help move things forward." The management of change needs to be coordinated with institutional assessments, and it needs to generate information that is available for use.

The third strategy is to engage in both short-term and long-term planning. "It's hard sometimes to think ten years down the road," Wesemann said, but it is necessary to keep moving forward.

Wesemann drew several "take-home messages" from the book and from the design principles. One is the importance of maximizing and leveraging the investments in undergraduate research. "Our institutions are making an investment. And of course our students who are involved have to make an investment as well."

Another is the need to provide incentives to help people break new ground. Wesemann pointed to the efforts that many project champions make and to the consequences when project champions leave. "They've given up their summers. They've done research with students. They've done it without pay. They've gotten external money. And at some point, if there's not a reward system put in place, what's going to happen to those faculty members?

They're going to burn out. They're going to leave. All of the work that was put into place is just going to be gone when they leave their institutions or turn their attentions elsewhere."

The consequences of relying excessively on individual leaders emphasize the need for collective efforts. "It can't just be individual champions," said Wesemann. "If we don't capture those efforts collectively, [we'll] put them to waste."

There also is a need to focus on excellence. Programs cannot afford to send a message that anything less than high-quality research is being pursued. Lowering the bar "is not good for the students, the institution, or the faculty involved."

Finally, commitments need to be sustained. Multiyear plans need to be developed, "because that is what it takes, on an institutional level, to move things forward."

HARVARD COLLEGE'S PROGRAM FOR RESEARCH IN SCIENCE AND ENGINEERING (PRISE)

In 2005 the recommendations of a task force at Harvard College led to several new initiatives designed to increase the numbers of women and underrepresented minorities in science and engineering. One initiative was the Program for Research in Science and Engineering (PRISE), which was launched in December of that year.

PRISE had multiple objectives, said the program's director, Gregory Llacer. It sought to foster community among science scholars, engage undergraduates with STEM faculty in a research environment, identify and encourage target populations, provide logistics support for students who want to pursue full-time summer research, and connect disparate research activities across Harvard in a meaningful way. Housing for undergraduates at Harvard is organized by houses, "which makes it very difficult to make any other kind of community," said Llacer. "You have a small group of people in your house who may share the same concentration or major as you, but beyond that, there are no structures within the university organization that can help foster a sense of community among scientists."

The organizers of PRISE analyzed several comparable programs elsewhere, such as the Meyerhoff program at the University of Maryland, Baltimore County, and the Research Experiences for Undergraduates program sponsored by the National Science Foundation. They also recognized that the program at Harvard had to overcome the isolating character of much scientific research. Students "typically do pipetting for a thousand years and then say, 'What kind of a career is this?' . . . We wanted to have an encouraging environment where they were networking with each other, sharing their stories, and getting consolation when they needed it."

Harvard faculty historically have had few available opportunities for undergraduate researchers. But PRISE has helped increase the number of student researchers dramatically. Llacer estimated that as many as 300 undergraduates conduct research in Harvard labs each summer. "PRISE is only a part of that now, but PRISE was instrumental in helping to make that happen."

One way the program has identified and encouraged target populations is by working with preexisting groups such as Women in Science for Harvard and Radcliffe and the Harvard Society of Black Scientists and Engineers. In turn, this collaboration has helped to connect research enterprises throughout Harvard. "Harvard is known as a silo institution, meaning every tub on its own bottom. Everything tends to be pretty isolated, not only within the faculty of Arts and Sciences but also in the medical school, the School of Public Health, [and other graduate schools] that don't have undergraduates as part of their student population. That's something we wanted to do."

The program has organized distinguished speaker series, faculty chats, seminars, social programming, study breaks, and social programming groups. Students live on the Harvard campus during the summer, organize many of their own activities, write their own research proposals, and earn money for their research. Alumni of the program become PRISE fellows and remain actively involved as mentors and speakers. At the end of the summer, the students present their research to the group. "It's the best part of the program. The kids love it."

The program has collected efficacy data from the outset, in part through a collaboration with the American Association for the Advancement of Science. Surveys have shown that the program has an extraordinary appeal to students, with a 97 percent approval rating among participants. Comparisons with a non-program group of summer researchers show that the PRISE students have significant differences in every measure of "connectedness," with the strongest connectedness scores among underrepresented groups. And participating in the program significantly helps rising sophomores become involved in research during the school year.

The PRISE fellows have started a Harvard Undergraduate Research Association, which holds a symposium every year. PRISE participants also have organized the Boston Regional Symposium, which brings together undergraduate researchers from surrounding college and universities.

The program has just completed a three-year pilot period. But "future funding is going to be a challenge," said Llacer, now that the program is no longer supported by seed funding. Still, Llacer predicted that a stable source of funding would be found and that the program would continue.

INVESTING IN DIVERSITY: AN INTEGRATED APPROACH TO SUMMER RESEARCH INTERNSHIPS

"Diversity includes everything," said Ana Corbacho, the assistant director for higher education with the Center for Biophotonics Science and Technology (CBST) at the University of California, Berkeley, "including gender, race, ethnicity, social and economic status, family background, interests, major career goals, work experience, accomplishments, and challenges. This is very different than using 'diversity' as a proxy for underrepresented minorities."

CBST has used this broad approach to diversity in organizing research internships for about 30 undergraduates each summer since 2006. The students in the program have had a wide range of family backgrounds and educational

experiences and have been roughly split between men and women. Creating this level of diversity has "taken some work," according to Corbacho, but careful attention to socioeconomic and academic factors during the recruiting process has produced a good mix of students.

The CBST program is 8–12 weeks long and features seminars, training in basic laboratory skills, specialized short courses, team-building activities, attendance at a scientific meeting, and other professional development activities. The program focuses on three areas of development: academic, social, and professional identity. During the first week, the interns participate as a group in a series of activities and workshops that help them develop a supportive community and prepare for their work in research laboratories. For example, in one workshop, called "Challenging Stereotypes," a diversity trainer facilitates a discussion about the effects of stereotypes, including stereotypes involving race, religion, gender, career choices, and being a scientist. Students then go on to their lab internships, typically in pairs, where each member of the pair comes from a different educational background and ethnic group.

Evaluations of the program from students have been very positive. Participants report becoming more aware of the different backgrounds of their fellow students, better able to counter negative stereotypes, more confident in doing research, and better able to communicate with others about research. Moreover, comparisons of underrepresented students with majority students showed that the underrepresented students had greater gains in research skills and confidence.

UNDERGRADUATE ACADEMIC EXPERIENCE FOR FIRST-YEAR ENGINEERING STUDENTS

At Texas A&M University, students who are underprepared in mathematics are likely to have difficulty achieving success in the College of Engineering, and minority students are overrepresented in this group of underprepared students. In response, the College of Engineering has established a five-week summer bridge program called Learning to Excel in Engineering Through Preparation (LEEP). The goals of the program are to help prepare students who plan to study engineering and to increase the diversity of the College of Engineering student body.

During the pilot of the program in 2007, students with mathematics SAT scores under 550 were invited to attend the program. In 2008 the College of Engineering implemented a mathematics SAT requirement of 550 for admittance, so students with scores between 550 and 600 were invited to attend.

The program has nine key components, including an orientation session, three courses to build mathematics skills, study skills training, mandatory study sessions, seminars, and mid-semester meetings. Students in the program also have a Facebook group so they can interact with each other, and after the fall semester they have an opportunity to return to their high schools and give a presentation about the College of Engineering and their experience in the LEEP program.

The schedule in the summer is full, and students "complain that there is little free time," said the project manager Jacqueline Hodge. "We structured the program to provide them instruction in math, physics, the design process, and study skills. We want them to experience the life of an engineering student, we want them to learn, and we want them to have a smooth transition when the fall semester comes."

Outcomes of the program include exposure to material in three critical STEM courses, meetings with faculty members and current students, exposure to the university, and the formation of relationships that last throughout their academic careers and beyond. Students participate in community service and recruiting activities and become engaged in university and college programs. Also, they earn six hours of course credit for their participation in LEEP, and students who perform at a certain level are eligible for monetary incentives.

In 2008, Hodge and her colleagues conducted a comparison between a group of LEEP Students and a group of students who were eligible for the program but did not participate. The average grade point for participants was 2.9 and for nonparticipants, 2.5.

Future plans are to implement pre- and post-program exams and use the results to advise students on which math course to start with and whether they should pursue math as well as physics in the first fall semester. Hodge also wants to increase the focus on study skills. "We want to improve where needed and be of better service to our students who come through the program."

THE RESEARCH EXPERIENCE: CREATING A VERTICAL NETWORKING COMMUNITY

"It's hard work to build community," said Brian Booton from the University of Missouri. "It takes real purpose." The most important step is to survey students to understand what they expect. "If that's not happening, then it is an intuition-based program" rather than a program that addresses the needs of students.

The University of Missouri has 28,000 students, but last year's entering class had just 481 African Americans. Building a research community among such a relatively small group of students is different than at a historically black college or university or at majority campuses with larger minority populations. At the University of Missouri, the Exposure to Research for Science Students, or EXPRESS, program, links new students with older students, including junior transfers. "It's a very, 'cast-your-net-wide' approach," said Booton. "The student just has to have an interest in science." The 30 to 50 students in the program each year range across all fields of science and engineering and, in the most recent year, even include several philosophy and psychology majors. The majority of the participants in the program self-identify as pre-med students.

The goals of the program are to expose minority students to research, retain them in STEM fields, make them aware of STEM-related careers, and prepare students for graduate school. The students work part-time in a labo-

ratory eight to twelve hours a week with a faculty member, with students interviewing three to five faculty members to make an appropriate match. Students have weekly meetings with each other and individual meetings with peer mentoring program staff. Students are paid for doing research and are required to attend the weekly meetings.

Recently the program brought in an outside consultant and did focus groups with upper level students who had gone through the program. One response from the students was that they felt the program had not provided enough social support. Booton said that the program was so focused on academics that it had not emphasized the social development and connections of the students. As a result, the program made several programmatic changes related to building community and social support. It looked at the role of ethnic student organizations in cultural adjustment at predominantly white institutions. The program also focused new attention on the cultures and subcultures of the students in the program. In response, one result was to provide students with "a designated space to hang out. Very, very simple."

The program also increased its use of peer mentors. The goal is to have the mentors, many of whom are doing research themselves, meet regularly with program participants. Peer mentors meet individually with sophomores every two weeks and with first year students every week. In addition, Booton schedules regular meetings with the students as well.

The program organizes trips to different laboratories and other research sites. It also engages students in purposeful team building activities. For example, a point was made for students to learn the names of everyone else in the program, not just some of the people in the program. "I spent two hours for two different weeks until everyone knew everyone's name. And it made a huge difference in terms of a feeling of community."

A Saturday training session each fall involves graduate students, faculty, a safety workshop, and panel discussions. A poster session and reception each spring recognizes freshmen and sophomores in the program, the peer mentors, and participating faculty mentors. Graduating seniors also are honored at the reception and receive an honor cord that they wear at graduation. A monthly newsletter highlights accomplishments of both undergraduates and graduate minority science students. "We're seeing a lot more students together outside the meeting times." Students also have begun forming their own study groups for individual classes. "Now these things are taking place naturally."

Envisioning Careers

CORRELATES OF SUCCESS IN DIVERSITY GRADUATE PROGRAMS

To increase the number of students in training for science careers, the educational pipeline must be widened, according to Michael Leibowitz, professor of molecular genetics, microbiology, and immunology and director of several diversity programs at the University of Medicine and Dentistry of

New Jersey (UMDNJ)–Robert Wood Johnson Medical School. The programs Leibowitz oversees, all of which have been initiated since 1996, approach this goal in several ways. They offer summer and academic year research programs for underrepresented undergraduates, flexibility in the curriculum, training in cognitive skills, wellness counseling, English as a second language programs, a quantitative methods course, study groups, and a variety of writing courses, including courses and seminars in grant and proposal writing. In general, the programs were piloted with minorities underrepresented in the sciences (supported by grant funds) and then extended to all students with institutional support.

The unusual diversity of the programs aimed at broadening participation at UMDNJ has created an opportunity to correlate particular interventions with success in PhD programs. Among the interventions Leibowitz and his colleagues have evaluated are the use of mentors, a student's "sense of fit," a sense of fairness in the research relationship, and having a critical mass of similar students in a program. These interventions then were correlated with a variety of measures of success, including conference presentations, authorship of papers, authorship of grants, passing qualifier exams, and self-efficacy.

Preliminary results indicate that for underrepresented minorities, success was most strongly correlated with a student's identity as a scientist, use of mentors, and sense of fairness in the research relationship. For majority students, in contrast, the greatest correlation with success was with a sense of fit.

The number of underrepresented students in molecular biosciences graduate programs has grown steadily at UMDNJ over the past decade, and social barriers have not developed between trainees of differing ethnicities. Furthermore, the attrition rate of underrepresented minorities in these programs has been the same as that of the overall student population. However, there remain a number of barriers to institutionalization, Leibowitz observed. Issues that need to be addressed include continuity of funding, avoiding ethnic targeting while providing support for the members of groups who need it, achieving a critical mass of students, and documenting success.

THE EFFICACY OF OBTAINING A RESEARCH MASTER'S DEGREE AS A STEP TO A PHD

Several years ago, Frank Bayliss, professor and director of the Student Enrichment Opportunities Office at San Francisco State University, was invited to give a talk at a summit of the UC and California State University (CSU) systems on minority students who receive master's degrees at CSU institutions and PhDs at UC institutions. The data that he gathered for the talk were "quite revealing," he said. They showed that master's degrees from CSU institutions were "redirecting some of the leaking from the pipeline back into the pipeline."

Master's degrees can be stepping stones to several different futures. They can be terminal degrees for career positions, initial research experiences before the PhD, opportunities to explore a new field or move in a new direction from

an undergraduate major, or ways of making up for previous course deficiencies. The CSU institutions cannot grant PhD degrees, though they have faculty who are very active researchers. For many students, the master's degrees they earn at CSU institutions are their first chance to do research. Many students also are resolved to get a PhD, though they may not know exactly which field they are most interested in. And master's programs at CSU campuses can give students "much more attention . . . than they'd ever get at a PhD program."

Bayliss noted that the proportion of underrepresented minorities in the UC system decreases at each stage of the educational ladder, from 18 percent of bachelor's degrees awarded to 11 percent of the PhDs awarded, 8 percent of postdoctoral fellowships, and 8 percent of faculty. This underrepresentation is especially severe in STEM fields, with members of these groups making up less than 10 percent of enrollments in UC graduate schools in the life sciences and physical sciences.

The data Bayliss gathered for his talk show that significant numbers of underrepresented minorities who receive PhDs from UC institutions received their bachelor's and master's degrees from CSU institutions. Furthermore, the minority CSU graduates perform in these PhD programs at a level similar to that of minority students from the UC system or from other colleges and universities (measured by whether students complete their PhDs within ten years).

One conclusion Bayliss draws from this observation is that the predoctoral preparation programs in place in CSU institutions "are doing a really good job of preparing students to go into the PhD culture." Students coming out of funded programs like the Minority Access to Research Careers (MARC) and the Research Initiative for Scientific Enhancement (RISE) programs "are very well prepared and they're persisting."

The data also reveal the quality of the students coming from often overlooked institutions. "They're not being pushed. They're driven. They're prepared."

Finally, for students to perform at these high levels, "it's important that you have a rigorous program with high standards," said Bayliss. "These underrepresented minorities would not be successful if they didn't meet the challenges that they need to be prepared for UC."

SEALING THE HOLES IN THE MIDDLE OF THE PIPELINE: INTERVENING WITH PHD STUDENTS

Many PhD students reach a point of great confusion, concern, and even anger during their graduate education. They are confused about what they are supposed to do after their first year. They are concerned about comprehensive exams. They do not know how to write a dissertation, and they might not have peers in their research group who are advanced enough to help them. They don't know how to write predoctoral grants and fellowships or how to start looking for a postdoctoral fellowship. Especially for many underrepresented minorities in PhD programs, the consequences are all too apparent—they drop out and fail to achieve a degree.

At the University of California, Los Angeles, Heather Tarleton has helped establish an intervention for these PhD students in the natural sciences at all ten University of California campuses and for social science PhD students at the campuses of Santa Barbara, UCLA, and Berkeley. The intervention is a two-day retreat for the social science students and a one-day retreat for the natural science students, who often have more difficulty getting away from a laboratory. The retreat strives to both provide support and empower students to continue supporting themselves through their four, fifth and sixth years.

Underrepresented minorities in PhD programs face the same set of problems that other students do, including gaining financial support, accommodating domestic responsibilities, and finding a mentor. Many underrepresented minorities also face additional challenges. Their background may not be as broad as for students from other ethnicities. For example, their parents may not have gone to college or graduate school, so they may receive less support from home. They can be overwhelmed at a large campus where they are a member of a relatively small group. They may have a greater need for a mentor and at the same time have a harder time finding a mentor. They may feel insecure about their academic or social abilities. These stresses may require that they draw on emotional and mental health resources.

One benefit of a cohort-based intervention is that it brings together a group of students who are facing similar issues. "They get to see each other in one room," said Tarleton. "They get to discuss and ask questions as a group." It is important to provide support for each cohort of students as they progress through graduate school. "I would say that this is one of the biggest lessons I have learned as an administrator and as a mentor throughout this past year and doing these interventions."

A pre-retreat survey revealed four categories where students expressed concern. The first was support for writing. "We assume that students come into graduate school and they know how to write, and that is true. But they do not know how to write in certain formats, such as dissertations or grants."

The second concern expressed by students was for mentoring. "Overwhelmingly the students . . . do not have someone who can mentor them. They have a faculty research advisor, but they do not have a mentor, and this is where they fall into that feeling of being lost."

The third concern was about developing a curriculum vitae. "They really do not understand a professional CV. They do not know how to organize it, and they do not know how to create priority in their academic portfolio."

The last concern of students was self-management—"staying focused, staying motivated, maintaining balance." Students reported that they had gained weight during graduate school, that they were tired, that they were surviving off coffee. "That is what happens in grad school, but we should not just allow that to be the status quo. That needs to be something that we address with the students."

A key factor in organizing the retreats was the involvement of faculty, according to Tarleton. A three-to-one ratio between students and faculty was maintained, and faculty members were paired with students based on their research, interests, and disciplines. Students also were generally placed with

faculty that they did not know, so that they could get a different perspective and air concerns they had about situations in their departments.

The retreats were structured as safe spaces where students could work on their personal and professional growth. Sessions at the retreats looked at the dissertation process, mentoring, and research discussions. For example, during the research discussions, faculty members worked with small groups of students on two-page prospectuses for their research. In addition, the retreats included things like ten-minute yoga breaks and stretches to remind the students that the retreats were not just about academia.

The students remarked in post-retreat evaluations that they were especially grateful for the faculty members' attendance. "This was emotional and mental support for them." They reported that they enjoyed being able to talk to faculty in a small-group context. Most said that they learned something new about working in the academy. Ninety-six percent indicated that they would recommend the retreat to a colleague or to a peer.

However, the faculty panel discussions received mixed reviews, Tarleton said. The students enjoyed being able to ask questions about the dissertation process. What they did not like was how the faculty tended to avoid certain subjects. An example might be, "I am having a disagreement with my dissertation chair. What do I do?" The students felt that the faculty tended to skirt such issues. Perhaps a negotiation or mediation workshop by someone who is not on the faculty at the University of California would be able to tackle these concerns, Tarleton said.

Tarleton has been considering the possibility of holding a two-day retreat on or off campus followed by a single-day or half-day retreat later in the academic year. Involving a campus psychologist could be a valuable addition. Also, students of color often want to give back to their communities, but they hear from faculty that they should not do that, and "it creates a tug at their hearts." Students need tools and information about how to remain connected to their communities but also maintain their progress toward a degree.

"If we do not address the issue of anxiety, procrastination, and anger before the third or fourth year, then the students have checked out. They are taking their master's and they are leaving because they view academia as hostile to them."

DISSERTATION HOUSE: GRADUATE INNOVATION IN PHD COMPLETION AND RETENTION

The University of Maryland, Baltimore County (UMBC), also has implemented a retreat for graduate students called "Dissertation House." It is a four-day retreat, either on campus or off campus, that focuses on the roadblocks graduate students can face. One such roadblock is when they have completed their coursework and qualifying exams but not their dissertation. According to Wendy Carter of UMBC, 17 percent of graduate student reach this all-but-dissertation (ABD) stage and do not finish their PhD. Another roadblock is when students spend years looking for a research topic. Or a student might have a topic in hand but be unable to write a research proposal.

The biggest problem in these and other circumstances, according to Carter, is time management. Many other interventions for graduate students focus on the writing process, but even "the best writers struggle to finish their dissertation." Students often think that with a good editor they could finish their dissertation quickly, but that is generally not the case. "Time management is one of the biggest roadblocks I find," said Carter, "and that is what we focus on in the Dissertation House."

Dissertation House provides graduate students with tools and techniques that they can use both during the retreat and later, when they are on their own and not making progress. They learn how to set realistic goals and make steady progress toward those goals. They learn how to make progress even when they are not writing or the writing is going poorly.

Dissertation House can be done either on or off campus. Doing it off campus means that students can get away from the Internet, telephones, and other distractions. "You have a longer day, and you can work as long as you want and then start again real early in the morning." Off-campus retreats tend to be more informal and comfortable, like working in a house.

Holding Dissertation House on campus lowers the costs and makes it more accessible to students. Student employees who work on campus can attend to crises while attending. Students also can use on-campus resources like the library or the counseling services center, since it can be more difficult to get counselors to attend a Dissertation House off campus.

Students at a Dissertation House post their goals at the beginning of the retreat. They also can share their goals and involve others online, which broadens the range of people who can participate. Dissertation House speakers provide 30-minute minilectures on such topics as procrastination, which are then posted online for students to review. At the end of each day, students summarize what they have accomplished and what they plan to work on the next day. "Generally, students come to the Dissertation House without knowing exactly what it is they are going to do. They often come based on a friend's or advisor's recommendation. All they really know is that it is supposed to help them finish."

