UNDERSTANDING INTERVENTIONS

That Broaden Participation in Research Careers

2011

VOLUME IV

FROM CONFERENCE TO COMMUNITY

Anthony L. DePass and Daryl E. Chubin, Editors

INTERVENTIONS
RESEARCH
DIVERSITY

AAAS
ADVANCING SCIENCE, SERVING SOCIETY

UNDERSTANDING INTERVENTIONS
THAT BROADEN PARTICIPATION IN RESEARCH CAREERS

VOLUME IV

From Conference to Community

SUMMARY OF A CONFERENCE
VANDERBILT UNIVERSITY, MAY 26–28, 2011

Anthony L. DePass and Daryl E. Chubin, Editors

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Acknowledgments

The 2011 Understanding Interventions conference was once again a team effort, as the pages that follow amply demonstrate. In addition to essential support from our sponsors, the Planning Committee, and the Conference Planning Team, we received unparalleled assistance from our local host, Vanderbilt University School of Medicine.

As our vision for the 2012 conference comes alive, we are fortified by how colleagues dedicated to a scholarly yet practical mission can accomplish so much in the spirit of making "common cause" for current and future generations of STEM and medical professionals.

We thank you all.

<div align="right">Daryl E. Chubin and Anthony L. DePass</div>

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Preface

In 1873 New York City tycoon Cornelius Vanderbilt contributed $1 million to start a university in Nashville, Tennessee, that would "contribute to strengthening the ties which should exist between all sections of our common country." The historical theme of collaboration across diverse interests made Vanderbilt University an appropriate place to hold the Fourth Annual Conference on Understanding Interventions that Broaden Participation in Research Careers. From May 26 to 28, 2011, approximately 200 people gathered to hear 46 separate presentations on efforts designed to increase the numbers of underrepresented minorities working not just in biomedical research but throughout the sciences. As one conference participant observed in the final session, it was the most successful of the conferences held thus far.

The Understanding Interventions conferences have become progressively broader since the first was held in 2007. That initial workshop brought together practitioners and social science researchers 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.national academies.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 and demonstrated 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.understandinginterven
tions.org/wp-content/themes/simpla_widgetized/files/08Understanding_
Interventions.pdf.) The 2009 conference sought not only to inform practice
with research, but also to enrich research with lessons from field-based
practice. It illustrated effective strategies implemented in successful STEM
programs, presented applications-oriented results from hypothesis-based re-
search studies, and developed approaches to translate research into practice.
(A summary of the third conference is available at http://php.aaas.org/
programs/centers/capacity/documents/InterventionsReport2009.pdf.)

The fourth conference had an even more diverse set of objectives. In part,
these objectives reflected data generated before the conference. Of the 60
registrants who responded to a pre-conference survey, 77 percent listed learn-
ing about effective program design strategies as a motivation for attending.
Slightly lower percentages listed as motivations networking with colleagues
(75 percent), hearing about the latest research findings (70 percent), finding
ways to evaluate or measure outcomes (68 percent), and meeting potential
collaborators (55 percent). All of these objectives informed the design of the
conference.

The preconference survey also asked about respondents' major focus
when it comes to interventions that encourage minorities to pursue research
careers, with multiple responses allowed. Slightly more than half (52 percent)
replied that they are currently conducting or would like to conduct research
into factors that support women and minorities in pursuing research careers.
Slight less than half (48 percent) said that they are responsible for conducting
program evaluations or demonstrating the outcomes of programs in this area,
46 percent said that they are the principal investigator or program director
for one or more training grants or programs, 39 percent said that they were
in a position to influence institutional or agency policies and practices that
promote diversity in science, and 31 percent said that they would like to im-
prove their effectiveness as a mentor.

This diversity of interests mirrors the wide range of people who attend
the Understanding Interventions conferences. In its preparations for this con-
ference, the planning committee identified four principal audiences:

- Social science researchers, including academic and translational
  researchers
- Emerging interventions researchers, including those from various re-
  search disciplines who are interested in further exploring the interven-
  tions research base
- Training program directors, including those who are interested in
  developing better programs
- Evaluators, including those who are formally trained and those who
  have learned on the fly

Of the registrants, 28 percent were life scientists and 22 percent were so-
cial scientists, which is similar to past conferences. Forty percent were faculty,
25 percent were administrators, 9 percent were graduate students, and 26

percent fell into other categories. Sixty-two percent were first-time attendees at the conferences, which is comparable to earlier conferences. Travel awards were particularly valuable in allowing participants to come to the conference who otherwise would not have been able to make the trip to Nashville.

Bringing together people with such a broad range of backgrounds and interests generated passionate conversations and satisfied a broad range of needs. Program directors are interested in learning how to translate the literature or, more specifically, what the literature says. Emerging interventions researchers are interested in learning more about experimental techniques in interventions research. Future program directors want to learn more about effective ways of administering programs. All of these needs could be met through the presentations and conversations that took place during the conference.

The fourth conference in the series incorporated a variety of other innovations. It was the first held away from the East Coast and at a university—and not only a university but a medical school, reflecting the incorporation of medicine as a theme in the conference. The breakout sessions incorporated tracks so that participants could stick to a particular subject, like undergraduate education. It had four sponsors: the Educational Testing Service, the Howard Hughes Medical Institute, the National Institutes of Health, and the National Science Foundation. This diversity of funders reflects the value of the conference. It has no institutional home or regular source of funding; the fourth conference came about through a partnership between Long Island University and AAAS. Yet the conferences and the publications and websites derived from the conferences have generated great interest and enthusiasm for future conferences.

In part, this interest and enthusiasm arise from the fact that no similar conferences exist. Scientific meetings tend to fall into two categories: disciplinary meetings in which people interested in interventions are relegated to the margins, and meetings in the social, behavioral, or economic sciences that are more academically than practically oriented. The Understanding Interventions conference fills the unique space where people who are informing their research with practice can interact with people who are running programs.

This summary volume of the conference is organized into ten chapters around overarching themes identified by the planning committee and emerging from the presentations. The final plenary session at the conference, which is summarized in the final chapter of this volume, consisted of a talk-back session in which the participants discussed the future of the Understanding Interventions conferences. How can the communities represented at the conference grow? What are the communities' needs in the short and long term? What does it mean to transform research and practice? How can the discussions at the conference contribute to this transformation?

The Understanding Interventions conferences started in 2007 as a way to bring communities of practice and scholarship together. Since that first meeting, our hopes and plans for the series have been amply realized. Scholarship and practice have been not only informed by each other but have blended in new and productive ways. Interventions are based on hypotheses, and

hypotheses grow from experience with interventions. The Understanding Interventions series has become more than a conference—it has become the basis for a community.

Anthony L. DePass, co-chair
Long Island University–Brooklyn

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1

Setting the Context

The subject matter of the series of conferences on Understanding Interventions that Broaden Participation in Research Careers has been moving toward the top of the national agenda. In 2009, President Obama established as a goal that "by 2020, America will once again have the highest proportion of college graduates in the world," which will require that 8 million additional young adults beyond current projections earn associate's and bachelor's degrees.[1] The America COMPETES Reauthorization Act of 2010 mandates the creation of an inventory of federally sponsored education programs and activities in science, technology, engineering, and mathematics (STEM), including assessments of the effectiveness of such programs and the rates of participation by women and minorities underrepresented in STEM fields. The President's Council of Advisors on Science and Technology, in a report entitled *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics*, focused attention on the "underrepresented majority"—the women and members of minority groups who now constitute about 70 percent of college students yet receive only about 45 percent of undergraduate STEM degrees.[2] Policy makers and the general public have become increasingly aware that retaining America's historical preeminence in science and technology requires much broader participation in research careers by all sectors of the U.S. population.