A survey at the end the Dissertation House asks students about the experiences and what should be done in the future. Students have said that it is important to emphasize a range of skills, not just writing, and to provide assistance to students who are at various stages of their education. That allows students who have succeeded at a particular stage to give advice to those who are at that stage. Dissertation House alumni also come back and talk to the students about the PhD process. In the survey, students mentioned that facilitators can move the process forward, while one-one-one meetings with faculty are also especially valuable.

Dissertation House reinspires students when enthusiasm for their research topic has started to wane. "It is important to see other people struggling just like yourself, because when you are just doing it by yourself and struggling at home by your computer you think, 'I must be stupid. I do not know why I am not done yet. How come everybody else is finished?' But seeing other people struggling, it helps you to be more realistic."

One question on the survey asks whether Dissertation House is a good use of university funding, and the majority of students say yes. In fact, they tend to say that they wish they had come to Dissertation House earlier.

ALIGNING POSTDOCTORAL TRAINING WITH THE ACADEMIC PROFESSORIATE

The traditional postdoctoral fellowship has focused on independent research, grant-writing, and some mentoring skills. But there is a "huge mismatch," said Brian Rybarczyk, the director of academic and professional development at the University of North Carolina, Chapel Hill, between these activities and the responsibilities of a faculty member. In addition to research, grant-writing, and mentoring, faculty members need to master the scholarship of teaching and learning, teach their classes effectively, manage research groups, and become adept at administrative skills such as budget management. These are skills that "you don't necessarily get as a graduate student and maybe not as a postdoc."

In 1999 the NIH created an Institutional Research and Career Development Award aimed at balancing research and teaching among postdoctoral fellows while also forging partnerships between research-intensive and minority-serving universities. One such program is the Seeding Postdoctoral Innovators in Research and Education (SPIRE) program at UNC–Chapel Hill. The program supports two years of research and one year of teaching for postdoctoral fellows. Fellows conduct research at UNC–Chapel Hill and take a twelve-week seminar to develop their pedagogical skills. With the assistance of a teaching mentor, they then teach at one of five partner minority-serving institutions, Fayetteville State University, Johnson C. Smith University, North Carolina A&T State University, North Carolina Central University, and UNC–Pembroke.

Building community is a cornerstone of the program. With a traditional postdoc "you go into a lab individually," says Rybarczyk. "But with the SPIRE program, you come in as a cohort . . . to build a personal and professional network."

Rybarczyk and his colleagues have conducted research on the SPIRE program directed at two questions: Does a structured postdoctoral training program designed to provide both research and teaching opportunities result in attainment of academic career tracks? And how does the program impact undergraduate education at minority-serving institutions?

The researchers have hypothesized that participation in the SPIRE program does not significantly hinder the scientific productivity of the postdoctoral fellows, even with their additional responsibilities for teaching, administration, mentoring, and so on. "To be honest, our research community was very skeptical at UNC–Chapel Hill," Rybarczyk said. But the research has shown that participants are equally productive and that the opportunities provided by the SPIRE program match with the characteristics of academic faculty positions. "We still have our naysayers, but overall the campus is very positive in supporting the program."

The study design compared SPIRE postdocs with other postdocs on the UNC–Chapel Hill campus who did not participate in SPIRE. Data collected since 2005 look at scientific publications, presentations at scientific meetings, students mentored, courses taught, professional development activities, service contributions, job interviews and offers, and a number of other measures of productivity. The data show that the two groups have no significant differences in terms of the number of peer-reviewed papers published. In other categories—including seminars presented, service-related contributions, professional development opportunities, presentations at scientific and educational conferences, courses taught, and guest lectures—the SPIRE postdocs were significantly more productive than the non-SPIRE postdocs.

According to national data gathered by NSF, about 47 percent of postdocs enter academic institutions. In contrast, 90 percent of the SPIRE postdocs are currently at academic institutions. And about 70 percent are in tenure-track positions, a number three times higher than the national average.

Undoubtedly, some self-selection influences these results, in that many applicants see the program as aligned with their career goals. Yet the program has been remarkably effective in helping postdocs achieve those goals.

The SPIRE program also has had significant effects on the minority-serving institutions. More than 100 courses have been taught, including 18 new courses that had not been taught before. The fellows have revised courses and laboratories and have provided research-based opportunities for undergraduates. They have taught more than 2,000 students since 2002, providing students with role models, mentors, and research opportunities both during the summer and during the academic year. At least 15 students have gone to graduate schools and other post-baccalaureate programs after being taught by SPIRE fellows. And nine former SPIRE fellows are now tenure-track faculty at the partner minority-serving institutions. "That speaks to a much longer-term kind of impact that we're having at our minority-serving institutions at North Carolina."

In the future, Rybarczyk and his colleagues would like to investigate characteristics that are important for retention in science careers at the postdoctoral level. Some of the fellows have entered the program saying that they did not know whether they wanted to conduct research for the rest of their lives. But they have become more excited about research when they have seen how it can be integrated with undergraduate education. The experience has created "a renewed perspective on science, which is really great."

Rybarczyk also would like to explore the long-term impacts of the SPIRE program on career paths. Furthermore, the same data-gathering techniques could be applied to undergraduates and graduate students. "We think we have a strong way to measure productivity in terms of career development."

DISCIPLINE-SPECIFIC WORKSHOPS: BECOMING A RESEARCHER

Since 2006 the Computing Research Association's Committee on the Status of Women and the Coalition to Diversify Computing have been holding discipline-specific workshops either as part of a conference or as a standalone summer session. The workshops have brought together somewhere

around 40 to 70 people to discuss technical and professional development topics within a specific sub-area of a field. They are being funded by the National Science Foundation through a Broadening Participation in Computing grant.

Three key elements distinguish these workshops from others, said Elizabeth Bizot of the Computing Research Association. First, they mix technical and career content with a tight focus on the sub-field under consideration. Second, the speakers include both the top people in a field and a diverse group of practitioners. Third, the workshops are structured to provide many networking opportunities in a friendly environment.

Some of the workshops are aimed at undergraduates, some at graduate students, and some at people throughout the educational and career pipelines. With students, workshops tend to emphasize why they might want to be a researcher in this field. "What is exciting about it? What is cool? Why do the people who are speaking like to get up and go to work in the morning?" Speakers try to let students know how to become a researcher. The workshops also let students begin to build professional networks in fields they are considering entering.

The workshops contain technical content, but the key is not trying to teach the subject thoroughly. "The technical talks mostly do not get into too much detail," said Bizot. "They are higher-level views of the field and [discussions of] things that are popular, like hot topic sessions. . . . You want to engage the students. You want them to see what is really interesting and exciting because that sometimes gets lost in the nitty-gritty of what you have to do from day to day." Technical sessions also try to explain how a sub-field relates to the fields around it, such as what people working on operating systems ought to know about programming languages.

During discussions about careers in the field, the key is keeping a tight focus. Most attendees have heard about broad topics like effective communication before, but they can learn something new if the topic is discussed in the context of a particular discipline. Career development also is discussed in the context of various career options. What does it mean to be on the faculty of a research institution, on the faculty of a teaching institution, or working in a government lab?

Each of the speakers is asked to talk briefly about his or her career path and life outside research. "Students tend to assume that big names in the field went directly from point A to point B and that they always knew they were going to be stars. It is really helpful for them to hear, 'Well, I did this for a while, but it didn't work so well, so I went and I did that.'" The workshops also have what they call a one-slide rule for the speakers, where every speaker is supposed to have one slide about life outside work. "It can be anything—family, hobby, adventures—and that is another opportunity for students to make a connection. Actually it is interesting for the other speakers as well when it turns out that a person you have known for 10 years professionally restores vintage cars on the side or goes whitewater rafting in the summer or whatever."

Creating networking opportunities requires two things: a structured interaction to break the ice, and time for unstructured interactions. For the

former, workshop attendees might practice elevator speeches, introduce themselves, or sit at topic-specific lunch tables. For the latter, the workshops have long breaks, informal dinners, or activities like picnics or boat rides. Speakers are encouraged not just to talk with each other but with attendees as well.

Participants fill out feedback forms immediately after the workshops. An online survey asks the speakers about their experiences and what they thought the workshop was like for students. A follow-up survey done about a year after the workshop assesses whether people are making the connections intended.

The workshops were designed to help students and other attendees, but "we discovered almost by accident that the workshops were doing something really good for the discipline as well," said Bizot. "Yes, we are encouraging a diverse group of future researchers. That is what we set out to do. We also found, though, that we are engaging some senior researchers who may not previously have been involved in diversity efforts."

ENHANCING THE TALENT POOL: A MULTI-INSTITUTIONAL APPROACH

Another model to build capacity is offered by the Leadership Alliance, which consists of 33 institutions that focus on critical transitions in the educational pathway. The alliance has four principal programs, two of which were described by Valerie Wilson, associate dean of the graduate school at Brown University. (She did not discuss the annual symposium held by the alliance or the faculty resource network for faculty professional development.)

At the undergraduate level, the alliance seeks to reinforce the transitions students need to make in pursuing STEM careers. To participate in the alliance's summer undergraduate research programs, students need to have a minimum of a 3.0 grade point average, have at least one semester remaining in their undergraduate education, and be interested in attending graduate school. The students then do research at 22 of the alliance's institutions across the country. Every summer between 175 and 200 students from a variety of institutions engage in research. Students range widely in age, experience, and disciplines, so it is necessary to have core elements for the summer program that are employed by the different institutions to meet students' needs in a uniform way.

In the face of this variety, the alliance focuses on three specific goals. It seeks to develop the ancillary skills that are needed to do research, such as training in different types of research methods, how to do critical reading of journals, and how to conduct research responsibly. It also seeks to develop communication skills. "It's no good if you know it all and can't communicate," Wilson said. "We really try to strengthen students' ability to do presentations, to write abstracts, and to communicate their knowledge through a variety of venues." Finally, it seeks to provide students with the information they need to make good decisions about how to further their academic careers.

Each institution may not offer the same approach to each of these elements, but each offers a core of activities within these three critical categories.

Each year the alliance does an inventory of each program to find out exactly what types of core activities are offered at each campus and how many students participated in those activities.

For the past seven years, the alliance has conducted an in-depth analysis and assessment of student satisfaction with the stated goals it has for students. Each student completes an evaluation at the end of the summer, "so we really do know what we know." The alliance then uses this information as feedback to improve the program. For example, it determines whether students are having trouble with a particular activity at a particular campus and uses the survey results to reinforce things that are going well. "We're pleased with the numbers that we have," said Wilson, "and it's interesting to see that there are still ways in which we need to improve."

The alliance wants to both further the preparation of students who are fairly sophisticated in research as well as bring in students who may not have participated in research. One interesting finding from the surveys is that a significant cohort of students in the program are rising seniors who have not had a research experience previously. "What we interpret this to mean is that even on campuses that have honors programs and support programs, there are many more students than there are slots in those programs. So programs like ours provide the opportunity for these students to get this critical exposure."

Data collected by the alliance show that the undergraduate research program has helped more students enter into doctoral programs. Furthermore, the documented increase in the numbers of students entering PhD programs is not at the expense of those who pursue MD degrees. "These increases represent a net of new individuals who found that this was the most appropriate career decision for them."

The second component of the alliance's effort that Wilson discussed is a focus on graduate and postgraduate transitions that need to be made successfully to build leadership among minority researchers. So far, 141 students who participated in programs organized by the alliance have received either a PhD or an MD-PhD. Furthermore, Wilson predicted, given the numbers of students in graduate programs, that this number will increase by 25 to 35 every year, so that more than 200 students will have emerged from the program by the year 2011. More than half of these students are in the biological sciences, but there also are students in the social sciences, the humanities, and the physical sciences.

The alliance also has found that its students are going into postdoctoral training at higher-than-national rates. And these students have been able to serve as role models for those who are earlier in the training pathway. "This is a way in which our network reinforces itself by bringing back people at different levels of the training pathway. These individuals, who have been successful, encourage others and also provide a realistic assessment of what is required as trainees move toward their career choices." Already, 47 alumni of the program hold faculty positions in a wide variety of colleges and universities, and others are working in government, industry, and the nonprofit sector.

Wilson has derived several strategies that have been critical to the alliance's success. One is to work closely with the leadership at all levels of institutions to inform them about the alliance. "Coordinators at each institution need the support of their presidents if they are to do their jobs effectively." However, Wilson noted that leadership at all levels changes. "As you know, presidents come and go, and institutional coordinators come and go. So it is critical for us to have seminal documents, like a membership manual, that provide past and current policies to which all members have access, and an annual event where we update new people who have come into our alliance."

A second strategy involves shared governance within the alliance. There are five different committees that govern the work of the alliance, upon which institutional coordinators of the alliance serve. This provides for multiple perspectives on policies related to the alliance and ensures that each individual can represent the alliance at different forums.

The final strategy is that "none of this is possible without engagement of the faculty." Faculty members are needed not only to host student research projects but also to stay engaged over multiple years. "We challenge these mentors to hold students to the highest possible intellectual standards because that's the only way that students will be able to get to the next training level." The alliance also invites current and prospective faculty mentors to the annual symposium to see the breadth and depth of the talent pool and begin to recruit from that pool.

How Faculty Thrive

PRESERVING THE PROFESSORIATE BY BROADENING PARTICIPATION IN STEM RESEARCH CAREERS

The Preparing Future Faculty (PFF) movement began in the early 1990s as a collaborative effort between the Counsels of Graduate Schools and the American Association of Universities and Colleges. Targeted to doctoral students, it is an effort to prepare future faculty members for positions in the academy.

In 2000 the Indiana University–Purdue University, Indianapolis (IUPUI), campus established a PFF program. Beginning with four to eight students, it now has an average of 65 students participating each year, said IUPUI's Etta Ward. The program gives graduate students an opportunity to be exposed to different aspects of faculty life through workshops, seminars, and symposiums. Over the past few years, the program also has developed a mentoring component with other institutions of higher education in Indiana.

Each year the PFF program prepares a plan of activities throughout the course of the year. The plan draws on resources from the Center for Service in Learning, the Office of the Vice Chancellor for Research, and other offices at participating institutions. Master's students who have completed at least one course can join the program. Students complete 12 units—half in teaching and

half in research, service, and professional development. As part of the service unit, students act in a service capacity for their profession or area of study, such as working with undergraduates or putting together a conference.

A capstone unit features an accomplishment made during a student's time in the program, whether a submitted proposal, a course component developed with the Center for Teaching and Learning, a teaching portfolio, or some other project.

According to Nelson Soto, the PFF program—along with an Alliance for Graduate Education and the Professoriate (AGEP) program at Purdue University—serves as an umbrella to promote collaboration across campuses and STEM disciplines. A one-day PFF institute began four years ago focused on what it is like to be a faculty member. The program expanded to 100 to 150 students the following year, and the range of topics covered expanded as well.

More recently, the PFF and AGEP programs established links to summer research programs for undergraduates. This year roughly 200 undergraduates are participating in summer research, enabling preparation for graduate school to begin in the undergraduate years. Among the topics to be covered in a one-day workshop for undergraduates held the day before the PFF institute are writing a CV and proposals and finding external funding for fellowships.

AGEP also sponsors an event focused on surviving and thriving in graduate school. Subjects include how to write a dissertation, work–life balance. Students propose and develop the workshop subjects. The cooperation forged between the PFF and AGEP programs has had great benefits by involving not just underrepresented minorities but everyone in the graduate community, said Soto. "My question to you is, Where are units that you can collaborate with?" For example, can student life or campus facilities help in some way? How about counseling and psychological services? "That is something we want to leave you to think about."

INFORMING THE CAREER DECISIONS OF NEW PHDS

While working on her master's thesis at Purdue University, graduate student Megan Grunert decided that self-efficacy, which was the theoretical framework of her thesis, was not sufficient to explain the decisions female graduate students were making as they entered the workforce. "It wasn't enough to look at how confident women were in making choices about their careers," said Grunert. Equally important were "the value judgments about different careers that were out there."

As a result, Grunert broadened the scope of her research to look at the rewards and obstacles that chemistry graduate students associated with different careers. She also sought to compare those perceptions with the descriptions of their careers from women who had made a range of career choices. The perceptions of graduate students "were not always accurate," said Grunert. Graduate students "need to have more accurate information available if we want women to make informed decisions that hopefully will lead to happy, successful careers."

Grunert conducted interviews with chemistry graduate students from two different institutions and with faculty members from three research-intensive institutions—one with a high percentage of women faculty, one with a low percentage, and one with an intermediate percentage—and at three predominantly undergraduate institutions. The students were a year or two away from their PhD degrees, "so they were seriously thinking about what they were going to be doing with their life." She transcribed the interviews and looked for common themes and relationships. She was guided by expectancy-value theory, which combines ideas about self-efficacy with the concept of the valuation ascribed to a career, and by the "standpoint feminism" framework developed by UCLA philosopher Sandra Harding.

She found that the graduate students she interviewed do not have positive perceptions of academic research or lifestyles. "I haven't interviewed a woman yet who hasn't said, 'I don't want to be my boss.' They look at the lifestyle of their boss, regardless of if they have tenure or if they're brand new, and they don't like it." Graduate students see research as overly competitive, lacking in social networks, damaging to a work–life balance, and too distant from real-life impacts. As one student said, "[When] you're shooting for tenure, you're here 70 to 80 hours a week, you're driving your grad students . . . all the grants . . . and I see so many professors here, even once they have tenure, they're here Saturdays and Sundays, . . . It's just totally unappealing."

Graduate students talked more favorably about careers in predominantly undergraduate institutions, government, or industry. They thought such careers were more likely to have a positive impact on the world, whether through teaching or an influence on policy. "They talk about wanting to change the world. This is a really big motivator for them."

Students also expressed a desire to interact with people. As one student put it, "I love the school as a grad student, but I don't think I would like it as a professor because you don't get to interact as much with your students, you don't get to know their names, and I mean, I like being a TA here because I get that one-on-one connection." Students also express a desire to educate others, including the public, for chemistry as a profession and the country to keep moving forward.

The faculty members Grunert interviewed tended to have a different perspective. They believed that their research was making the world a better place—maybe not immediately, but at some point in the future. They also emphasized the intellectual freedom associated with their positions. "They used that exact wording every time I talked to them," said Grunert. "The fact that once you get tenure, you can study whatever you want to study. Nobody's going to tell you what to do. You get to mold your research program. And that was incredibly important to them when choosing their career."

Faculty members also emphasized the rewards of guiding graduate students and postdoctoral fellows. As one faculty member said, "I've had six people graduate so far. . . . Seeing them mature, that is by far one of the most satisfying parts. You feel like you're having an impact on someone." And, as Grunert pointed out, this is a reward that often is not visible to individual graduate students.

Faculty members also had good things to say about their lives. They recognize that being a researcher is challenging. "You've got to have a really supportive spouse," Grunert said. "But they can do it. . . . You've got to be really passionate about this and be willing to make sacrifices for it."

Faculty members at predominantly undergraduate institutions had another set of perceptions. Many of these women had had negative experiences in graduate school or, later, in industrial positions. "They didn't have a good advisor. The research didn't go the way they wanted it to. They got really frustrated, so their confidence in their ability to do research was a little bit lower." But many of these faculty members had had good experiences in teaching settings, and those experiences tended to be their guiding influence.

These faculty members tended to value the flexibility of their positions. Tenure decisions at predominantly undergraduate institutions generally depend on teaching and service to the community as well as research. "I've heard the 60-30-10 [guideline] come up a lot, where it's 60 percent teaching, 30 percent service, and only 10 percent research. There's not that expectation to get out and publish and get grant money."

These faculty members talked about how rewarding it was to teach and work with students. They acknowledge that it can be a challenge to teach students who have had only a semester or a year of chemistry. Also, undergraduate researchers are in a lab for only a semester or a year or two while graduate students can be in a lab for four or five years. Still, these faculty found these experiences rewarding, Grunert said.

Grunert's preliminary findings are that women faculty at research institutions are not positive role models for many graduate students. Graduate students see only part of their professors' lives and can forget that they have a life outside of the university. But many faculty members are not very forthcoming about what their lives are like at home. "I'm not even sure if my advisor has kids," said Grunert. "So there's a disconnect there. There's no communication going on between these two populations."

Among the interventions suggested by this research are changing the departmental climate and opening up routes of communications between not only advisors and advisees but also among other faculty members and students. Family-friendly policies, maternity leave, child care, flexible tenure clocks, and clear departmental expectations about work schedules also could ease misunderstandings among students and faculty. Finally, it is difficult to make research more collaborative when people need individual recognition to be granted tenure and achieve funding. Changes in this reward system would need to happen at departmental, institutional, and nationwide levels.

THE NSF ADVANCE PROGRAM: STRATEGIES TO INCREASE THE ADVANCEMENT OF WOMEN

The goal of the ADVANCE program, which is funded by the National Science Foundation, is to increase the representation of women at all ranks of the faculty and advance women to positions of leadership in science and engineering. The program is based on the premise that diversity has many benefits to research, said ADVANCE program officer Jessie DeAro. A diverse

faculty provides different perspectives for students in higher education, and those students will work in diverse workplaces. Diverse faculty members also provide role models for students as well as direct and indirect encouragement for them to explore possible careers in science and engineering, including faculty positions in those fields. A diverse faculty, like a diverse student body, contributes to the vitality of academic institutions. In addition, a diverse faculty can contribute to the variety of science and engineering research questions being pursued and the range of methodologies being used to answer those questions.

Women continue to face obstacles at every point of the science and engineering career pathway, from middle school to the PhD and beyond, said DeAro. But the ADVANCE program focuses on just one part—science and engineering faculty—and for a specific reason. Although women have increased their representation in the pool of people who earn PhDs in the United States—from 17 percent in 1976 to more than 40 percent today—the number of women entering faculty careers does not reflect these gains.[18] Among the reasons cited for the underrepresentation of women in faculty positions are explicit or implicit bias, the differential effects on women of conflicts between work and family, unequal access to resources in the workplace, and low numbers of women in academic leadership and decision-making positions.[19,20,21] "Women are either going someplace else—out of the field or into industry—or into unemployment," said DeAro. "We think that there is a way to take advantage of this talent pool."