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[1]See "Meeting the Nation's 2020 Goal: State Targets for Increasing the Number and Percentage of College Graduates with Degrees," http://www2.ed.gov/policy/highered/guid/secletter/110323insert.pdf.

[2]President's Council of Advisors on Science and Technology. (2012). *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics.* Washington, DC: Executive Office of the President.

In the initial plenary address of the 4th Annual Conference on Understanding Interventions that Broaden Participation in Research Careers, which was held at Vanderbilt University on March 26–28, 2011, Michael Nettles, Senior Vice President of the Policy, Evaluation and Research Center at the Education Testing Service (ETS), provided a broad statistical overview of the status of underrepresented minorities and women in STEM fields. Later in the conference, Lorenzo Esters, Vice President of the Association of Public and Land-Grant Universities (APLU), and Daryl Chubin, Director of the Center for Advancing Science & Engineering Capacity at the American Association for the Advancement of Science, provided additional statistical information on the inclusion of underrepresented groups at different educational and professional levels. This chapter combines data from their three talks to provide context for the presentations and discussions that followed Nettles' keynote address.

In his introduction of Nettles, Marc Nivet, Chief Diversity Officer of the Association of American Medical Colleges, suggested replacing the pipeline as an academic metaphor. "It is an overused and inappropriate metaphor for what we are really trying to do," he said. He recommended a supply chain metaphor, which gets away from thinking about narrow points of entry and exit and emphasizes the roles of individuals and institutions in making talent available.

Similarly, he urged a mental shift away from a recruitment and retention framework, since it allows institutions to see the poor representation of minorities in the sciences as an external problem. Many effective interventions exist, Nivet pointed out, but they are like putting a gas mask on a canary rather than fixing the surrounding toxicity. "We need balance between putting the gas mask on and lowering the toxic levels within our institutions." He suggested that administrators and educators think of attracting students and helping them thrive.

K–12 EDUCATION

Demographic changes will have a major influence on efforts to increase educational attainment. As Esters observed, more than half of all U.S. children will be members of minority groups by 2023, and minorities will constitute more than half of the population by 2042, according to current projections. In 2050, minorities will account for 54 percent of the U.S. population, which is expected to total 439 million, and one in three Americans will be Hispanic.

Minority students have narrowed some of the gaps in educational attainment with white students over the past three decades, Nettles pointed out. According to the National Assessment of Educational Progress (NAEP), blacks and Hispanics have improved their mathematics scores at ages 9, 13, and 17 over the past three decades, with similar improvements in reading and other subjects (Figure 1-1). But black and Hispanic 17-year-olds still achieve on average at the level of white 13-year-olds.

Furthermore, Nettles observed that continued gains are threatened by several ongoing developments. One is what he described as the "re-segregation" of public schools. In many cities, whites have moved from cities to the sub-
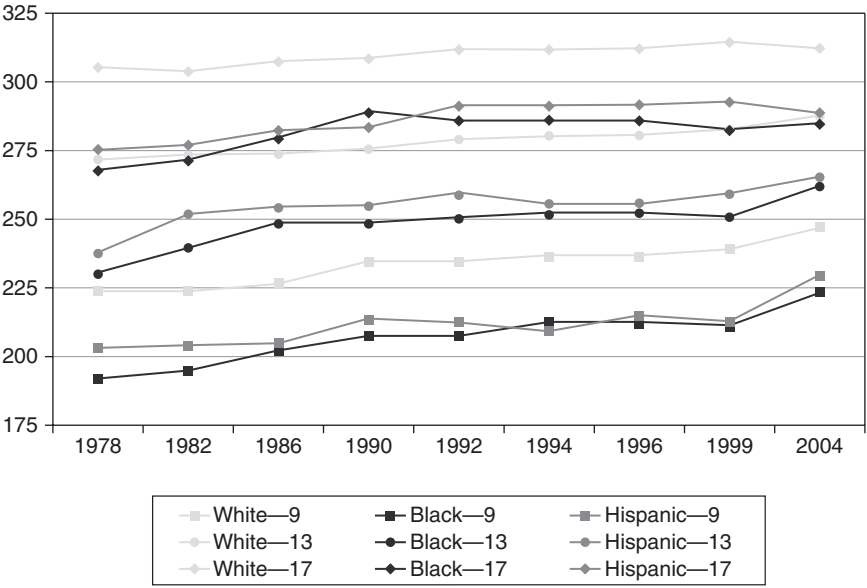
FIGURE 1-1 Black and Hispanic students trail white students in mathematics.
SOURCE: National Center for Education Statistics.

urbs. In other cases, they have shifted from public schools to private schools. In 1972, whites in the southern part of the country represented 70 percent of public school enrollment, but by 2004 they accounted for only 54 percent of public school students (Figure 1-2). One motivation behind charter schools, he pointed out, is to attract students back to public schools in cities, countering the trend of lower white enrollments.

Nettles also noted that the greater the African American enrollment in a school, the lower the scores on the NAEP fourth grade reading exam, on average. However, even in some schools that are predominantly black, the black students score at or above the white mean nationwide, and in some predominantly white schools the white students perform poorly. "This is a very interesting and complex picture," Nettles said. "It is not just the racial composition of the school."

Dropout rates are another indicator of a remaining achievement gap, with 18 percent of Hispanic students leaving school, 10 percent of blacks, and 5 percent of whites. These rates also have also dropped over the past three decades (Figure 1-3), but the differences between groups remain substantial. Furthermore, fewer of the black and Hispanic students who complete high school are in college by the following October compared with white high school completers, though these numbers, too, have gradually risen (Figure 1-4).
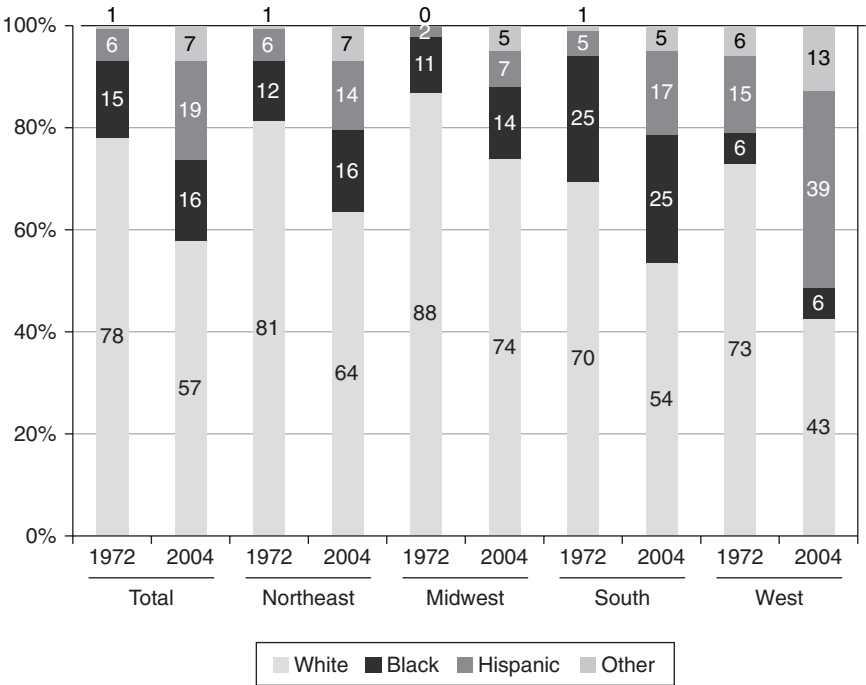
FIGURE 1-2 The percentage of minority students enrolled in public schools in kindergarten through 12th grade has fallen in all regions of the country. SOURCE: The Condition of Education, 2006.
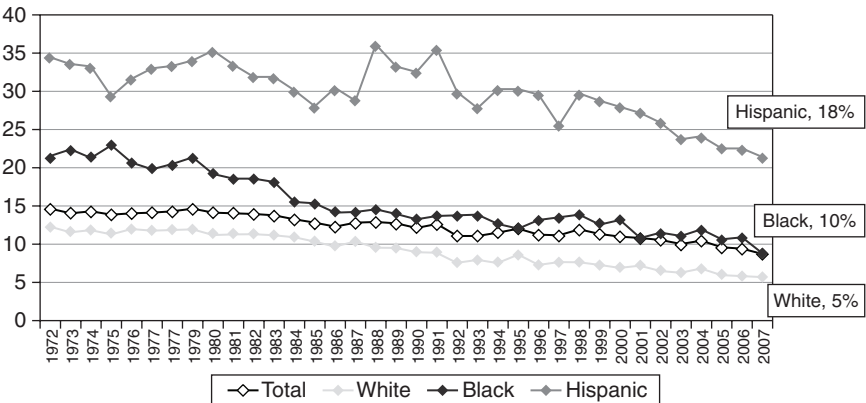
FIGURE 1-3 Dropout rates for whites, blacks, and Hispanics ages 16 to 24 have declined since 1972. SOURCE: National Center for Education Statistics.
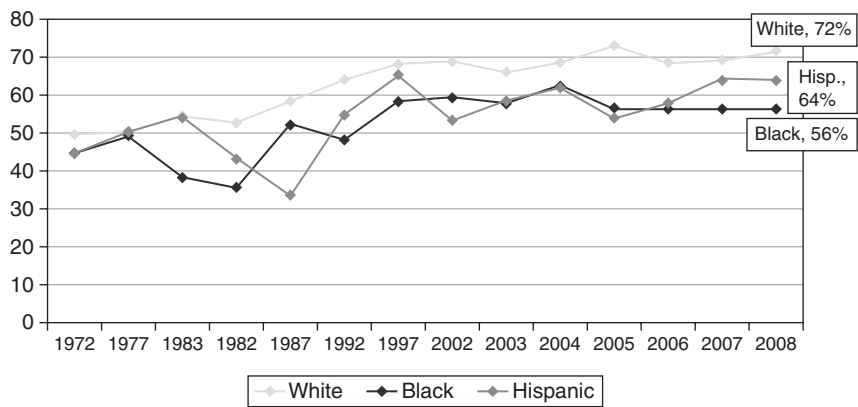
FIGURE 1-4 The percentage of high school graduates enrolled in college the October after completing high school has been above 50 percent in recent decades. SOURCE: Digest of Education Statistics.