The ADVANCE program has three components.[22] Institutional Transformation projects are five-year, comprehensive grants awarded to academic institutions. These grants, which are typically several million dollars in size and have been awarded since 2001, are intended to transform the culture of a college or university to address organizational barriers that may work against achieving a more diverse faculty. A second category of smaller grants provides support for institutions to prepare for institutional transformation. For example, one of these grants might support data collection, review of policies and procedures, and figuring out what kinds of strategies are appropriate given a particular context and mission. Partnerships for Adaptation, Implementation, and Dissemination (PAID) is a third category of grant. These are one- to five-year grants that can support the adaptation of proven strategies

[18]Burrelli, Joan. (2008). "Thirty-Three Years of Women in S&E Faculty Positions." InfoBrief Science Resource Statistics, National Science Foundation, Division of Science Resources Statistics (NSF 08-308).

[19]Valian, Virginia. (1998). *Why So Slow? The Advancement of Women.* Cambridge, Mass.: MIT Press.

[20]Rosser, Sue V., Eliesh O'Neil Lane. (2002). Scientists and engineers: Family-unfriendly policies. Low numbers, stereotypes, and harassment. *Journal of Women and Minorities in Science and Engineering* 8:163–192.

[21]The National Academies. (2007). *Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering*. The National Academies Press, Washington, D.C.

[22]ADVANCE: Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers, program solicitation (NSF 09-504).

to new institutions, dissemination projects, as well as social science research on gender in academics.

The centerpiece of the ADVANCE program is institutional transformation, said DeAro, because "focusing on institutional change is expected to impact many more faculty and students over a longer period of time than a program that provides direct support to individual faculty." The program has drawn on the organizational change literature for guidance on how institutions can transform the way that they operate in order to support diverse faculty. "Academic institutions as they exist now are based on pretty much a 14th-century model of an organization," said DeAro. "It's not that we're trying to change the mission of the institution, but we're trying to make sure that it operates in a way that helps to meet its mission effectively."

Institutional transformation needs to focus both on human resources and on the organization. In particular, institutional policies, procedures, and practices—such as how a position is announced or the hiring process—must be thoroughly examined. In addition, the culture of an organization, which is determined by the attitudes, experiences, and beliefs of the individuals making up that organization, needs to be addressed.

Since the ADVANCE program was initiated, several important lessons have been learned.[23,24,25] The first is that there may be organizational barriers that negatively affect the participation of women and other underrepresented groups. Policies, procedures, and practices need to be transparent, such as how hiring and promotion are approached and what a tenure clock extension means for tenure decisions. Also data need to be collected that can inform decisions. "One of the best things ADVANCE has done is to give data to deans so that when they have decisions to make about allocations of resources or space, or they have to approve a recommendation from a search committee, they have data to give them some context about a department's historical activities," DeAro said. Considerations of diversity need to be incorporated throughout an institution into administrative positions, departmental leadership positions, and faculty. Diversity should not be relegated to a separate office; it should be part of everyone's job. "If every dean has a diversity goal, it's not dependent on who the dean is, but on the job description of the dean and their performance evaluations."

The second important lesson is that a work–life balance is important for faculty satisfaction and retention. This applies not just to women with families but to everyone. Dual-career hiring programs, flexibility for dependent-care responsibilities, automatic tenure clock extensions for births or adoptions, and similar policies can benefit men as well as women. At the same time, it is known that women are disproportionately affected by family life issues,

[23]Bilimoria, Diana, S. Joy, and X. Liang. (2008). Breaking barriers and creating inclusiveness: Lessons of organizational transformation to advance women faculty in academic science and engineering. *Human Resource Management* 47(3):423–441.

[24]Stewart, Abigail J., Janet E. Malley, and Danielle LaVaque-Manty, Eds. (2007). *Transforming Science and Engineering: Advancing Academic Women.* University of Michigan Press, Ann Arbor, MI.

[25]ADVANCE, program brochure (NSF 09-41).

like family care, so these issues need to be addressed to recruit and retain women.

The mentoring, leadership development, and networking resources available to faculty also are important for both men and women. If these career supports are not provided, "you might have a retention problem over time." Women tend to be disadvantaged when career support activities are purely informal, so the ADVANCE program has promoted formal mechanisms to help women achieve greater satisfaction with their careers.

Finally, individuals need to be empowered with knowledge about gender equity issues, including scholarly research on gender and diversity. They also need to have the tools and resources to address barriers in their organizations. Explicit bias may be on the decline, but implicit bias still influences important decisions. "For example, we know that individuals rely more on implicit bias when they are stressed for time in making decisions, so if you can give them more time and an adequate stress-free situation to make decisions, you're more likely to have decisions that are not impacted by implicit bias."

These kinds of strategies can have a big effect on job satisfaction and on the institutional climate for women as well as underrepresented minorities, DeAro said. In fact, departments outside science and engineering also benefit from these strategies. "Some institutions report that they are more competitive for faculty [across the board] if they have an ADVANCE grant or mention ADVANCE in their search ad. This has an even greater impact than we anticipated."

THE URI ADVANCE INSTITUTIONAL TRANSFORMATION PROGRAM

The University of Rhode Island (URI) received an institutional transformation award from the ADVANCE program in 2003, so the five-year grant period and one-year no-cost extension are just finishing. At URI, the grant was directed toward several goals, said Joan Peckham, a URI faculty member currently working at NSF. One goal was to assess the institutional climate and institutional practices for promoting women in STEM fields. Another was to increase the number of tenured women in the STEM faculty. The program sought to promote the careers of women in the STEM disciplines all along the pipeline. And it fostered the development of global support networks for women.[26]

URI is a small university, so the hiring of just a few women can make a difference in the institutional climate. For example, when the oceanography department made an explicit effort to include women in the search process for several faculty positions, the department was so impressed by the quality of the female candidates available that it hired four women from the search pool. "I was the first tenure-track faculty member in my department," said Peckham. "It was fabulous to work with other women and have a group of

[26]http://www.uri.edu/advance/ (Accessed August 7, 2009).

women to think about these things with. . . . A lot of us were coming out of corners where we were pretty isolated."

The leaders of the ADVANCE program worked hard to promote organizational change at all levels with institutional leaders. "This is a delicate issue, because these are our administrators. Who are we to say that we should train them in order to administer us?" Nevertheless, by being creative and engaging administrators in situations where they could provide advice but also learn about new initiatives, the program was able to promote changes in the cultural climate.

One way the program accomplished its goals was through a faculty fellows program. Fellows had release time from their courses and support to begin their research. "This is probably pretty standard at research one institutions," said Peckham, "but it was not standard at our institution." Search committees were trained to seek out female candidates. Faculty development meetings looked at such issues as mentoring, being mentored, and how to generate good first impressions. A mini-grant program allowed faculty members to compete for support to begin new research projects.

The program led to URI's first parental leave policy, "and the first person to take advantage of this was male, which opened up the floodgate, because women didn't want to be the first." A dual-career hiring program acknowledged the responsibility of the university to try to secure jobs in the university or in nearby companies for spouses. A work–life family center was established along with a permanent staff position for that center. Even a lactation center was established for students and faculty. "We have really changed the way we do business."

Today, recruitment for STEM faculty positions at URI is more than 50 percent female, and "it was nowhere near that before." A formal faculty mentoring program assigns mentors to all newly arrived faculty members, male or female, with training provided for both the mentors and mentees. "Faculty who have come to URI have told us that the reason we have such a high-quality candidate pool in oceanography and other places is that we're an ADVANCE institution now. If you're an ADVANCE institution, and you make that very clear, I think it can strengthen the quality of the candidates you attract."

The experience at URI has resulted in several lessons learned, according to Peckham. Continuing efforts are required to foment institutional change, and the support and prestige of an NSF grant can promote those efforts. Leadership needs to provide a strong and committed endorsement, and structures of accountability are necessary to monitor progress. A wide buy-in from faculty and administrators is necessary, even as those individuals change over time, and a focus on the wider benefits to an institution can help achieve this buy-in.

THE "FORWARD TO PROFESSORSHIP" PROGRAM

Rachelle Heller from George Washington University described the "Forward to Professorship" program that has been conducted through the ADVANCE program. The intent of the program is to bring women and mi-

norities who had completed their PhDs through to the threshold of tenure.[27] The program has three components.

The first component is an annual workshop that features meetings with chairs and deans who are from different institutions than the participants, which allows them to speak freely about the job-seeking and negotiation processes. Over the course of three days, workshop participants put together future plans based on their research and teaching statements and their desired goals. Participants then get feedback on those plans from the chairs and deans at the workshop. "You can try out things that you are thinking about in a safe environment with people from institutions where you have no intention of applying," said Heller. Following the workshops, participants have an opportunity to participate in once-a-week conference calls to report on how they are doing. Ongoing e-mail contact and surveys also track the progress participants make in achieving their goals.

The Forward to Professorship program also has a component called Mind the Gap, which focuses on the period when PhD recipients are between jobs or are taking a hiatus from a job. During a gap period, a PhD recipient may not be actively involved in an academic career. He or she might be anticipating a new child, caring for a sick relative, going to NSF as a rotator, or following a spouse. Heller and her colleagues are in the process of interviewing people who are in the gap or have gone through the gap to learn about the pressures and needs of people in these situations. For example, she pointed out, emeritus faculty members almost always get reduced rates on professional dues, but people in the gap do not. "We have counseled people in the gap to ask [for reduced fees], because being part of a professional organization while you're in the gap keeps you connected."

People returning from a gap period are greeted back to the workforce in different ways. People who have been in the gap for work–life reasons tend not to get much of a welcome, while people who have been working at NSF as a rotator can be welcomed back with great enthusiasm because of the information they have acquired. People who have taken time off to be in the military also tend to be treated well when they return, said Heller.

[27]http://student.seas.gwu.edu/~forward/advance/ (Accessed August 7, 2009).

4

Data and Evaluation

BUILDING A LONG-TERM REGIONAL DATABASE

A major problem with many current evaluation programs, said Alan Peterfreund, the executive director of SageFox Consulting Group, is that they typically are limited by the duration of a project. Yet the outcomes of greatest interest often do not occur until well after a project is over. As a result, evaluations tend to be focused on near- and mid-term activities and surrogates are used for longer-term outcomes.

Over the past two years, Peterfreund has been involved with an effort that has pioneered a different approach. Working with clients in Massachusetts who have six different NSF grants, he and his colleagues have been collecting data from a variety of institutional partners. Starting with five community colleges and four universities, they soon will have data from ten community colleges and eight four-year colleges and universities. "This allows us to take a very different perspective," he said. "It allows us to create a baseline understanding at the regional and local level, which is very different than what one hears from an individual institution or from the national perspective."

For example, the data have revealed extensive movements between community colleges and four-year institutions. "There is an enormous swirl out there," said Peterfreund. In addition, "community colleges are very different one from another depending on the communities they serve. They are very responsive to the demands of their local community, and they shift programs" from year to year. For example, one year a course might focus on networking, while the next year it focuses on web design. "How one then evaluates that as a baseline of activity gets really interesting and complicated."

Typically, more than two-thirds of students coming into community colleges require developmental courses in mathematics or English, Peterfreund

noted. Perhaps these students are interested in STEM fields, but instead of taking courses in those subjects they receive negative feedback in developmental courses that may not be as interesting to them. They do not get the opportunity "to discover the joy of learning at a college level." A large pool of students begins higher education in community colleges. "How do we capture them? How do we motivate them? How do we excite them?"

Multi-institutional data help to reveal the lack of cohesiveness in many STEM strategies. Proposals tend to be piecemeal. "They are about workshops for middle school or high school students, or they are about teacher professional development, or they are about supporting students at a particular phase of academic development, or they are about changing curriculum in some fashion or another. It is very rare that we see a cohesive strategy on a regional basis." Developing cohesiveness will be difficult as long as funding mechanisms are limited to specific opportunities and do not take longer-term views of change. "We keep reinventing the wheel over and over and over and over again." Program leaders tend not to share programs, "so there is a real challenge here of capturing the investment that we make, which has been substantial. Let's be honest. It has been a substantial investment that has occurred the last 30 years, and we do not see the yield because it is not very cohesive."

The data that Peterfreund and his colleagues are gathering also can help the partners in an alliance understand each other's programs and intentions. "It helps them understand, for example, that programs that may be thought of as designed for traditional students coming from high school or community college to college are not going to work when your students are actually 24 or 26 years old and returning from other experiences," students who can have very different work schedules and commitments to family life.

In addition, richer stores of data can help institutions take advantage of opportunities. For example, said Peterfreund, there has been an enormous surge of interest in forensics, and many high schools and middle schools have developed interesting ways of getting students to be inspired to go into chemistry by drawing on this interest. Even community colleges and colleges have been taking advantage of this opportunity produced by the media.

The data provide insights into the issues students face as they progress through STEM fields. A particular focus has been gateway courses in mathematics, physics, chemistry, and biology at different institutions, so that institutions can tailor courses more likely to be effective with their students. Another focus has been outcomes. For example, the data show many students not completing STEM majors at particular institutions. But many of these students may be transferring to other schools and continuing to pursue STEM degrees there, a movement that has not been tracked before.

Peterfreund pointed out that community college programs and pathways to four-year institutions differ greatly from state to state. Many students are in two-year colleges for more than two years, and usually they are focused on training in a specific field and entering the workforce. In addition, structural barriers stand in the way of pathways to four-year schools for many of these students. For example, the amount of teaching expected of community college faculty prohibits many of them from having opportunities to engage in

research, which in turns limits the involvement of their students in research. In addition, community college students are more like to have a year-round job, and it may be hard for them to quit that job to participate in research in the summer.

Some researchers express concerns about the readiness of both two-year and four-year students to contribute to research over short time periods. But students can be prepared to contribute. For example, the University of Massachusetts, Boston, has prepared a course that students take prior to working in a lab to learn basic statistics, how to collect data, how to do graphing. It provides an excellent opportunity for faculty to provide students with a more meaningful summer research experience.

This is "a very different way of approaching evaluation," said Peterfreund. "Rather than using the limited resources from individual projects, we are starting to aggregate them to do a more in-depth and richer data collection." These data then can provide baseline information to leaders from different campuses so that they can match interventions to outcomes. For example, the data could demonstrate whether programs in high school to increase the number of students interested in computer science are working or whether peer mentoring is increasing retention in STEM fields. The data also can be used to compare national trends with regional trends to discern the influences of an institution or program. "This is very hard to do at the student level, but I think you can begin doing it at an institutional level."

DECIDING WHAT WORKS: A SEVEN-STEP MODEL FOR EVALUATING STRATEGIC PROGRAMMING

Evaluators and researchers respond to different audiences, pose different types of questions, communicate their findings differently, and have different expectations regarding the use of their results, said Linda Thurston and Jan Middendorf of Kansas State University's Office of Educational Innovation & Evaluation. Evaluations, in particular, are geared toward improving a project or discontinuing interventions that are not working, and their audiences tend to be those involved in the projects. Different kinds of evaluations also have different purposes. Formative evaluations generate information to improve a program; summative evaluations collect data to judge the ultimate success of a program; and impact evaluations judge the overall worth and utility of a project's results.

Thurston and Middendorf presented a seven-step process that they have developed to conduct evaluations and provide information to stakeholders. The steps are:

- Create a logic model as a theory of action
- Ask the right questions
- Decide on an evaluation design
- Design or select measures of outcomes
- Develop a feasible timeline
- Collect and analyze the data
- Report findings or outcomes

The first step is to create a logic model or program theory to make sure that the program activities logically and theoretically fit with the desired outcomes. A logic model provides program participants with a clear map of the road ahead, fosters relevant information and feedback to create a continuous improvement process, generates new insights, identifies impacts, and guides communications with key stakeholders and diverse audiences. "All good evaluations are based on a program theory, a theory of change," said Thurston. "That usually is described by a logic model. When we work with clients, we spend plenty of up-front time working on a logic model to serve as the foundation for the evaluation plan."

A logic model should have a logical chain of connections and illustrate the relationship between what is done and the impacts of those activities. It can incorporate the context or environment, relevant assumptions, inputs, activities, outputs, and outcomes (where outputs are defined as a combination of what is done and who is reached and outcomes are defined as short-term, medium-term, and long-term impacts). A logic model is "a picture of the organization, how it works, and the assumptions behind the choices that you've made for these interventions," said Middendorf. "It links the outcomes to both short-term and long-term goals and the program activities to ensure that all program components are aligned."

Step two is asking the right questions. Evaluation is a way of answering important questions that arise at the beginning, in the middle, and at the end of a program. For example, evaluation questions might center on awareness, attitudes, knowledge, and skills; behavior, practices, and policies; or the social, economic, and educational context. Identifying the right questions with stakeholders helps clarify goals and outcomes and makes it possible to provide meaningful results to stakeholders.

The third step is to decide on an evaluation design, of which there are three major types. Randomized assignment to intervention groups versus control groups is the gold standard. "We always aim for that," said Thurston. But it is not easy to carry out this type of evaluation. "It's very expensive to do, and it's not even always possible." Quasi-experimental designs are more commonly employed. They usually use some sort of control or comparison group, but the groups are not randomized. A time series is an example, in which a pre-test and a post-test are conducted. "Program participants serve as their own control group," said Thurston. Finally, a case study evaluation of a program might look at, for example, changes in policies over time at a university to see if they have become more inclusive toward women.

Effective evaluation plans are developed at the beginning of a project, involve stakeholders in the identification of relevant questions and indicators, determine how data will be used, and focus on outcomes of critical interest. Evaluation is often treated separately or as an afterthought, Middendorf said. "Oh yes, that's right, we've got to evaluate it. What does program evaluation mean? How do we do it?" In fact, evaluation needs to be an integral part of a program. Whenever funds are sought to achieve particular goals, evaluation ought to be embedded in the process.

An outcome is an end result or effect that is linked to a program. For example, it might be a change in attitude of science teachers about working with

students with disabilities, or it might be the attitude of a faculty member in mentoring a postdoctoral student for a scientific career. Outcomes can be both expected and unexpected, and "sometimes unexpected outcomes are the most fun and most interesting," said Thurston. Evaluations should be designed to get some unexpected outcomes and also to get both positive and negative outcomes. In the latter case, if outcomes are being used for formative assessment, the program can be modified to eliminate the negative outcomes.

The fourth step is to select outcome measures that are measurable and clear. There are many ways to collect outcome data, including interviews, focus groups, surveys, observations, pre-tests and post-tests, case studies, and document review. For example, document review is a powerful way to look at change over time, especially when considering institutional transformation. Small shifts in language in policies and procedures can make a big difference in welcoming diverse populations.

The fifth step, developing a feasible timeline, can be difficult but is essential. A timeline must include the relevant tasks and subtasks, the responsible entities, and when activities will occur. "This is something we grapple with in our office—developing a practical timeline that also takes into account the ups and downs of program development and implementation," said Thurston.

Step six is to collect and analyze the data. It involves working with stakeholders and collaborators to identifying existing information and gather new data. Both quantitative and qualitative options should be explored. "The evaluation plan helps us decide how we're going to approach collecting data and what kind of data we're going to collect," Thurston said. "It focuses on those outcomes that the stakeholders have told us are important."

Finally, the seventh step is to report results and findings. This can be done in many ways, including comprehensive written reports, working sessions in which information is discussed with those involved in an intervention or with funders, stand-alone executive summaries, newsletters, posters, presentations, or publications.

These seven steps can both motivate evaluations and help ensure that evaluations produce useful results. Evaluation "can make a difference," said Middendorf. "It can help you make better programs and disseminate good practices beyond your own institutions."

During the question-and-answer session, the speakers were asked how best to engage researchers in the evaluation process. Middendorf pointed to the importance of linking their involvement to the reward system in academia. "To engage scientists, you really have to provide some incentives, and one of the most powerful incentives in the university setting is attaching it to promotion and tenure packages."

In response to another comment, Thurston pointed out that evaluations have to be multifaceted, both within and across assessments, because different stakeholders can have different questions. What does the funder want to know about your project? What are a funder's reporting requirements for an intervention grant? If school districts are involved, what do the science teachers want to know? What do the counselors want to know? What does the school board want to know? What do they consider success? How will

they know if the intervention works? "Good evaluation questions will help lead to good results," she said.

EVALUATION, DESIGN, AND DATA FROM THE TEN-CAMPUS UC AGEP

The Alliance for Graduate Education and the Professoriate (AGEP), which is funded by the National Science Foundation, has the twin goals of increasing minority degree production at the PhD level and changing the culture of universities to foster parity. The ten campuses of the University of California (UC) system participate in AGEP, and each campus has developed a different set of interventions to diversify the PhD pipelines, reflecting the different needs and characteristics of each campus. This diversity of interventions has created "something of a natural experiment," said Colette Patt, the director of science and diversity programs at the University of California, Berkeley. "How do you create change in a large system of universities that are quite varied?"

Patt and her colleague Abram Rosenblatt at the University of California, San Francisco, have conducted evaluations to measure the effectiveness of the AGEP programs on the UC campuses using three different methods. The first uses a logic model to link programs with desired outcomes, thus providing a way of looking coherently at data collection. Using a previously developed worksheet, an evaluator works with a campus to create a logic model for a set of interventions. The evaluator then determines what kinds of data are available or could become available to probe the influences of the interventions on outcomes. These outcomes can be short term, medium term, or long term. Specific interventions, such as professional development activities, can be linked to outcomes using data gathered from students, faculty, and other sources. "The campuses actually have a fair amount of [data]," said Patt. "Where they don't, the evaluator works with the campus to create data collection methods that can be done on a continuing basis. So there's some capacity-building activity there on the part of the evaluator."

Where there are no data, it can raise the question of an intervention's effect. "Sometimes people do things just because they've always done them, or because they think it's a good idea, and not because they can show or demonstrate that those things are connected to actual desired outcomes."

With a logic model for each campus, it is possible to identify commonalities among campuses and aggregate data from multiple campuses. In those cases, interventions can be viewed as a system-wide activity that would benefit from multi-site program coordination. The development of a logic model and the collection of data to explore that model also can be used in formative evaluation. "We're encouraging people to think in a way that ties their programmatic effort with the outcome that they'd like to see instead of these things being dissociated," said Patt.