Researchers at ETS have reviewed the literature to identify 16 correlates of achievement gaps, which Nettles listed during his address.

- Curriculum rigor
- Teacher preparation
- Teacher experience
- Teacher absence and turnover
- Class size
- Classroom technology
- Fear and safety at school
- Parent participation
- Frequent school changing
- Low birth weight
- Environmental damage
- Hunger and nutrition
- Talking and reading to children
- Television watching
- Parent–pupil ratio
- Summer achievement gain/loss

Efforts to increase the educational attainment of minority students will require attention to combinations of all of these factors.

HIGHER EDUCATION

Black and Hispanic tenth graders' expectations of attaining a bachelor's degree have more than doubled over the past three decades and are now roughly the same as white students' expectations. However, the members of

these groups still enroll in college at lower rates than white students. Today, African American students represent 14.4 percent of 18- to 24-year-olds in the nation but only 11.5 percent of first-time freshmen enrolling in college, a population made up primarily of 18- to 24-year-olds (Table 1-1). When enrollment is narrowed to the most competitive 71 institutions in the country in terms of admissions, that number drops to 6.4 percent. In contrast, African American students are overrepresented at less competitive schools. "The good news for this country is that any student who graduates from high school has a seat in a college or university," said Nettles. "The challenge for us is to continuously increase the competitiveness of these children for competitive admissions institutions."

As with expectations of earning a bachelor's degree, black, Hispanic, and Native American students express just as much interest as Asian or white students in obtaining a STEM degree, Esters observed. However, their completion rates in STEM after five years vary widely, from 42 percent among Asians, to 33 percent among whites, to 22 percent among Hispanics, to 19 percent among Native Americans, to 18 percent among blacks.

Esters pointed to several factors that affect the probability of earning a STEM degree. Prior academic preparation is the strongest predictor of STEM degree completion, and undergraduate research opportunities are positively related to completion. Black students at historically black colleges and universities (HBCUs) are more likely to complete STEM degrees than black students at majority institutions or Hispanic-serving institutions. Also, the effects of race persist after controlling for socioeconomic status and prior academic achievement.

The underrepresentation of blacks, Hispanics, and Native Americans continues in graduate school, as measured by the numbers of PhDs earned by different groups (Figure 1-5). Chubin pointed out that this underrepresentation also varies by field (Table 1-2), with blacks and Hispanics especially underrepresented in the physical sciences.

Women now earn more than half of the PhDs in the life sciences (Figure 1-6), a number than has risen from less than 40 percent two decades ago. But women remain severely underrepresented in the physical sciences and engineering.

THE SCIENCE AND ENGINEERING WORKFORCE

Finally, at the level of the science and engineering workforce, blacks, Hispanics, and women are represented at levels much lower than their levels in the population (Figure 1-7). Reducing the gap between population levels and workforce representation is the ultimate objective of the Understanding Interventions conferences, Chubin said.

The unemployment rate for scientists and engineers is less than for the total workforce, both Chubin and Esters pointed out. But the rate for Asians and for underrepresented groups is somewhat higher than for whites (Figure 1-8). Also, women scientists and engineers tend to be employed part time much more often than men (Figure 1-9). A portion of this part-time employ-

TABLE 1-1 Representation of First-Time Full-Time First-Year Students at U.S. Colleges and Universities

Fall 2006	Total	African American		Asian American		Hispanic		White		American Indian/ Alaska Native	
		N	%	N	%	N	%	N	%	N	%
U.S. Population Ages 18–24	26,541,000	3,810,000	14.4	1,038,000	3.9	3,956,000	14.9	17,496,000	65.9	241,000	0.9
Total First Time Fr Enroll. (N=2,196)	1,481,125	170,025	11.5	95,450	6.4	122,476	8.3	962,208	65.0	12,778	0.9
Most Competitive (71)	84,134	5,363	6.4	12,872	15.3	6,296	7.5	48,012	57.1	468	0.6
Highly Competitive (107)	184,365	10,552	5.7	21,856	11.9	12,750	6.9	124,866	67.7	900	0.5
Very Competitive (279)	324,476	18,083	5.6	22,696	7.0	20,230	6.2	239,001	73.7	2,578	0.8
Competitive (626)	528,528	66,104	12.5	25,497	4.8	40,248	7.6	358,491	67.8	4,246	0.8
Less Competitive (217)	130,219	34,910	26.8	4,791	3.7	14,295	11.0	66,074	50.7	1,334	1.0
Non-Competitive 4 Yr. (99)	59,144	10,051	17.0	1,800	3.0	5,886	10.0	35,780	60.5	954	1.6

NOTE: These data represent student enrollment at institutions ranked by Barron's Profile of American Colleges 2007 with 2006 IPEDS enrollment data. Includes only Title IV institutions. The total number of institutions ranked is 1,399.
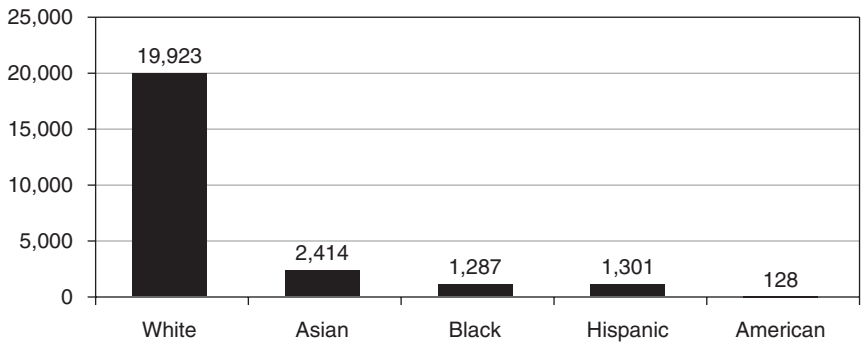
FIGURE 1-5 Far more whites than members of other groups earned PhDs in science and engineering in 2007. SOURCE: Science and Engineering Indicators, 2010.