The second evaluation method is to collect a common data set across all ten campuses. Given that the goal of AGEP is to increase the production of PhDs among minority students, important information to obtain includes the number of graduate schools applications from underrepresented minorities

in STEM fields, the number of students admitted, the number of enrollments, and PhDs granted. These numbers provide an overall "indicator of performance," said Patt. The numbers are then disaggregated by ethnic groups, by STEM fields, and by campus and broken down over time to indicate comparative effectiveness. These data indicate that the AGEP program has substantially increased both minority enrollments and PhD production. "Hopefully, that's a trend that will continue as recruitment continues to pay off and the program gains momentum."

The third evaluation method is to compare the UC system with other universities. Patt, Rosenblatt, and their coworkers have just begun such a comparison using data from universities similar to those in the UC system—public, research-intensive universities in states with similar policy environments. These results are not yet ready to release, but Patt expects them to "benchmark what we do."

During the question-and-answer session, a participant asked whether increasing minority enrollments could reflect demographic changes in the student population rather than the effects of a particular set of interventions. Patt replied that the comparative data should provide a solid answer to this question, since then the experience in the UC system can be compared with what has happened in other places. "If we see that comparable institutions haven't had the same results that we do, then that will influence how much we can attribute to AGEP."

INVESTIGATION OF FACILITATED STUDY GROUPS, PAST AND FUTURE

Facilitated study groups are a form of interventions for undergraduates centered on a workshop, class, or other kind of session that supports a difficult course, usually a gatekeeper course. They are held on a regular schedule, rather than as drop-in sessions, and the materials they incorporate are supplemental rather than remedial. Usually they are led by peers, though they also can be led by graduate students or even faculty members. The targeted participants may be members of particular groups, or the sessions may be open to anyone. Usually, they emphasize cooperative learning.

Participation in facilitated study groups has been associated with increased performance in the class being supported, higher rates of taking subsequent classes in that subject, greater persistence in the major, and higher graduation rates. They typically have fairly equal effects on the members of different groups, though sometimes there are exceptions.

Kenneth Rath and his colleagues from the SageFox Consulting Group have been studying facilitated study groups at a range of institutions as part of their evaluation work and under a research grant funded by the National Institutes of Health. "That's given us the opportunity to compare some of the performance and outcomes that we see across different implementations of facilitated study groups," said Rath. "And we see that there are, in fact, differences in how they work out."

For example, in a comparison of two general chemistry courses at New Mexico State University and at San Francisco State University, the facilitated

study group in New Mexico decreased the number of F's and increased the number of B's. In San Francisco, on the other hand, all grades went up. There was a large increase in the number of A's and A–'s.

There are also differences among courses. At San Francisco State University, facilitated study groups had a different impact in an introduction to biology course than in chemistry. Similarly, there can be differences among groups, though these are infrequent, according to Rath. In the introduction to biology course, for example, members of underrepresented minority groups had a substantially larger increase in grade point average than did the other students. There can even be differences in the effects of facilitated study groups between fall semesters and spring semesters.

Rath and the participants at the session explored a number of factors that could account for these differences, including the facilitators of the groups, nonmajors taking gatekeeper courses in the spring, the academic calendar, and the nature of the course. In particular, the SageFox group is investigating three categories of factors associated with the groups—the institutional structure (such as whether the groups earn credit or not), factors associated with the facilitator, and factors associated with the groups—and two categories of factors not associated with the groups—the student population and the course being supported. They are then comparing these factors with a variety of outcome measures, such as grades, subsequent course taking, effects on different groups, and whether they earn degrees in that field. Altogether, the researchers are examining 23 different factors and 9 different outcomes. "This is a complicated thing that needs to be addressed in order to understand what the models are for facilitated study groups that best lead to the various measures of success."

The group is looking for funding to extend this analysis to 12 to 15 different institutions, both four-year and two-year, "to understand what the most effective practices are within particular situations." Site visits, surveys, and interviews with facilitators, students, and faculty members would provide information about the study groups and their contexts. "We would like to have a checklist of activities that occur in facilitated study groups, which will allow us to look at, on a meeting-by-meeting basis, what's going on in each one so we can get a sense of not only what's happening but with what frequency." The researchers also plan to gather institutional data to understand the populations of students and the variety of outcome measures.

PEER-LED TEAM LEARNING AND SUCCESS IN FRESHMAN CHEMISTRY COURSES

At Morehouse College, 50 to 55 percent of the students who enroll in general chemistry traditionally have passed the course with a grade of C or better. The course has three sections with three different instructors and has a required laboratory. Also, students can withdraw from the course up to two weeks before the final exam.

Morehouse is an African American all-male institution. All STEM majors at Morehouse have to take general chemistry and they have to earn a grade of

C or better to pass it. Eighty-five percent of the students enrolled in the course are also enrolled in Calculus I or a higher-level mathematics course.

In 2004, the chemistry department at Morehouse began providing Peer-Led Team Learning (PLTL) in one section of general chemistry. Ten percent more students passed the course, so PLTL was implemented in all of the sections. The groups include eight to ten students, and sessions last for about 80 minutes. Two faculty members, Subhash Bhatia and Lance Shipman, meet with the peer leaders once every week to go through the workshop material.

The distinction between supplemental and remedial material in the PLTL sessions is not always obvious. Problem solving is emphasized in the groups, so the group work can be seen either way. The syllabus states that 5 percent of a student's grade is for attending the PLTL groups, but in reality that guideline is not observed.

Since the groups began, the number of students who remain in the course and achieve a passing grade substantially increased, plateauing at about 77 percent. The number of students who withdraw from the class has steadily declined, from more than 20 percent in many of the years before 2004 to about 10 percent currently. Meanwhile, the percentage of A and A− grades has gone from about 12 percent to about 20 percent.

Surveys and focus groups have revealed a number of impacts of the program. For example, the peer leaders observed in surveys that the PLTL sessions force students to think, appear to help the borderline students the most, and encourage students to form their own study groups.

One major change that Bhatia has noticed since the program was instituted involves the attitudes of students. "In the beginning, it was difficult to tell students why they should attend all the sessions of PLTL. [But] the perception has changed. Now most of them want to attend."

MORE THAN GETTING US THROUGH: CULTURAL CAPITAL ENRICHMENT OF MINORITY UNDERGRADUATES

When alumni of the Biology Undergraduate Scholars Program (BUSP) at the University of California, Davis, were asked which aspects of the program were especially salient to their individual success, they identified three factors: the role of advisors, the influence of peers, and the impact of their undergraduate research experience. Brian Veazey and two colleagues—Sarah Ovink and Memo Villarejo—have been focusing on these factors in exploring the influence of cultural, social, and professional capital for underrepresented minority students.

Their study is based on a survey followed by 106 in-depth semi-structured telephone interviews. The interviews allowed the investigators to discuss issues they believe are important while allowing the students to raise additional topics. "My training is as an ethnographer," said Veazey, "so my goal is to try to see the world through the eyes of my subjects."

BUSP is an academic enrichment program started in 1988 that was designed to encourage underrepresented minority students to complete biology undergraduate majors and proceed to advanced degrees in the biological sci-

ences. The program includes comprehensive academic enrichment in chemistry, math, and biology; advising on a quarterly basis; and an on-campus research experience. It admits 45 to 65 new freshmen every year and is a multiyear bridge program in that classes begin in the summer before their freshman year and continue through to the end of the sophomore year. Seventy percent of BUSP alumni enter the biomedical professions, and about 12 percent earn biomedical PhDs.

Veazey and his colleagues drew on the concepts of cultural, social, and professional capital in organizing their study. Cultural capital is the specific set of skills, knowledge, and dispositions that people acquire in their class of origin. Social capital consists of the networks to which people have access and accrue benefits. Professional capital is the set of technical and "soft" skills common to members of an occupational community. "We try to augment underrepresented minority students' stores of capital in ways that bridge the gap between the capital they are expected to have (for success in academics and careers in the biological sciences) and that which they actually possess."

Past directors of the BUSP program have reported that the two most important functions BUSP advisors serve are providing reliable advice tailored to a student's individual needs and a willingness to directly intervene in the educational planning process. As Merna Villarejo, the founding director of BUSP, pointed out, "If you're planning on registering for three science classes next quarter, and you took out C's in your sciences classes this quarter, or you're getting C's in your mid-terms, the advisor will say, 'Uh-uh, two max. You can't take three science classes at a time. You can't handle that. Choose something else.'"

Knowing how to plan a schedule "may sound like something any eighteen-year-old should be able to handle," said Veazey. But it is actually a complex skill that middle class parents who are familiar with a university setting can pass on to their children. By teaching students how to plan their schedules in ways that avoid burnout and maximize their grades, advisors are transmitting cultural capital to students.

Sometimes advisors took a more hands-on approach. When one student told his advisors that he was thinking of going to Sacramento State, his advisors told him that he was aiming too low. Taking the advisor's advice, the student eventually earned a master's degree at Princeton and took a job in Washington, D.C. "The advisor's direct intervention functioned as a form of cultural capital, transmitting a particular vision of what was possible for the student and allowing him to adjust his aspirations to something he had never considered on his own. This is a result of augmentation in cultural capital," Veazey said.

The second factor identified by alumni was the influence of peers. When students spoke about their experiences with BUSP, they frequently mentioned the importance of being surrounded by other high-achieving minority students with a strong interest in the biological sciences. "BUSP appears to augment the social capital of students by providing an institutionalized space where minority students with an interest in science can gather and see that their goals are not impossible, that other people just like them are achieving and striving for such goals every day."

Study groups were frequently the mechanism through which students gained support from their peers. Not only did students help each other in challenging classes in these groups but they informally disseminated information about deadlines, requirements, and other useful tips. They also kept the pressure on each other to keep up their grades.

The third factor considered in the study is the undergraduate research experience. Directors and alumni stressed that exposure to research as an undergraduate helped students determine if research was a good fit for them. Research "is not for everybody," said Veazey. "Standing behind a bench for hours and hours and hours just to have your experiment flunk on you, that's tough. So you need to make sure you fit some experience with that and see if that works."

When thoughtfully designed, undergraduate research also can augment students' professional capital by transferring valuable technical and soft skills. As former director Gina Holland said, "[We taught] students how to be professionals. To exist and succeed in an academic environment, it helps if you know business and academic etiquette. . . . People, whatever the culture, are going to assume that you know the rules. If you don't, you stand out."

So strong was the sense of community BUSP managed to nurture that eventually a very empowering subcultural identity developed among its constituents. Alumni derived a great deal of pride from their association with this community of high-achieving people of color who were known to routinely "get the highest grades" or "throw the curve" in many classes. This BUSP identity gave students an alternate identity to rally around, one in which being a person of color was equated to (not separate from) being successful in the sciences.

Veazey and his colleagues have concluded that "traditional intervention strategies addressing academic and financial deficiencies alone are insufficient." Instead, targeted and explicit efforts are needed to augment deficiencies in cultural, social, and professional capital, in conjunction with academic and financial assistance.

UNDERREPRESENTATION: THE ROLE OF FACULTY, PEERS, AND PROCESS

Since 2004, a research team at the University of Maryland, College Park, has been working with the National Society of Black and Hispanic Physicists to collect data on the retention of minority undergraduates in science fields. Sharon Fries-Britt, Toyia K. Younger, and Wendell D. Hall presented results drawn from those data on the interactions that undergraduate science students have with faculty members and with peers.

Interactions with faculty members and peers are "pivotal points in the success of students," said Fries-Britt. The researchers examined these interactions in the context of the students' academic experiences inside and outside the classroom, their social experiences, and specifically their racial and ethnic experiences. Data were drawn from interviews and focus groups with more than 100 students majoring in physics. The students were about 65 percent male and 35 percent female and from a wide range of four-year colleges and

universities across the country. The intent of the work was "to really understand their lived experiences as students in physics."

A major finding from the analysis, said Younger, is that "what faculty say and do matters." The attitudes and beliefs of faculty members can be conveyed in both subtle and not-so-subtle comments. One junior woman, for example, was deeply offended when she was told by a professor at the beginning of her junior year, "we are going to need somebody to clean the lab, so it's good to have you back." This student, however, used the statement as a motivation to remain in the major and to prove that she deserved to be there and was more than just a person who could clean the lab equipment.

Faculty members often imply to students that they should know some material already. "When they're teaching, they make comments like, 'Oh, you don't know this already? Well you should have learned this,' instead of stopping and saying, 'It seems like you all are struggling in this. Let's go back and revisit this.'"

Faculty members also sometime ask students whether they have thought about changing their major. A typical reaction from students, Younger said, was to think, "well, maybe I'm not cut out to do physics." Such comments from faculty members can plant seeds of doubt that drag down a student's confidence.

Faculty behaviors, both verbal and nonverbal, also can have positive influences on students. For example, students appreciate when faculty members share their own struggles about learning a particular subject. "When they worked through the problem and acknowledged that they, too, had struggled learning this, it really gave the student a sense that, wow, this faculty member understands me, cares about me, and really wants to make sure that I learn this material."

Instructors who are invested in teaching concepts creatively and with enthusiasm have a positive influence. "A faculty member who seems engaged in wanting to make sure that the student is learning the materials as opposed to someone who is not really paying attention or interacting with the student, that, too, made a difference for these students."

Finally, students praise faculty members who set high expectations but also offer support and have confidence in students. Students do not want the material to be dumbed down, they do not want faculty members always to start at the beginning. "They wanted to be challenged, but they also wanted to be interacting with faculty members who are going to support them and help them achieve the levels that they need."

There are some differences by institution type. Students attending historically black colleges had more positive interactions with their faculties than did students at majority-serving institutions. In addition, women tended to give more help and more time to students, and students felt more connected to some of their female faculty members than they did to male faculty members.

Peers also have a great influence on student retention—especially in physics, where the numbers of undergraduates tend to be low. During their free time, physics students often spend time with peers in their program, and they also interact with peers while doing labs or research projects. "Peers are

very critical to their academic success," said Hall, "especially when they don't have very engaging relationships with their faculty members."

Peer interactions can be both positive and negative. For example, the data have revealed that conflicts can arise between U.S. students and international students. Students may also feel a need to prove themselves with peers. With peers as well as faculty, students may feel that their academic competence is being questioned. "They feel like it's never ending," said Fries-Britt. "They may prove themselves in one class with one group of peers, but then when they go to another course, same thing." The result can be academic isolation and long-term challenges to retention.

Again, the data demonstrate some differences between academic institutions. For example, students at historically black colleges report that they have a much tighter connection to their peers than is the case at predominantly white institutions.

Fries-Britt pointed out that the partnership with the National Society of Black and Hispanic Physicists has resulted in the gathering of immense amounts of data that could answer many important questions. For example, findings that could be extracted from the data have implications for K–12 teaching, for the role of mentors in undergraduate education, and for approaches to deal with stereotype threat. "Our goal is to have enough voices to be able to say, here's a set of patterns we're starting to see."

FOSTERING MINORITY SCIENTISTS: THE ROLE OF BELONGING AND GOAL ORIENTATION

The educational pipeline is leakier at every juncture for students of color than for majority students. A wide variety of minority training programs (MTPs) have been implemented to plug these leaks, but much remains unknown about the effects of these programs on sustaining intentions to pursue a research career.

The Science Study is an ongoing, nationwide, prospective longitudinal study of minority science students that seeks to answer many of the questions surrounding MTPs. It has been following more than 1,400 talented minority undergraduates and graduate students at 45 colleges and universities across the United States, including historically black, Hispanic-serving, and majority-serving institutions. The students fall into two categories: those who are supported by an intervention program, and a control group of matched students who are not funded by any sort of program. The study has been following their academic trajectory through college, into graduate school, and beyond.

Anna Woodcock from Purdue University presented the results of a study that used a subset of the data gathered by the Science Study. The study had three main questions:

1. Does membership in an MPT increase a sense of "belonging" in the sciences?
2. What is the impact of belonging on intention to pursue a scientific research career?

3. Do MPT members experience the "climate" of the scientific community more positively?

The study used data from 126 matched pairs of undergraduates, about half African American and half Latino, with a small number of students with other ethnicities. About 70 percent of the undergraduates were female. One member of each pair was supported by an NIH program designed to promote diversity in biomedical research careers, with the other members of the pairs serving as a control group. "When we put the panel together, we did a lot of work to make sure that the demographics of our panel really mirrored the demographics of students who were in these programs, so we weren't getting a subset," said Woodcock. Also, the control groups were matched with the supported students on 11 key variables, creating a control group "that was really as close to our intervention group as we could possibly get."

Both groups of talented minority students start off with high intentions to become a biomedical researcher. But for minority students who are not funded by a program, this intention wanes over time. In contrast, being continually involved in an intervention program buffers students from that declining interest. "Involvement in these programs tends to keep people in the pipeline and stop some of the leakage."

Membership in a minority training program also increases the sense of belonging in the sciences. Nonmembers start off with a high sense of belonging, and this measure stays more or less flat over time. But the minorities in MTPs have an increasing sense of belonging in the sciences and end up with a far higher sense of belonging. Furthermore, students with a greater sense of belonging express a higher desire to pursue a research career. "This is the pattern you would hope to see," said Woodcock, "particularly if you were running an intervention program."

Finally, members of MTPs experience the climate of the scientific community significantly more positively than do minority students who are not members of these programs. MTP students "tend to perceive the climate of the sciences as more supportive."

Woodcock related these results to a theoretical framework known as mastery goal orientation, which posits that goals are defined by developing ability rather than demonstrating ability. Thus, goals depend more on learning for the sake of learning and mastering the material than they do with showing others how much one knows. Furthermore, according to the theory, mastery goals are predictive of academic achievement and persistence and mediate the relationship between the school environment and academic achievement.

For the students supported by MTPs, a mastery goal orientation links a feeling of belonging with the intention to pursue a research career. "The more you belong, the more you're likely to adopt this mastery goal orientation. And the more you belong, the more you're likely to pursue a scientific career." However, for students who are not supported by an MTP, a mastery goal orientation is not associated with an intention to pursue a research career. "For those minority students who are not involved in any sort of program, this link that you would expect just isn't there," said Woodcock.

5

Technology

INTERACTING WITH REPORTERS

When young researchers are hired by universities, they often are told to concentrate on winning grants, doing research, and publishing in refereed journals. But researchers also need to think about interacting with the public and with publications that are not peer-reviewed journals, said Scott Jaschik, editor of the online magazine "Inside Higher Ed." "I realize that I have a high bar to get over to ask folks who have very busy schedules to think about the public in a different way," he said. But engagement with the media is essential if scientists are to retain the trust of the public.

"Inside Higher Ed" is a free website that is updated daily with news about everything in higher education—"how your budgets are getting cut; what Obama is doing; what Congress is doing; the curriculum, everything." The site has been attracting 600,000 individuals per month, and the number is rising. The site includes news articles, opinion pieces, job listings, and blogs on a very wide range of issues. For example, the site's most popular blog, "Momma PhD," is written by nine academic women about how they balance their lives as professors and as parents.

Today, researchers are not well served by much of the coverage of science in the press. But there are many ways of interesting reporters in stories about science and science education, according to Jaschik. First, despite troubles in the economy and internationally, President Obama has begun a national conversation on science and science education. "There is huge 'Obama impact' on science, and not just on the politics of science but on the role of science in American society."

As an example of the Obama impact, the norm in the Energy Department and in other federal agencies has been to have scientists serve as assistants to the secretaries, who are themselves non-scientists. Yet today a scientist is in

charge of the Department of Energy. In addition, the President, the First Lady, the Vice President, and the Second Lady have all worked in higher education. "They do not just view higher education as someplace where you have some pleasant memories from a distant past," Jaschik said. "This is a remarkable moment for science. It has never happened before."

In several of his speeches the President has talked about the goal of all Americans having at least year of post-secondary education. That, again, is a historic shift, according to Jaschik. It implies that the President foresees a very different job market in the future where students will need at least a year of post-secondary education to get a good job. "That is a remarkable shift in American society," Jaschik said. "He is talking about how we have to get students who are not getting in anywhere into higher education."

Similarly, by challenging stereotypes, President Obama has been able to say some "remarkably challenging things about race and policy in America." He is talking about an inclusive definition of diversity that encompasses class, race, and ethnicity. "He is saying a lot of things that have not been said before," Jaschik said. "President Obama in so many ways does not fit neatly in a box, and as a result people are only beginning to grasp the significance of some of what he is saying and doing."

To diversify the workforce, the research community needs to reach the public, and this diversification process needs to start with the young. Many high school students cannot become researchers because they get on the wrong track too early. Writers can be late bloomers, but most students need to take pre-college mathematics in high school to pursue a STEM degree, which means they have to be ready to take that level of high school mathematics. "So the battle to diversify America's science workforce is actually a battle for the hearts and minds of America's school teachers and America's parents," said Jaschik. "Is my child in the course that will make it possible for him or her to be a scientist? You may not even know if a student will become a scientist, but the doors are closing early."

There is also a battle for resources. Federal agencies face a constant tension between putting money in research versus putting money in programs that promote education, mentoring, and diversity issues. Education programs "can very easily be the stepchild of federal agencies." A public discussion is needed to focus attention on this issue.

A public discussion also could counter the impression held by some people that diversity in the science workforce is not an important issue. "One fear that I always have about conferences like these is that they can become a bit like preaching to the choir, because everyone shares this common value. You need to remember that a lot of Americans do not really care about the agenda that you are talking about, and you need to reach some of them." Some people have closed minds, but there is a large middle group of people who can be educated on the issue. "As people who care about these issues, you need to be part of the debate."

To reach the press, researchers need to devote time to working with the press. They should not rely simply on a university's public affairs office. These offices do not focus on diversity issues nearly as much as is needed. Also, many members of the press do not have extensive backgrounds in sci-

ence. But not knowing a lot about a particular subject does not mean that they do not care.

Timeliness is essential for reporters. When the stimulus money became available, researchers had a golden opportunity to communicate with the press about how they would use the money to solve particular problems, not only in science but also regarding the future workforce. Similarly, the swine flu epidemic provided an opportunity to communicate with journalists. "Journalists like problems and solutions. Here is a problem: there are not enough scientists. Here is what we are doing about it."

Researchers should not be afraid to ask reporters about what they know and do not know. A good rule of thumb for researchers, Jaschik said, is to pretend that you are at Thanksgiving dinner and you are explaining your work to your aunt. He provided the following example of the wrong approach: "I was once doing a story that involved German philosophy, and I was talking to a professor about Nietzsche. He said to me, 'Well, have you read him in the original?"

Researchers always have the option of finding out more about a reporter who calls. "What publication is this? Can I see the publication? What is the topic of the story? What is the overall story about?" At the same time, journalists operate within a 24/7 news cycle, and they need information quickly to be competitive as reporters.

If a researcher is not sure that a reporter understood, there is nothing wrong with a follow-up e-mail. A follow-up communication might summarize the main points, provide additional information or telephone numbers, and, what Jaschik called "really key," include a cell phone number that a reporter can call as he or she is writing the story. A reporter typically cannot show drafts of a story to a source to check for accuracy, but there are other ways to help a reporter get a story right. Nor can reporters usually send questions in advance to someone they plan to interview, usually because the responses they get to such questions are likely to be too canned to use and there is no opportunity for follow-up questions.

During the question-and-answer session, Carol Bender from the University of Arizona described a valuable activity undertaken in the university's undergraduate research program. A university press officer comes to the orientation for undergraduate researchers and provides a brief review of how to write a press release. "Our STEM students do not know how to do it, and they need to know that as STEM professionals they will be expected to communicate with the public about what they are doing," Bender said. At the end of their research experience, the students write a press release that can be sent to their home-town newspapers. In small towns some of the press releases are published, while others released are published in newsletters for the undergraduate research program.

BROADENING PARTICIPATION THROUGH NETWORKING RECRUITMENT VIA THE WEB

Information exchange among faculty and administrators and matching students with STEM resources can make undergraduate and graduate STEM

programs more accessible to underrepresented minority students, and much of this work can be done using the Internet. Liv Detrick of the Institute for Broadening Participation, a small, non-profit organization with a central office in Maine and several satellite offices around the country, described how to make websites more effective in attracting students and as a resource for faculty and staff.

Detrick offered a basic checklist of five simple but important elements to make a site more effective. First, put the most basic information first and give users a good orientation to your program or topic. For example, it is important to spell out acronyms and provide a clear "About Us" section. "In many cases, you come to a site, and you're not really sure what that site is all about. It's nice to have this right on the front page." Having an easy navigation menu with the components of the website, and highlighting the goals and name of an organization right on the home page, can make for a clean and usable design.

Second, keep your audience in mind and make it easy for viewers to find the information they are looking for. The audience for a website is often more than one group. It may include students, funders, and faculty members, and each group should have a clear-cut way of using the site.

Third, give your program a human face. A site can provide profiles or bios of the faculty members, students, and even alumni of a program, enabling students to picture themselves in a program. Providing information about people also helps generate a sense of community, which is especially important if a program is geographically dispersed.

Fourth, provide contact information for people who can answer questions, either by e-mail or phone. When possible, it is preferable to provide a name rather than a generic e-mail address, as well as different e-mail addresses based on the type of question.

Finally, provide up-to-date information and links. Maintaining links can be difficult but is very important, especially with programs that have applications, deadlines, events, and news. Tools that can be downloaded to a computer and used with a browser can quickly check for dead links on a website, which helps make the process smoother.

In addition to these five tips, several other tools can help with website evaluation and accessibility. Basic web statistics can help assess the presence of a website on the Internet. Tools generating web statistics also can generate figures and graphs for grant writing and evaluation. In addition, web statistics can generate ideas for improvement and identify basic errors that are easy to fix.

Web tools use some basic vocabulary that is important to understand. A "visit" occurs each time a person accesses a site. If a person accesses a site in the morning and then comes back and accesses it again in the afternoon, that is two visits. In contrast, "unique visitors" is a term that tries to narrow down the broad category of visits to the actual number of people who are seeing a site. That statistic may not be entirely accurate, but it can be an important measure to have.

A page view is generated every time a visitor looks at a new page. If a single visitor looks at three different pages on a website, that is three page

views. This statistic provides an indication of how much time people are spending on a site and which pages are being visited more than others.

Page hits are the number of files being sent from a web server to a computer. If a single page has many images and icons, a single page can generate many page hits. So a statistic that talks about page hits may have more to do with the page design than with the actual traffic visiting a site.

Detrick often imports the output of web tools into graphing programs to demonstrate the effects of the institute's programs. For example, she has been able to correlate traffic to a website with outreach activities, demonstrating the effectiveness of outreach in drawing visitors to a site.

Many companies offer web statistics programs that are easy to use, said Detrick, including Google. But these programs do not necessarily provide much insight into how to improve the site. To gather information on how to enhance the usability of a site, Detrick recommended the use of focus groups, interviews, hard copy surveys, or web surveys. Small focus groups are often most effective—just three to nine participants. "If you had five participants, you would get probably 90 percent of the errors or problematic portions of your website identified." Among the questions that might be asked in a focus group are: What kind of information do you want? Can you find answers on a site? Does the navigation menu of a site make sense? Do particular pieces of content make a site more appealing?

Surveys or questionnaires should go to more people because they do not offer the possibility of back-and-forth dialogue. Surveys or focus groups also should try to include representatives from each of the target groups as well as users with disabilities if possible. Take excellent notes or make a tape recording, Detrick advised, since these sessions can generate lots of information. Targeted questions can relate to the core goals identified for your site, but open-ended dialogue also can uncover important points. Finally, try to keep focus groups and interviews to under an hour so that people do not get tired.

For short online surveys, Survey Monkey is a free, online survey tool that is easy to use and helpful. "You could just leave it up on your site for as long as you want and collect information as time goes on."

Website design is an iterative process. As more information is added to a site, it can be refined using feedback from people who are using the site. If users visit a site and cannot find what they need, they will not come back. "You're trying to avoid that by continuously updating things."

BRAVE NEW WORLD: HOW TO CONNECT WITH COLLEGE STUDENTS IN THE INTERNET AGE

Social networking sites such as Facebook, LinkedIn, and MySpace can be a valuable way to track students and provide information to funding agencies. Jessica Yellin, Lori Miller, and Elena Hernández from the University of Washington described the history and workings of social networking sites and discussed some social, legal, and ethical considerations involved in their use.

Social networking sites allow people to construct a semi-public profile within a bounded system. Everyone interacts with family and friends in private life. But in a social networking site, "friend" has a somewhat different meaning. People have lists of friends, and they can view their friends' information and connections.

More than 90 percent of college students use social networking sites like MySpace, LinkedIn, and Facebook, with slightly more female than male users. Also, ethnic minorities typically use these sites more than do white students, "which makes them a great outlet for minority outreach and retention programs," according to Hernández.

Facebook began in 2004 as a site for college students and more recently has opened up to people with other backgrounds. Today it has more than 200 million active users, more than two-thirds of whom are not in college. A Facebook profile has a wall where people can type public messages. Each user also has a home page with posts of what your friends have said on someone else's wall, what events they are attending, and what pictures they have posted. In addition, profiles have an information section where people can list interests, hobbies, jobs, and schools.

Another commonly used site is LinkedIn, which was founded in 2003 and now has 39 million members. LinkedIn is an online portfolio with public information for professionals. It allows users to create and collaborate on projects and reach potential clients, service providers, and recommended experts.

Yellin, Miller, and Hernández are associated with the University of Washington's Genomics Outreach to Minorities (GenOM) project. GenOM is an NIH-funded research program that supports underrepresented college students in pursuing careers in genomics. The program uses social networking sites to connect with people who are currently or have been involved in the project. A group page can include as many people as desired. It has discussion boards where links, pictures, files, and questions can be posted. Messages can be sent to the entire group rather than to each individual person, so that meetings or reunions can be advertised on the group page. Social networking sites also offer a way to market a program. For example, program managers might post information on a wall about undergraduate summer programs.

The director of the GenOM project, Lisa Peterson, also uses Facebook to send messages to individual students, and "they usually respond better to the messages on Facebook than they do to e-mail," said Hernández. In addition, the project uses Facebook as a community building and communications tool, as an in-depth data source for evaluations, and as a means of connecting and reconnecting with alumni.

Outreach to administrators and other staff on Facebook has increased significantly in the past few years, said Hernández. More than 300,000 faculty and staff are on Facebook, and many students feel that the site provides an excellent way to communicate with teachers. This form of communication also can create problems, in that instructors may wish to establish a particular classroom environment. For example, teachers may choose to be less revealing in a profile. "You have to maintain professionalism," said Yellin. At the

same time, teachers are able to give, for example, classroom examples and describe their teaching style.

The use of social networking sites has raised a variety of ethical, legal, and social issues, said Miller. Facebook has established policies that describe what information the site collects, retains, and shares with others. Facebook tells its users that the information they post may become publicly available. Both Facebook and LinkedIn use consultants for online privacy issues and adhere to the European Union Safe Harbor Privacy Framework. This framework has seven basic privacy principles involving notice, choice, onward transfer, security, data integrity, access, and enforcement.

There is little legal precedence for addressing online privacy issues, Miller noted. In essence, social networking site profiles are considered to be as public as a yearbook or a bulletin board located within a building to which only a certain group of people have access. Legally, users do not have a legitimate expectation of privacy once they turn over data to a third party on these sites. Most of the legal issues associated with these sites involve the Fourth Amendment to the U.S. Constitution, which is the part of the Bill of Rights that guards against unreasonable searches and seizures.

Facebook has been used by authorities to document bad behavior by students. To remove the evidence of such behavior, students may scrub their pages and photos of themselves that their friends have posted. But Facebook does not actually delete the data "for some time, if ever," said Miller. "There is no guarantee that the photos or information are still not retrievable." In addition, some people capture screen shots of pages and store them for later use. The GenOM project educates students about privacy risks and the potential loss of future opportunities by inappropriate posts on a website.

These sites raise interesting issues about the distinctions between research and outreach and between publishing and internal evaluation, Miller observed. Research traditionally is purposeful and involves the reliability and validity of data. Outreach also is purposeful, but is generally focused on student progress and program evaluation. Thus, while publishing research findings is different than compiling evaluations of an outreach program, both processes have similar aspects. For example, published articles may cite references for the ideas used while program evaluations may cite student quotations or informational data from a social networking site.

When considering the ethical uses of social networking sites, it can be helpful to be explicit about the ethical framework being used, said Miller. "Otherwise, your argument will go nowhere." It also can be useful to review justifications for particular actions from different perspectives. In their session at the conference, the speakers handed out cards containing ethical dilemmas and asked the attendees at the session to judge the dilemmas within three ethical frameworks—one labeled "virtue" (if an action enacts a core purpose of the actor's position), one labeled "outcome" (if the good consequences outweigh the bad), and one labeled "principle" (if an action follows fundamental moral rules).

This exercise led to a discussion of whether it is necessary to get informed consent from students prior to using information from social networking sites for either internal evaluations or external reporting. Some participants

equated such uses to the use of a survey instrument and stated that consent provisions should be comparable. Others pointed out that the identities of individuals in very small groups, such as Latino students in electrical engineering or African American students in molecular and cellular biology, could be ascertained from data derived from a social networking site. Some program directors reported that they do get consent so that students do not later become upset at the way information they have provided is used. Others questioned the validity of some Facebook information, contending that not all of it can be assumed to be truthful. Several pointed to the usefulness of the exercise and asked if it might be made available electronically for use in training programs on online privacy issues.

SURVEYING CLIMATE TO IMPROVE UNDERGRADUATE RETENTION

How can program designers and managers know which interventions will be effective in recruiting and retaining undergraduates in STEM disciplines? The Program-in-a-Box developed by the National Center for Women & Information Technology (NCWIT) helps computer science departments answer that question. Joanne McGrath Cohoon, a sociologist at the University of Virginia, described NCWIT and its Program-in-a-Box while also addressing several broader issues involving undergraduates in computer science.

NCWIT was established to build capacity and infrastructure for existing programs that are aimed at increasing women's participation in computing. Individual organizations should not have "to reinvent the wheel," Cohoon said. "We work with them to provide resources and community."

NCWIT was formed in response to a specific problem. Computing is the only major STEM discipline where the trend over time has been toward *less* participation by women. The percentage of women undergraduates peaked in 1985 at about 35 percent and since has fallen to around 12 percent.

NCWIT offers a variety of research-based tools for undergraduate computer science departments that have been designed to attract women and keep them in computer science once they enter the major. It generates statistical summaries and reports about the involvement of women in computer science. It has created a digital library on "Broadening Participation in Computing" through a grant from the National Science Foundation. It has produced one-page compilations of exemplary practices and talking points that can be used to raise awareness in departments and institutions. Its website, which features free research reports, blogs, newsfeeds, interviews, and resources, logged five million hits to public and private users in 2008. "Everything is based on social science research, but our process is to take the research and translate it into practices that work. And we push evaluation of everything, because how are we going to learn if we don't know what works, or what works in certain settings and not other settings?"

The Center also produces boxes—self-contained turnkey programs that can be downloaded and customized for specific organizations. The boxes reflect the insights of Vivian Lagesen at the Norwegian University of Science and Technology, who argues that researchers should focus on the inclusion,

not exclusion, of underrepresented minorities and women. Furthermore, "it's not enough to do one thing," said Cohoon. "You can fix one thing, and something else is still going to push everything in the direction that you don't want it to go. . . . If you want to make things better for women in computing, you need to recruit them *and* motivate them *and* empower them *and* support them, and that can make a difference. A systemic approach is needed."

The boxes are turnkey systems because practitioners wanted something that they could use right away. They are designed to provide a program with everything necessary for undertaking a particular activity. Many programs are undertaken by "well intentioned people who do not necessarily know the relevant social science research," said Cohoon. The Programs-in-a-Box are meant to bring these practitioners up to speed quickly on research-based approaches for retaining women in computing.

Cohoon described a particular tool called the Student Experience of the Major (SEM) Survey-in-a-Box (http://www.ncwit.org/sem), which is designed to assess the climate of computer science programs, reveal problem points, and allow for tracking conditions over time. She and Lecia Barker at the University of Texas, Austin, drawing on more than 30 years of combined experience with survey research, created and refined the survey, which is known as the Student Experience of the Major (SEM) survey. The survey carefully avoids some of the common problems with ad hoc surveys, such as biased response options, naïve or poorly constructed questions, or middle-of-the-road responses that fail to reveal meaningful information. The box also includes materials to boost response rates. "You can get much better response rates if you deploy the survey properly."

In addition, the SEM survey explores four areas linked with women's retention in computer science: the curriculum, pedagogy, student–student interactions, and student–faculty interactions.

The survey also measures eight dimensions of student retention in the major. It produces results on which major or minor is pursued and why, whether courses in the major motivated taking further courses, participation in major-based student groups, the likelihood of completing the major, and demographic information. (Some demographic and enrollment data are collected with a different NCWIT tool.)

The survey and additional research Cohoon has done have revealed several major factors that influence women's decisions about remaining in computer science programs. In research she has conducted at the graduate level, for example, she found that women in computer science think about leaving doctorate programs at much higher rates than do men in the program. In the first two years of graduate school, two-thirds of women think about leaving, compared with about 30 percent of men. Furthermore, the reason they give that is most predictive of whether they actually do leave is whether they observed or experienced sexism. The women who said they considered leaving because of sexism were 30 times more likely to leave a program than if they thought about leaving for some other reason.

Relevant and meaningful assignments and homework influence undergraduate retention by demonstrating to women the difference they can make in the world if they remain in computer science. They motivate people to

develop a talent for computer science. When homework and practice are emphasized as a means of building skill, women are more likely to persist in the major. Skill-building overcomes the mistaken assumption that people must have an inborn computing talent.

Interactions between students and faculty are another critical factor at both the graduate and undergraduate levels. In a study Cohoon did of undergraduate programs in computer science, she found that the gap in retention rates for men and women can be closed when student–faculty interactions are positive. Even where more faculty members simply encouraged students to persist in computer science, gender gaps were smaller. "It's such a small thing," said Cohoon. "I tell faculty that it's important to encourage students, even to say, 'You really did well on that assignment, you ought to become a computer science major.'" Interactions with teaching assistants also are important, because they can undermine or support what faculty members are doing in the classroom.

Whether other students are supportive or not has an effect on retention. In focus groups, undergraduates say that a major factor in their success is having another student in their class from whom they can get help. "What they need is someone who will work with them until they get it. And the men tend to have more access to that peer support than the women do." Similarly, collaborative learning tends to increase retention among both men and women.

Computer science classrooms have a tendency to be impersonal, according to research done by Lecia Barker. Instructors may not know or use first names, and some students may dominate classroom conversations and intimidate other students. One predictor of thinking about leaving their computer science graduate program is whether women are uncomfortable asking questions in class. In classes where instructors encourage questions and minimize showboating by experienced students, women feel more comfortable filling any gaps in their understanding.

Women in computer science encounter our culture's negative stereotypes about gender and technology. "When you have a stereotype that aligns with ability to do science or not, that's what affects confidence," said Cohoon. "Everything in your culture is telling you that you don't have what it takes to be a computer scientist. So as soon as you get a C, and you don't know that a C is the highest grade, that reinforces what everyone has been telling you." Experiences like this one drive initially interested and able women from computer science.

The Survey-in-a-Box allows departments and institution to take a variety of indices and use them to predict students' intentions to persist in computer science. The survey also can be customized for individual departments. Finally, NCWIT can work with departments to collect the data, interview students and faculty, do cross-institution comparisons, and provide information for individual faculty members to raise issues within their department or institution. The data empower people to take the next steps toward building diversity.

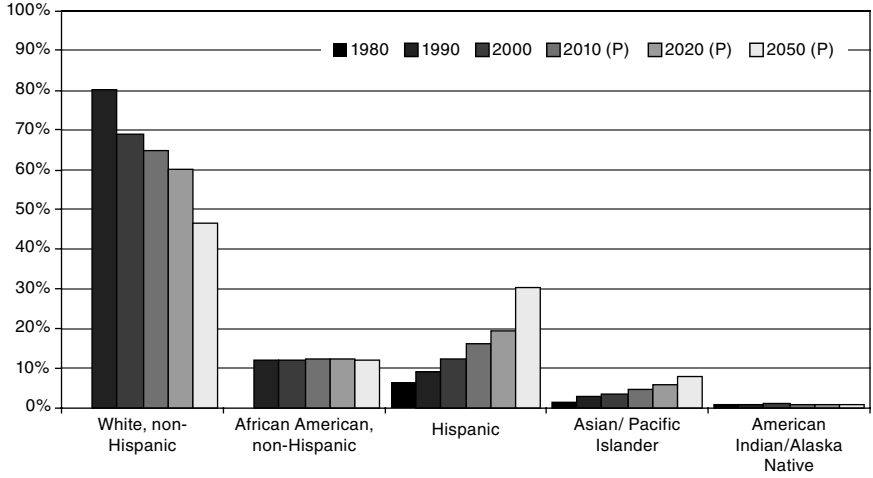
APPENDIX

Minorities and Women in Science and Technology

This appendix contains 46 figures prepared by the Commission on Professionals in Science and Technology (CPST) that summarize the status of minorities and women in science, technology, engineering, and mathematics. These and other slides, without the headlines accompanying the figures, are available from CPST at http://www.cpst.org/hrdata/pages/pubchoice.cfm?thechoice=PWM&ismem=N.

The proportion of Hispanics and Asian/Pacific Islanders is increasing. Currently 34% of 18-24 year olds are African American, Hispanic or American Indian/Alaska Native and 4% are Asian/Pacific Islander.

Figure 1. U.S. Population by Race/Ethnicity, 1980, 1990, 2000 (Actual) and 2010, 2020, 2050 (Projected)

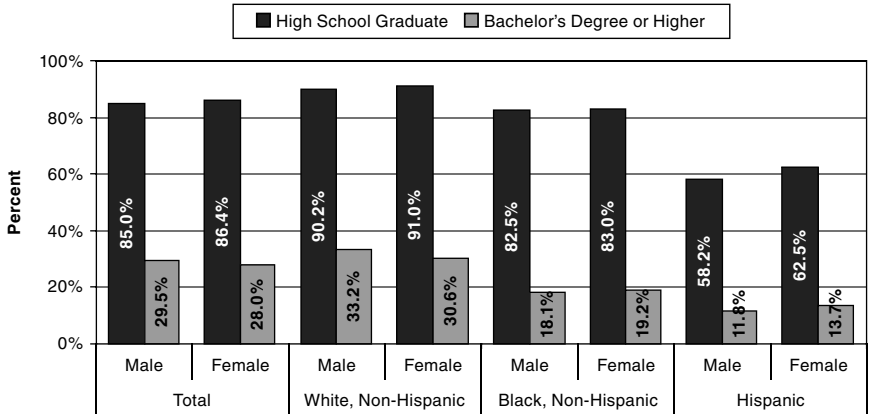


Note: For 2000, and the *projections* for 2010, 2020 and 2050, only includes those who reported one race.
Source: CPST, data derived from U.S. Census Bureau.

CPST

Females and males are earning high school diplomas and bachelors degrees at similar levels. However, Hispanics, especially males, still lag in educational attainment at age 25 and older.

Figure 2. Educational Attainment of Persons 25 Years Old and Over by Sex and Race/Ethnicity, 2007

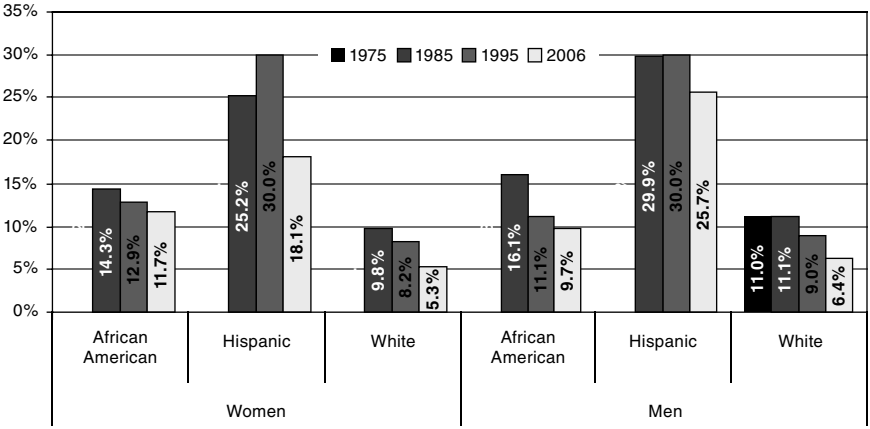


Source: CPST, data derived from National Center for Education Statistics *Digest of Education Statistics, 2007.*

CPST

High school completion for both Hispanic men and women has risen; however, Hispanic men continue to have the highest percentage of noncompleters.

Figure 3. High School Noncompletion Among 16-24 Year Olds, by Race/Ethnicity and Sex

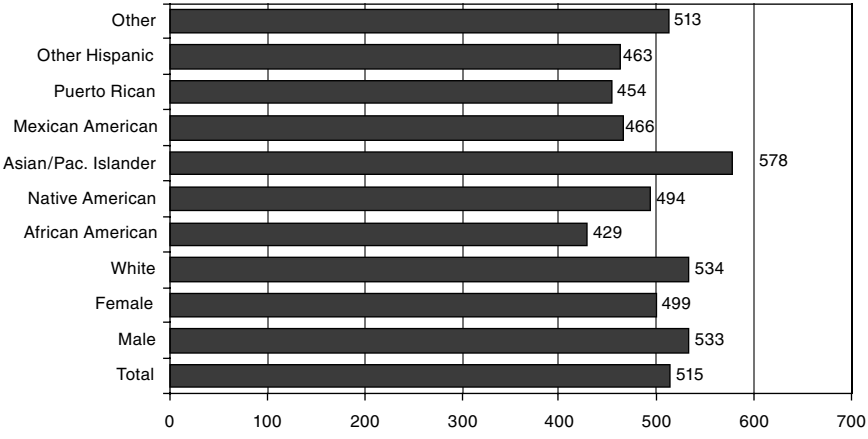


Note: "White" and "African American" are non-Hispanics within those groups.
Source: CPST, data derived from National Center for Education Statistics, *Digest of Education Statistics, 2005* and *2007.*

CPST

SAT scores differ by race/ethnicity: Asian/Pacific Islanders score highest on SAT exams, while African Americans score the lowest.

Figure 4. Average Math SAT Scores by Sex and Race/Ethnicity, 2007

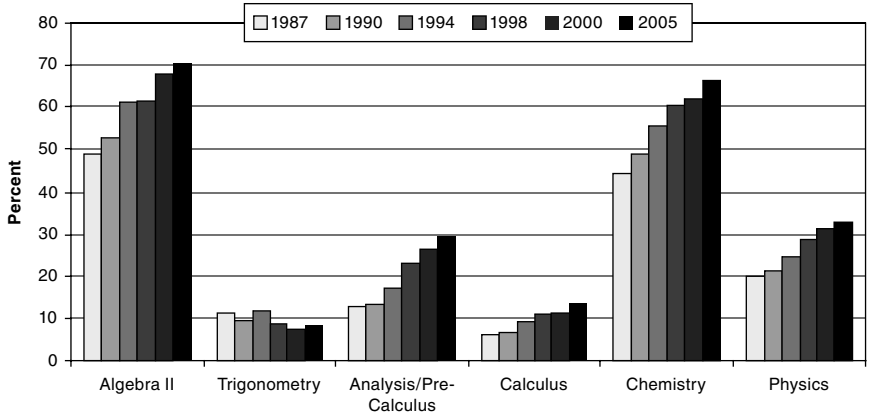


Source: CPST, data derived from The College Board, 2007.

CPST

High school students are taking more advanced math classes than in previous years, making them more ready for college coursework.

Figure 5. Trend in High School Graduates' Science and Mathematics Course Taking

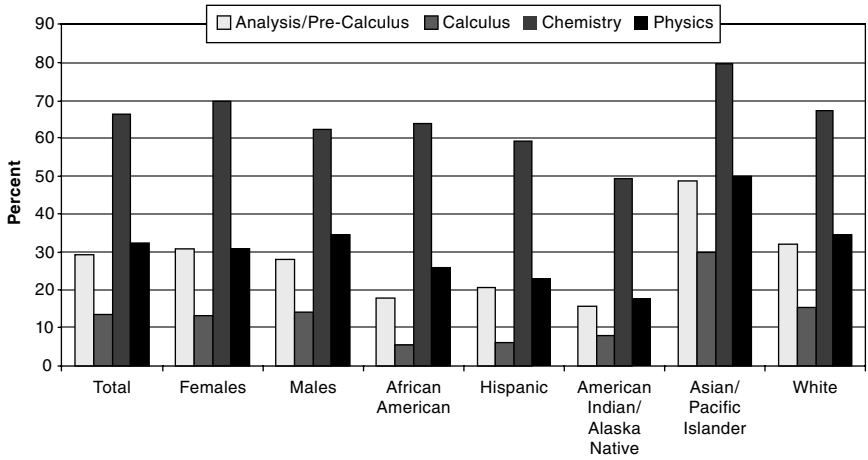


Source: CPST analysis of data derived from National Center for Education Statistics, *Digest of Education Statistics, 2007.*

CPST

High school females are more likely to take chemistry and pre-calculus courses than male students; however, they are less likely to take physics.

Figure 6. High School Graduates' Science and Mathematics Course Taking, Selected Courses, 2005 by Gender and Race/Ethnicity

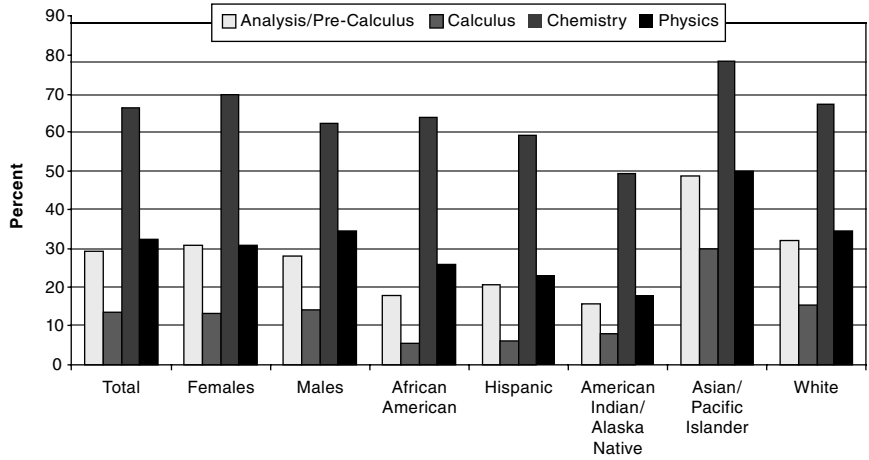


Source: CPST analysis of data derived from National Center for Education Statistics *Digest of Education Statistics, 2007.*

CPST

Persistent ethnic gaps are found in high school preparation. Two important factors: (1) course availability and (2) teachers' "lowered expectations" for Hispanics, African Americans and American Indian/Alaska Natives.

Figure 7. High School Graduates' Science and Mathematics Course Taking, Selected Courses, 2005 by Gender and Race/Ethnicity

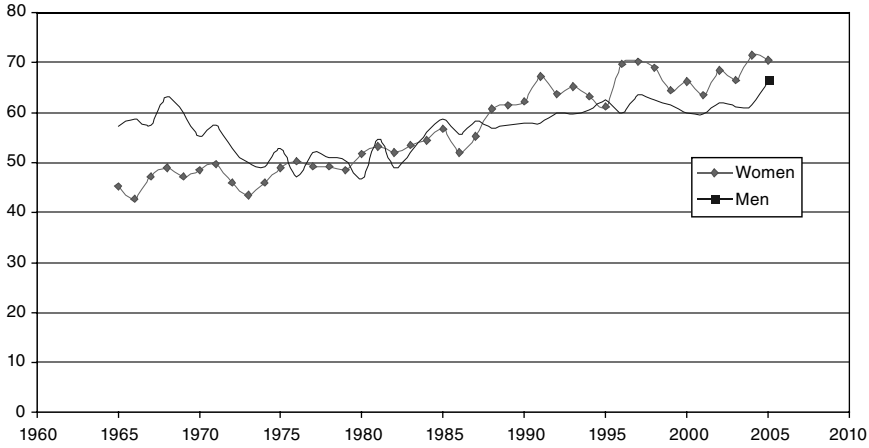


Source: CPST analysis of data derived from National Center for Education Statistics *Digest of Education Statistics, 2007.*

CPST

Women's enrollments have steadily increased since 1965. Although men had higher enrollment rate than women until 1975, they now have a lower college enrollment rate than women.

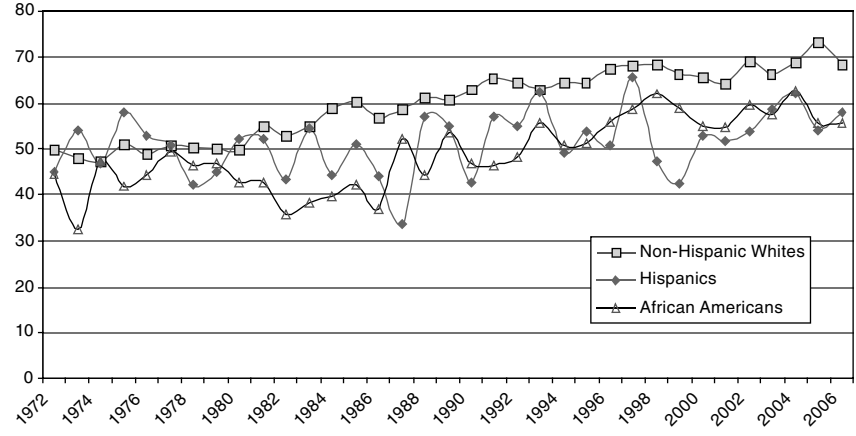
Figure 8. College Enrollment Rates of 16-24 Year Old High School Completers by Gender, 1965-2005



Source: CPST analysis of data from data derived from National Center for Education Statistics, *Digest of Education Statistics 2007.*

College enrollment rate increases have been steady for non-Hispanic Whites but erratic for Hispanics and African Americans. The rate of Non-Hispanic Whites surpasses that of other groups.

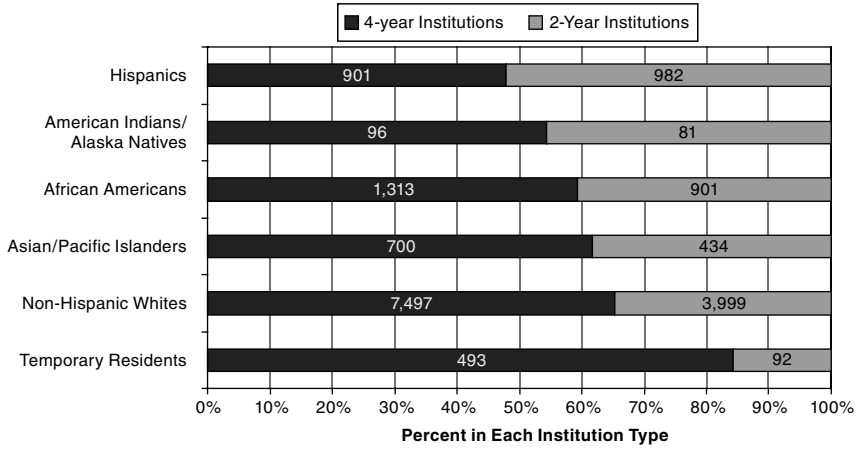
Figure 9. College Enrollment Rates of 16-24 Year Old High School Completers by Race/Ethnicity, 1972-2006



Source: CPST analysis of data from data derived from National Center for Education Statistics, *Digest of Education Statistics 2007.*

More than half of Hispanics are enrolled in 2-year institutions. Non-Hispanic whites and temporary residents are most likely to be enrolled in 4-year institutions.

Figure 10. Fall Enrollment in Degree-Granting Institutions by Race/Ethnicity and Citizenship and Institution Degree Level, 2005 (Numbers in 1,000s)

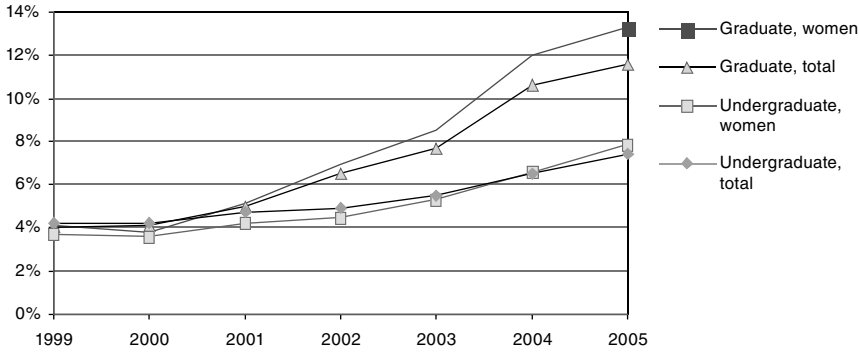


Source: CPST analysis of data from data derived from National Center for Education Statistics, *Digest of Education Statistics 2007.*

CPST

The trend towards increased full-time enrollment in for-profit institutions continued in 2005. Women in graduate programs were most likely to enroll in this type of institution.

Figure 11. Percent of All Full-Time College Students Enrolled in For-Profit Institutions by Level, 1999-2005

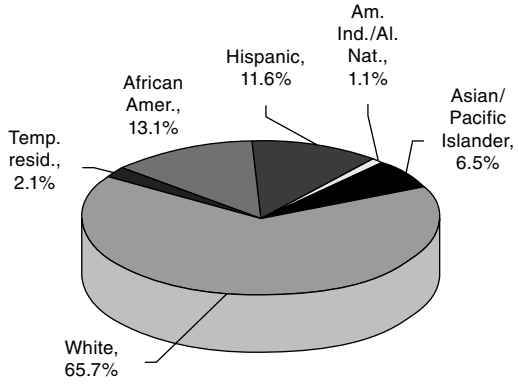


Source: CPST, data derived from National Center for Education Statistics, *Digest of Education Statistics, 2007* and earlier editions.

CPST

Most undergraduate students were non-Hispanic whites. Hispanics were particularly under-represented among undergraduate enrollees.

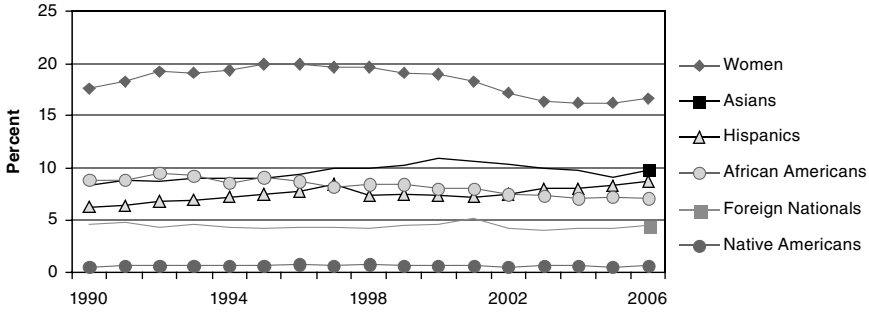
Figure 12. Undergraduate Enrollment by Race/Ethnicity and Citizenship, Fall 2005



Source: CPST, data derived from National Center for Education Statistics, *Digest of Education Statistics, 2007.*

Women's representation among first-year, full-time engineering students has declined since the early 1990s. The representation of minorities and foreign nationals has been relatively consistent over the past 8 years.

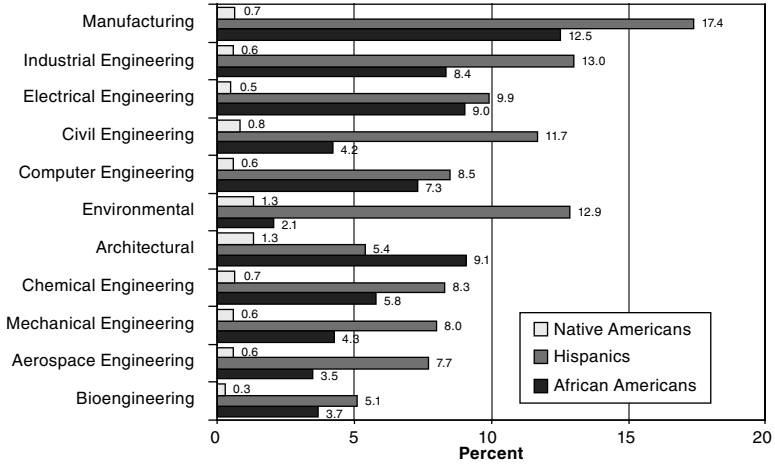
Figure 13. Women, Minorities and Foreign Nationals as a Proportion of First-Year, Full-Time Undergraduate Engineering Enrollment, 1990 to 2006



Source: CPST, data derived from Engineering Workforce Commission, *Engineering & Technology Enrollments, Fall 1990 to Fall 2006.*

Manufacturing engineering has the highest proportion of under-represented minorities among engineering disciplines, followed by industrial and then electrical engineering.

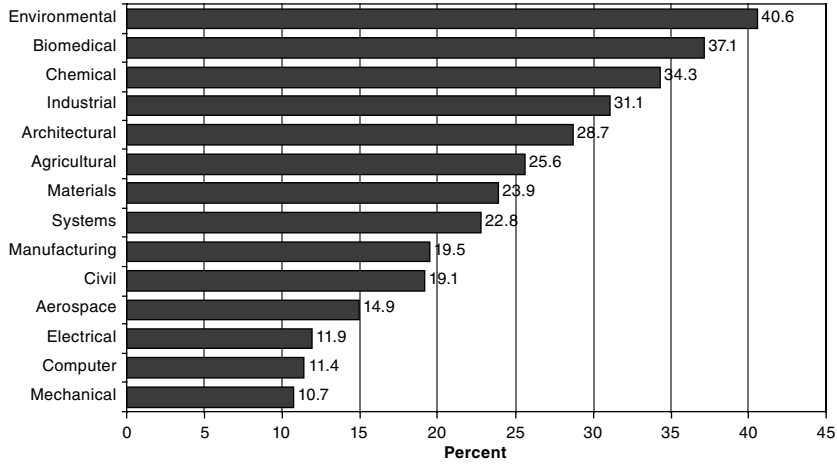
Figure 14. Underrepresented Minorities as a Proportion of Total Undergraduates in Engineering Disciplines, Fall 2006



Source: CPST, data derived from Engineering Workforce Commission, *Engineering & Technology Enrollments, Fall 2006.*

Women are most highly represented in the newer engineering disciplines of environmental and biomedical engineering. They have long been more highly represented in chemical and industrial than most other engineering fields.

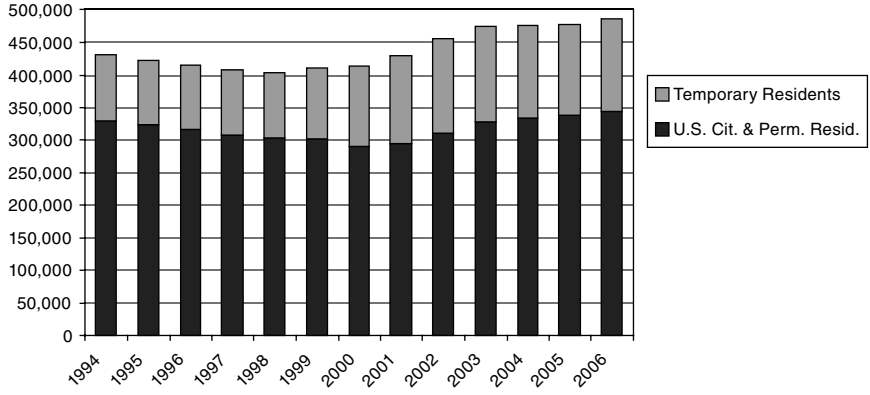
Figure 15. Women as a Proportion of Total Undergraduates in Selected Engineering Disciplines, Fall 2006



Source: CPST, data derived from Engineering Workforce Commission, *Engineering & Technology Enrollments, Fall 2006.*

Temporary residents have accounted for about 30% of graduate students enrolled in science and engineering since 2000. There were nearly a half million (486,287) graduate students enrolled in 2006.

Figure 16. Graduate Enrollment in Science and Engineering by Citizenship, Fall 1994–Fall 2006 (Excludes Health Fields)

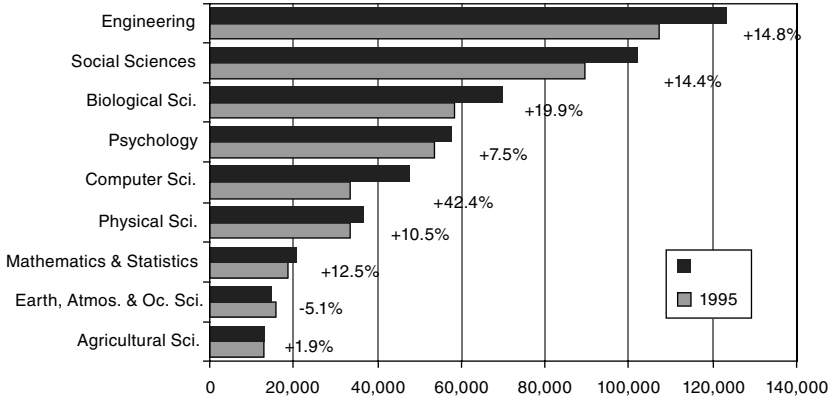


Source: CPST, data derived from National Science Foundation, *Survey of Graduate Students and Postdoctorates in Science and Engineering* accessed via the NSF WebCASPAR database system, 1994-2006.

CPST

Graduate enrollment has grown fastest since 1995 in computer science and the biological sciences. Among the sciences, the social sciences had the highest graduate enrollment in 2006.

Figure 17. Graduate Enrollment in Science and Engineering by Broad Field, 1995 and 2006 (Percent change for each field is noted)

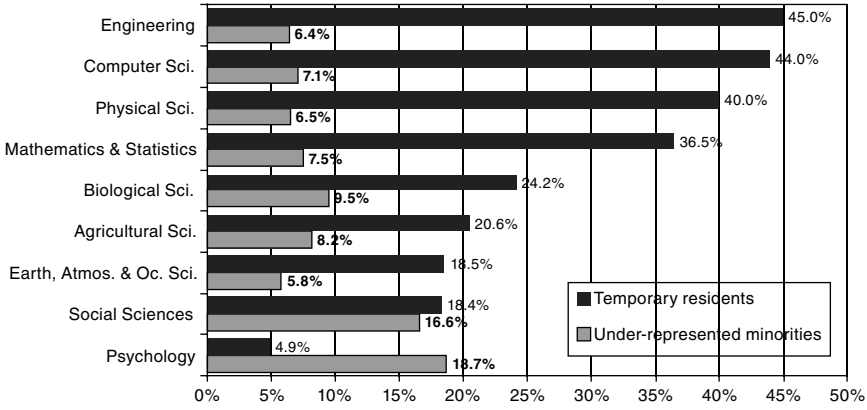


Source: CPST, data derived from National Science Foundation, *Survey of Graduate Students and Postdoctorates in Science and Engineering, 2006.*

CPST

Nearly half of engineering and computer science graduate students enrolled in 2006 were temporary residents. Psychology had the lowest percentage of temporary residents (4.9%).

Figure 18. U.S. Under-Represented Minorities and Temporary Residents as a Percentage of Total Graduate Enrollment by Broad Field, 2006

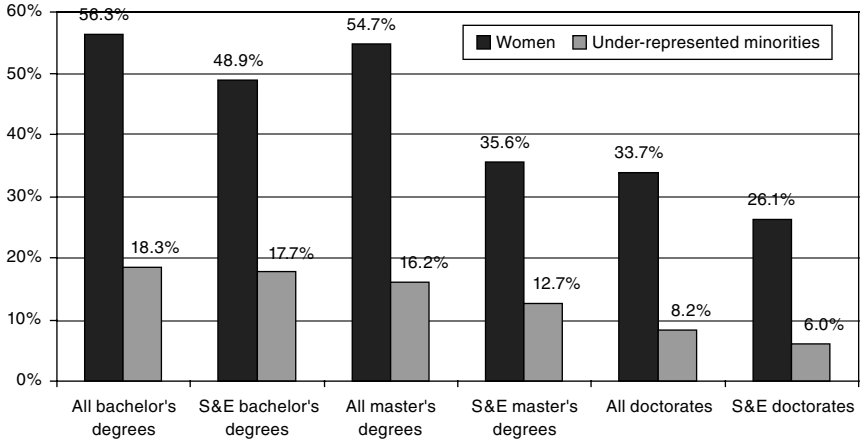


Note: Under-represented minorities includes U.S. citizens and permanent residents who reported African American, Hispanic or American Indian/Alaska Native race/ethnicity.
Source: CPST, data derived from National Science Foundation, *Survey of Graduate Students and Postdoctorates in Science and Engineering, 2006.*

CPST

As degree level increases, women's and URMs' share of degrees decreases. At each level, these groups are less likely to earn degrees in S&E.

Figure 19. Percent of U.S. Citizen and Permanent Resident Women and Under-Represented Minorities at Each Degree Level, 2005-06

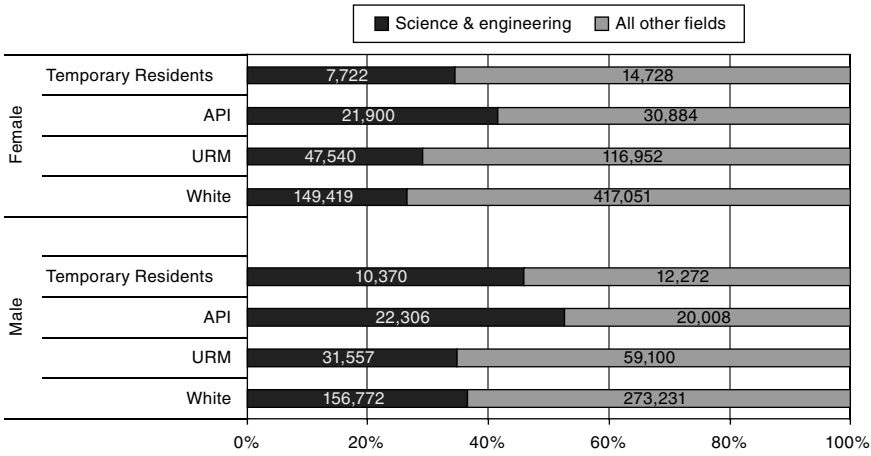


Source: CPST, data derived from National Science Foundation, *Science and Engineering Degrees, by Race/Ethnicity of Recipients: 1995-200*6.

CPST

Within gender, Asian/Pacific Islanders were most likely to receive bachelor's degrees in S&E: 41% of women and 55% of men who earned bachelor's degrees in 2006 did so in S&E.

Figure 20. Bachelor's Degrees by Gender and Ethnicity, 2005-06

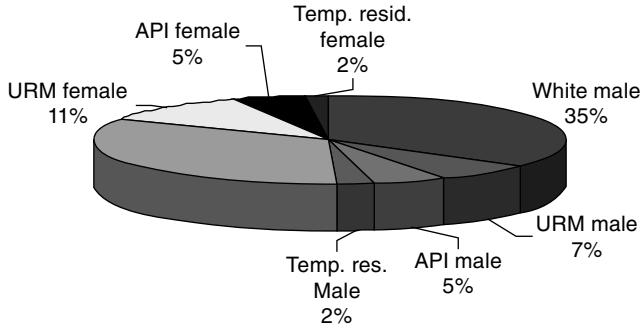


Source: CPST, data derived from National Science Foundation, *Science and Engineering Degrees, by Race/Ethnicity of Recipients: 1995-2006*

CPST

White males and females earned more than 68% of all science and engineering bachelor degrees. URMs of both sexes earned less than 20% in 2005-2006.

Figure 21. S&E Bachelor's Degrees by Gender and Ethnicity, 2005-06

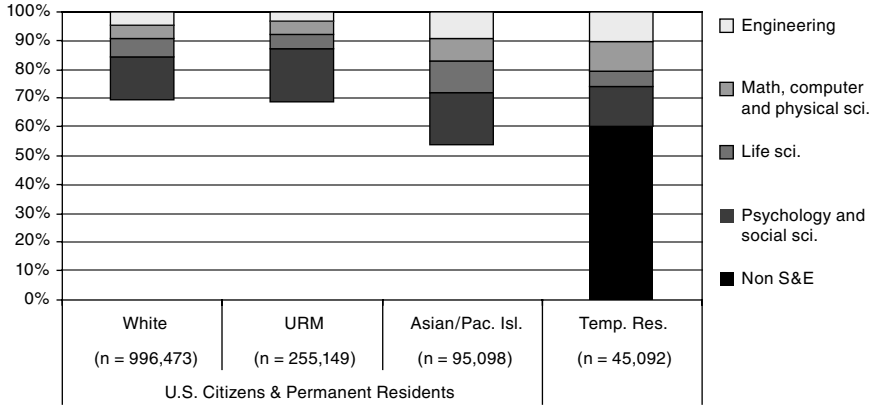


Source: CPST, data derived from National Science Foundation, *Science and Engineering Degrees, by Race/Ethnicity of Recipients: 1995-2006.*

CPST

The majority of degrees earned by all racial/ethnic groups are in non-S&E fields. However, Asian/Pacific Islanders and Temporary residents are more likely to earn S&E degrees than Whites or URMs.

Figure 22. Percent of Bachelor's Degrees in Broad Fields within Racial/Ethnic and Citizenship Groups, 2005-06

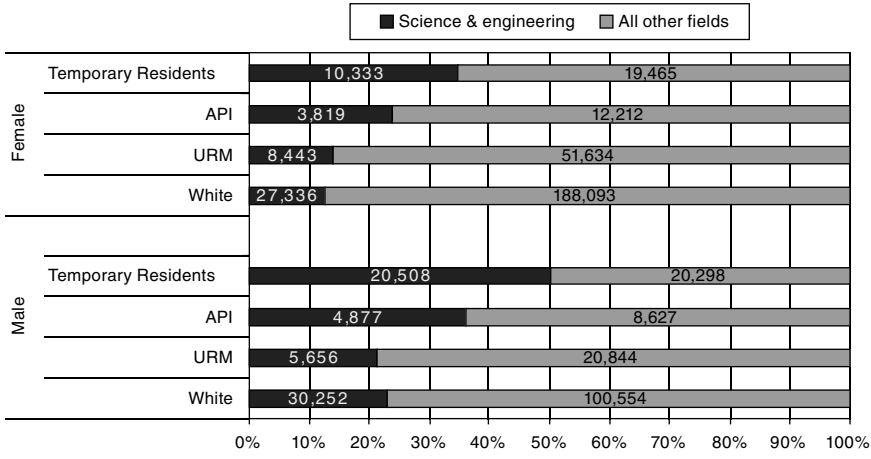


Note: URM = under-represented minority, includes African American, Hispanic and American Indian/ Alaska Native.
Source: CPST, data derived from National Science Foundation, *Science and Engineering Degrees, by Race/Ethnicity of Recipients: 1995-2006.*

CPST

Temporary residents are more likely to receive Master's degrees in S&E fields than any U.S. racial/ethnic groups.

Figure 23. Master's Degrees by Gender and Ethnicity, 2005-06

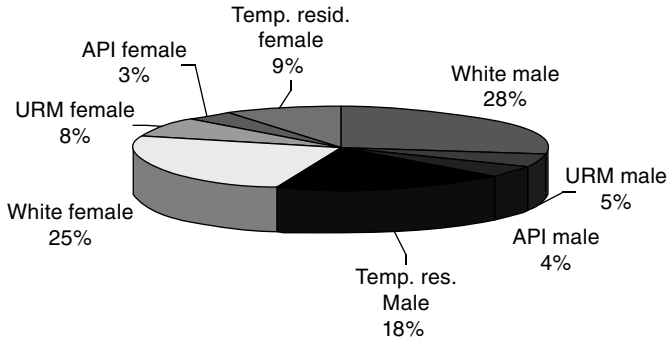


Source: CPST, data derived from National Science Foundation, *Science and Engineering Degrees, by Race/Ethnicity of Recipients: 1995-2006.*

CPST

White women and men have similar Master's degree attainment in S&E fields.

Figure 24. S&E Master's Degrees by Gender and Ethnicity, 2005-06

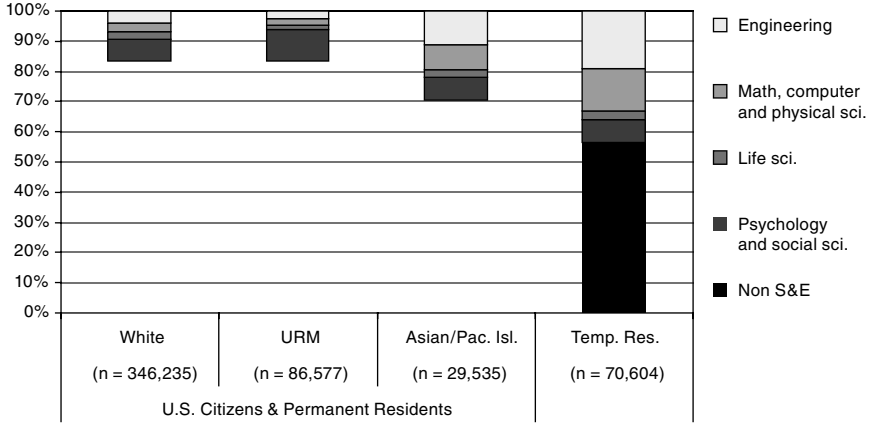


Source: CPST, data derived from National Science Foundation, *Science and Engineering Degrees, by Race/Ethnicity of Recipients: 1995-2006.*

CPST

At the Master's level, temporary residents and Asian/Pacific Islanders are most likely to receive degrees in S&E fields. URMs, overall, are more likely to receive degrees in psychology and social sciences than other S&E fields.

Figure 25. Percent of Master's Degrees in Broad Fields within Racial/Ethnic and Citizenship Groups, 2005-06

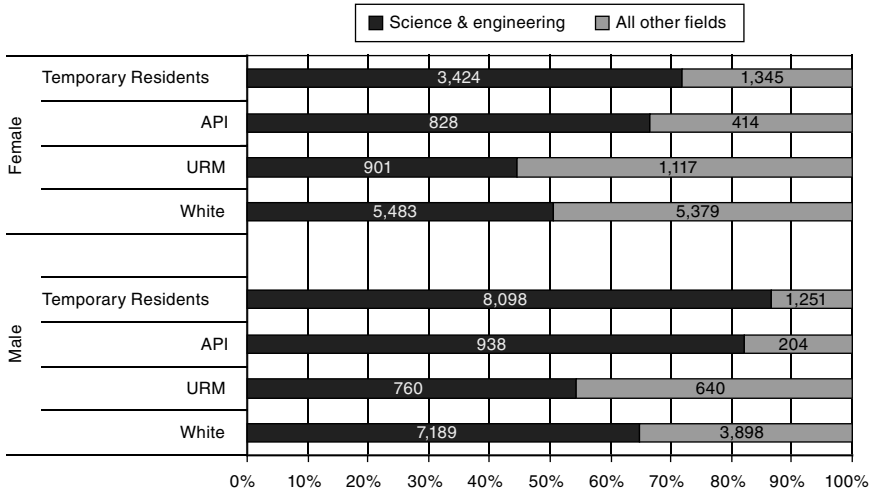


Note: URM = under-represented minority, includes African American, Hispanic and American Indian/ Alaska Native.
Source: CPST, data derived from National Science Foundation, *Science and Engineering Degrees, by Race/Ethnicity of Recipients: 1995-2006.*

CPST

Temporary residents are more likely to receive Master's degrees in S&E fields than other groups.

Figure 26. Doctoral Degrees by Gender and Ethnicity, 2005-06

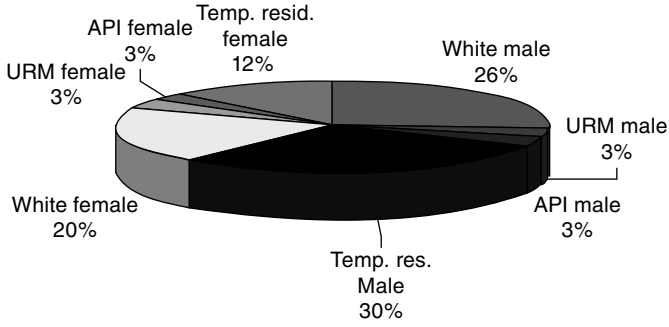


Source: CPST, data derived from National Science Foundation, *Science and Engineering Degrees, by Race/Ethnicity of Recipients: 1995-2006.*

CPST

Temporary resident males earned 30% of all S&E doctoral degrees, followed by white males (26%) and white females (20%).

Figure 27. S&E Doctoral Degrees by Gender and Ethnicity, 2005-06

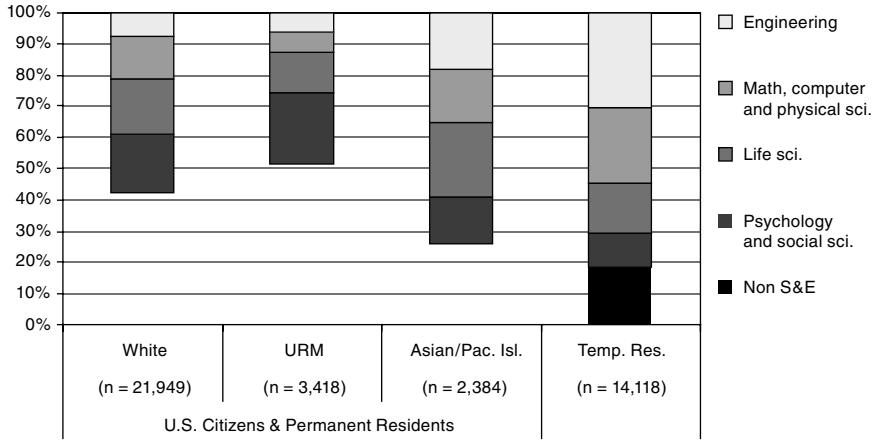


Source: CPST, data derived from National Science Foundation, *Science and Engineering Degrees, by Race/Ethnicity of Recipients: 1995-2006.*

CPST

At the doctoral level, temporary residents and Asian/Pacific Islanders are most likely to receive degrees in S&E fields.

Figure 28. Percent of Doctoral Degrees in Broad Fields within Racial/Ethnic and Citizenship Groups, 2005-06

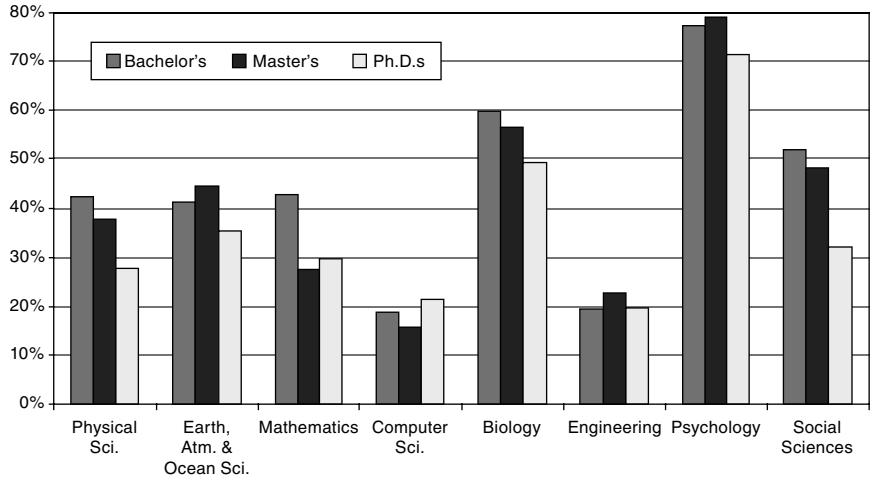


Note: URM = under-represented minority, includes African American, Hispanic and American Indian/ Alaska Native.
Source: CPST, data derived from National Science Foundation, *Science and Engineering Degrees, by Race/Ethnicity of Recipients: 1995-2006.*

CPST

Women's representation varies greatly across STEM fields and degree levels.

Figure 29. Women's Representation Among Science and Engineering Degree Recipients by Level of Degree, 2006

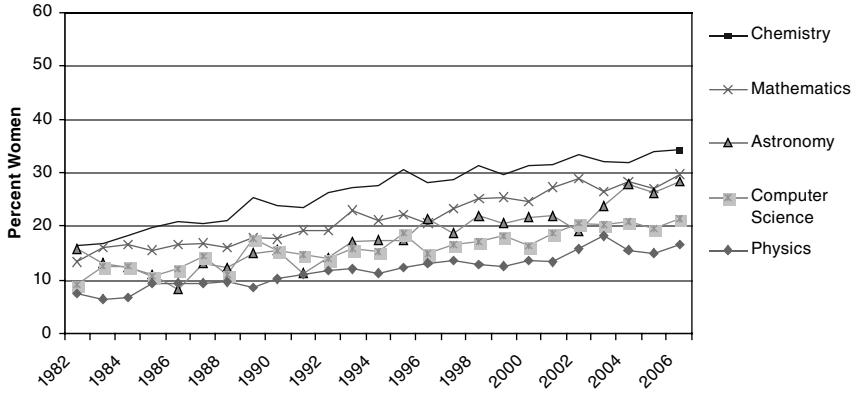


Source: CPST, data derived from National Science Foundation, Science and Engineering Degrees, 1950-1980 and 1966-2006.

CPST

While women have made consistent gains in most physical science doctoral awards, they have not yet reached parity. Women continue to receive less than 40% of doctoral degrees in all areas.

Figure 30. Trend in Women's Doctoral Awards in Physical Science Fields, 1982-2006

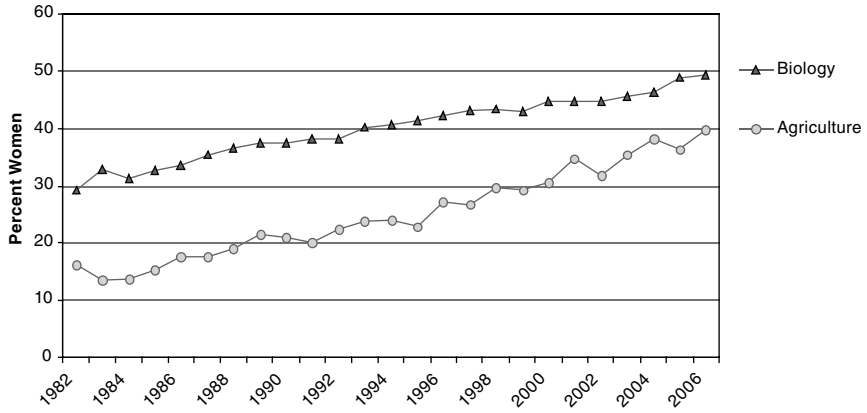


Source: CPST, data derived from National Science Foundation, Science and Engineering Degrees, 1950-1980 and 1966-2006.

CPST

In agriculture and biology, women have made significant progress since 1982. In biology, women have achieved parity, with agriculture close to parity.

Figure 31. Trend in Women's Doctoral Awards in Life Science Fields, 1982-2006

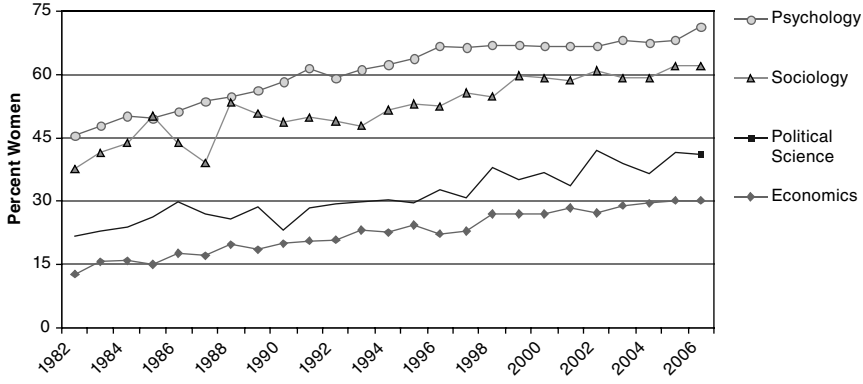


Source: CPST, data derived from National Science Foundation, Science and Engineering Degrees, 1950-1980 and 1966-2006.

CPST

Women earned more than half of all psychology and sociology doctoral degrees, but less than 45% of all political science and economic doctoral degrees.

Figure 32. Trend in Women's Doctoral Awards in Psychology and Selected Social Science Fields, 1982-2006

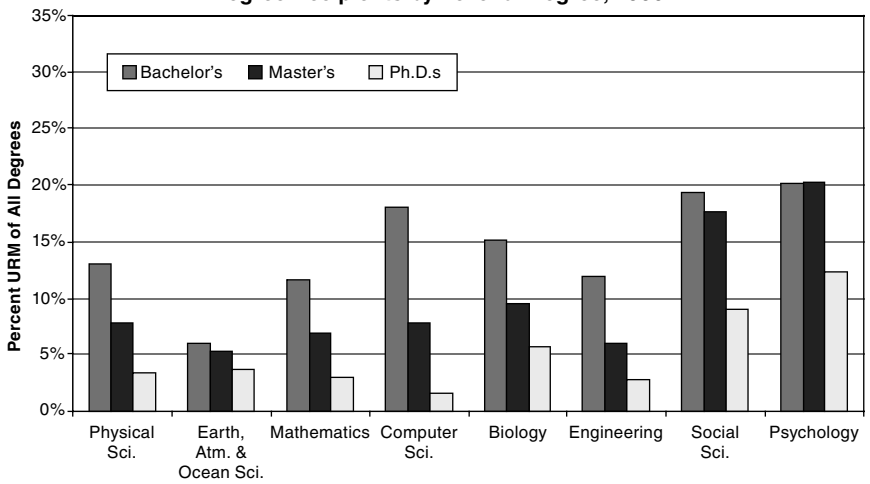


Source: CPST, data derived from National Science Foundation, Science and Engineering Degrees, 1950-1980 and 1966-2006.

CPST

URMs represent 34% of 18-24 year olds but are far from parity in every STEM field at all levels. Representation at the doctoral level is particularly low.

Figure 33. Under-Represented Minorities Among Science and Engineering Degree Recipients by Level of Degree, 2006

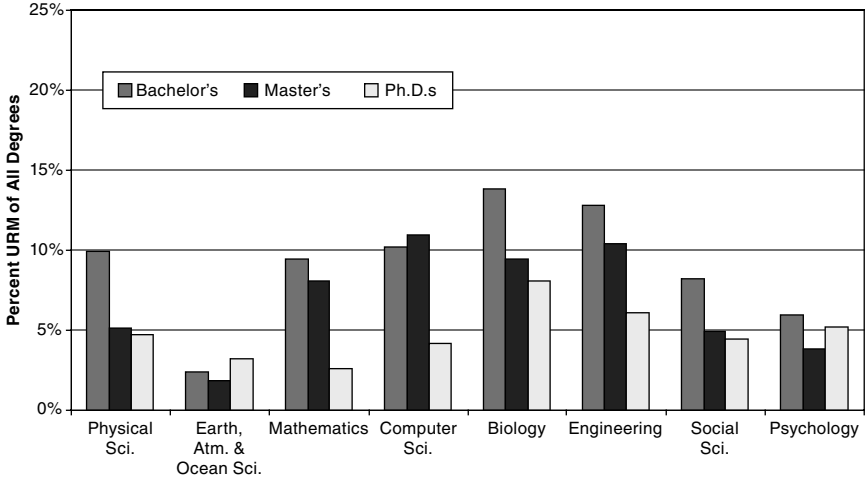


Note: Under-represented minorities includes African Americans, Hispanics and American Indians/Alaska Natives.
Source: CPST, data derived from National Science Foundation, Science and Engineering Degrees, 1950-1980 and 1966-2006.

CPST

Asian/Pacific Islanders are over-represented in many STEM fields. 4% of 18-24 year olds are from these groups.

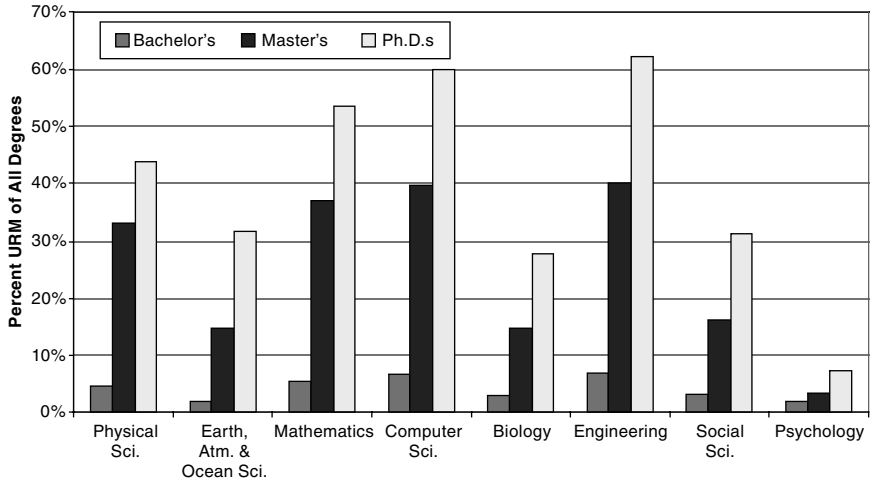
Figure 34. Asian/Pacific Islanders Among Science and Engineering Degree Recipients by Level of Degree, 2006



Source: CPST, data derived from National Science Foundation, Science and Engineering Degrees, 1950-1980 and 1966-2006.

Temporary residents accounted for more than half of the U.S. doctoral degrees in engineering, computer science and mathematics in 2006.

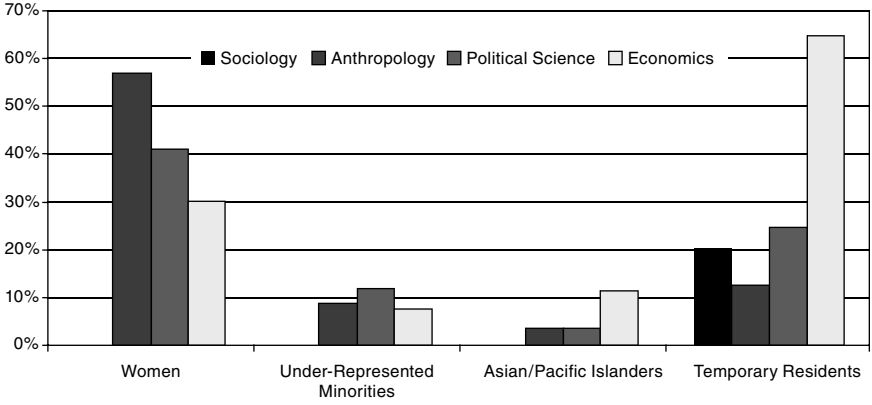
Figure 35. Temporary Residents Among Science and Engineering Degree Recipients by Level of Degree, 2006



Source: CPST, data derived from National Science Foundation, Science and Engineering Degrees, 1950-1980 and 1966-2006.

Temporary residents earned almost 65% of all economic doctorate degrees. Among the social sciences, sociology exceeds parity of women (62%) and URMs (17%) are closing the gap.

Figure 36. Doctoral Awards Earned by Selected Demographic Groups in Social Science Fields, 2006

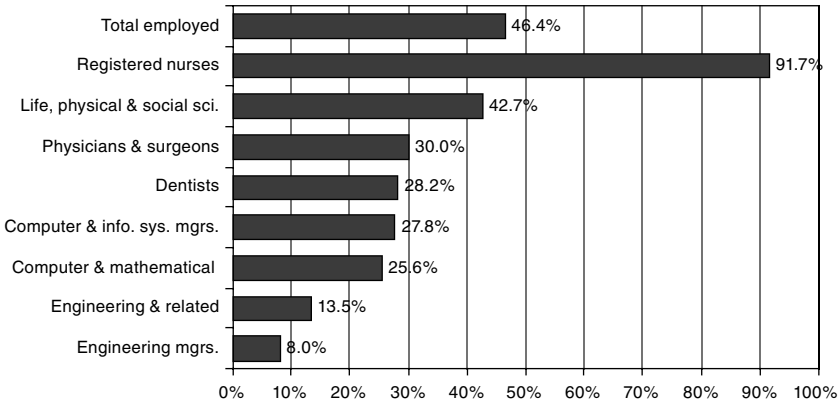


Note: Under-represented minorities includes African Americans, Hispanics and American Indian/ Alaska Natives.
Source: CPST, data derived from National Science Foundation, Science and Engineering Degrees, 1950-1980 and 1966-2006.

CPST

Women account for nearly half of the U.S. labor force but are under-represented in most STEM occupations.

Figure 37. Women as a Percent of All Workers and in Selected Occupations, 2007

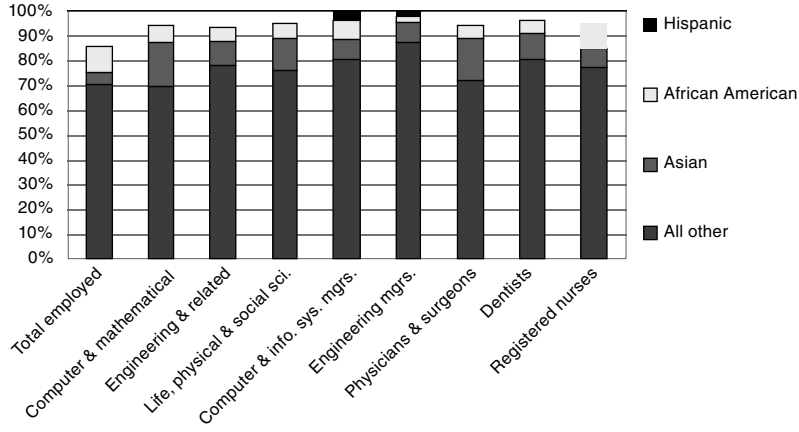


Source: CPST analysis of data derived from Bureau of Labor Statistics, Current Population Survey, Annual Averages.

CPST

Hispanics and African Americans account for 25% of the U.S. labor force, yet are under represented in the STEM jobs.

Figure 38. Racial/Ethnic Composition of U.S. Labor Force and Selected Occupations, 2007

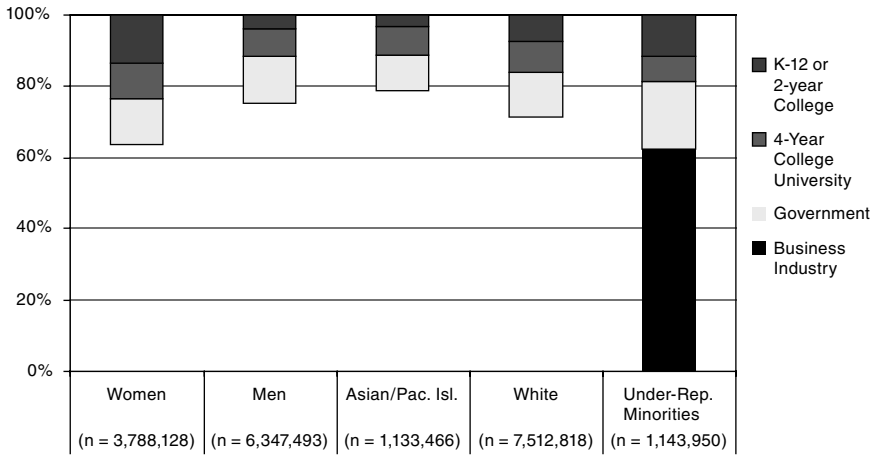


Note: "All other" is almost entirely non-Hispanic white, but also includes American Indians, who are too few in number for detailed separate analysis.
Source: CPST analysis of data derived from Bureau of Labor Statistics, Current Population Survey, Annual Averages.

CPST

Women and minorities are less likely to be in industry and more likely in K-12 or 2-year colleges. Minorities are most likely to be in government.

Figure 39. Employment Sector of Scientists and Engineers, Selected Demographic Groups, 2006

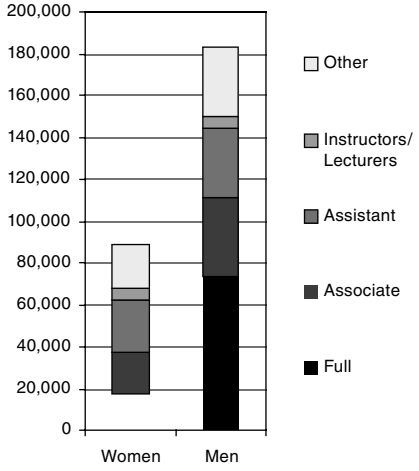


Note: Under-represented minorities includes African Americans, Hispanics and American Indians/Alaska Natives.
Source: CPST analysis of National Science Foundation SESTAT data base. The use of NSF data does not imply NSF endorsement of the research, methods, results or conclusions presented here.

CPST

Women account for less than half of "regular ranks" faculty with low representation among full professors.

Figure 40. Rank of Doctoral S&Es Employed at Four-Year Colleges and Universities by Sex, 2006

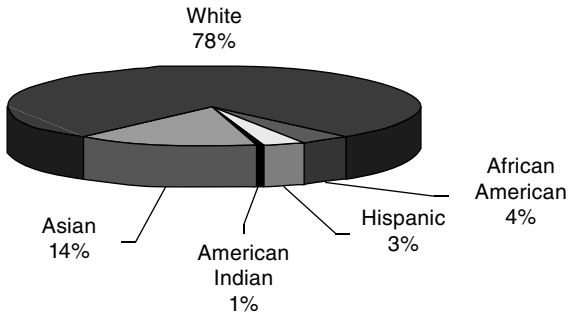


Source: CPST analysis of National Science Foundation SESTAT data base. The use of NSF data does not imply NSF endorsement of the research, methods, results or conclusions presented here.

CPST

Only 8% of doctoral scientists and engineers at four-year academic institutions are under-represented minorities.

Figure 41. Doctoral Scientists & Engineers Employed in Four-Year Colleges and Universities by Race/Ethnicity, 2006

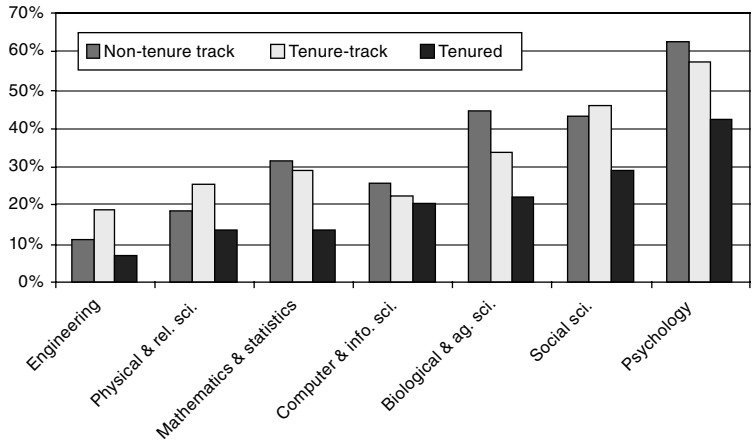


Source: CPST analysis of National Science Foundation SESTAT data base. The use of NSF data does not imply NSF endorsement of the research, methods, results or conclusions presented here.

CPST

Women's representation on the faculty varies by field in STEM and by level.

Figure 42. Women Doctoral Degree Faculty by Tenure Status and Field, 2006

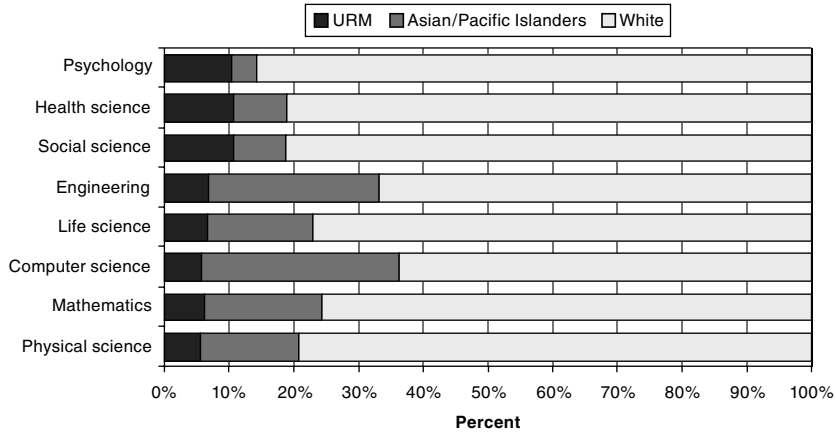


Source: CPST analysis of National Science Foundation SESTAT data base. The use of NSF data does not imply NSF endorsement of the research, methods, results or conclusions presented here.

CPST

Doctoral-degreed URMs account for less than 10% of most STEM field faculty at U.S. 4-year institutions.

Figure 43. Race/Ethnicity of Doctoral Scientists and Engineers Employed at Four-Year Colleges and Universities by Field of Doctorate, 2006

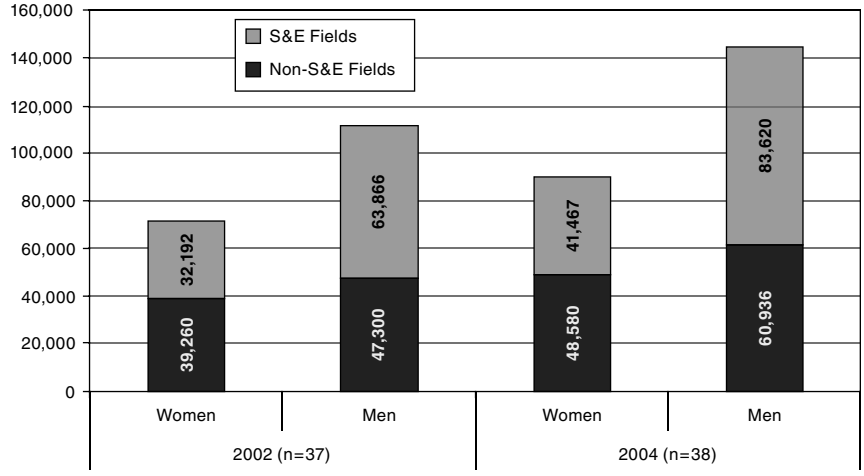


URM = underrepresented minorities, includes African Americans, American Indians, and Hispanics.
Source: CPST data derived from National Science Foundation, *2006 Survey of Doctorate Recipients, Characteristics of Doctoral Scientists and Engineers in the United States, 2006.*

CPST

Doctoral degree production increased greatly between 2002-2004 but growth was far higher for men than women.

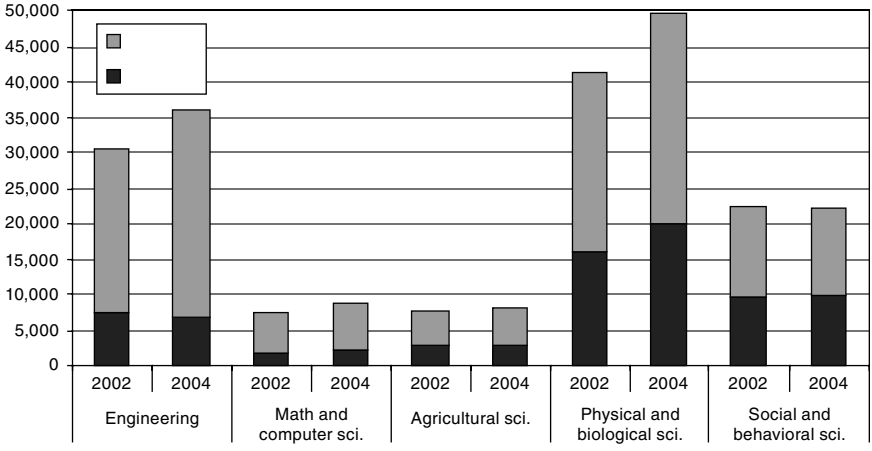
Figure 44. Doctoral Degrees by Gender



Source: CPST, data derived from National Science Foundation, Science & Engineering Indicators, 2008.

The number of doctoral degrees awarded to women grew in the physical and biological sciences, while for men, there was marked growth in most S&E fields.

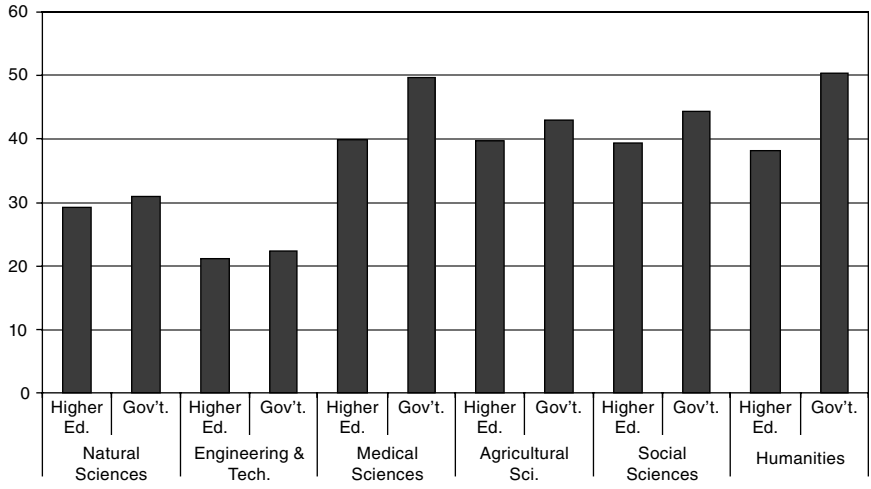
Figure 45. S&E Doctoral Degrees by Field, Gender and Year
(n = 37 in 2002, n = 38 in 2004)



Source: CPST, data derived from National Science Foundation, Science & Engineering Indicators, 2008.

Women are more highly represented as researchers in the government than in the higher education sector. They are least well-represented in engineering and technology fields.

Figure 46. Percent Female Researchers by Sector and Field, EU-25 Nations, 2003



Source: CPST, data derived from European Commission Community Research, *She Figures 2006*.

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