ment undoubtedly reflects career choices, but part is also due to a lack of full-time opportunities.

Scientists and engineers with disabilities have higher unemployment than their colleagues without disabilities (Figure 1-10). Also, a striking number of scientists and engineers with disabilities are not in the labor force—almost 30 percent.

NEW IDEAS FOR EDUCATING A CHANGING POPULATION

The magnitude of the educational challenge requires that all options be examined, said Nettles. Policy ideas that are currently popular include:

- Measuring teacher quality or effectiveness
- Rewarding performance
- Instituting common core state standards and assessments

TABLE 1-2 Doctorates Awarded to U.S. Citizens and Permanent Residents, 2009

Field	American Indian/ Alaska Native	Asian	Black	Hispanic	White	Two or More Races	Other
All fields	0.45	8.34	6.89	5.79	74.63	2.02	1.88
Life sciences	0.40	10.28	5.40	5.00	75.22	2.02	1.70
Physical sciences	0.20	9.86	3.06	4.24	78.66	1.79	2.20
Social sciences	0.48	6.30	6.78	7.08	74.65	2.71	2.00
Engineering	0.38	16.30	4.26	5.02	69.82	1.87	2.35
Education	0.83	3.93	14.53	6.92	70.80	1.58	1.40
Humanities	0.39	5.23	4.30	6.62	79.23	2.16	2.06
Other non-S&E fields	0.33	8.94	9.59	5.07	72.48	1.74	1.85

Percent
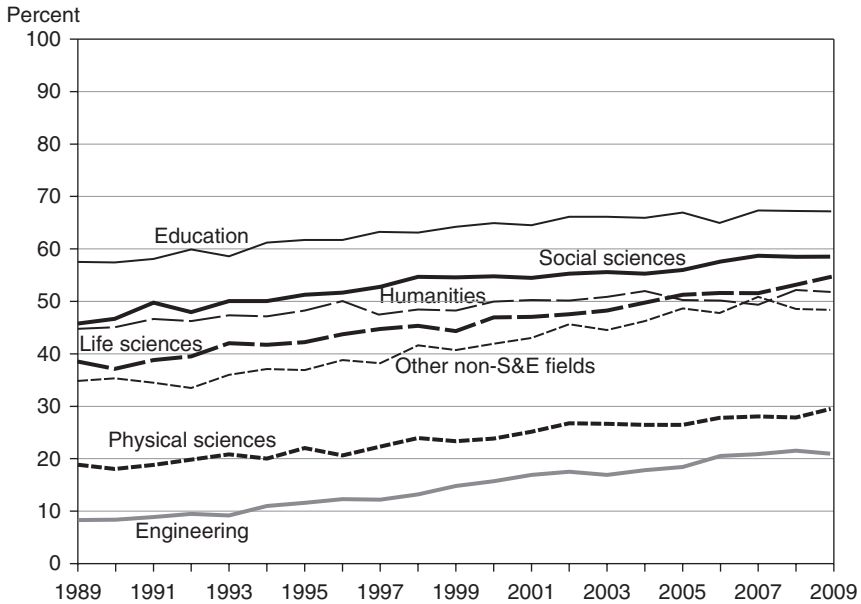
FIGURE 1-6 Women now earn more than half the doctorates in the life sciences but far less than half in the physical sciences and engineering. SOURCE: Doctorate Recipients from U.S. Universities, 2009.

- Developing next generation assessments
- International benchmarking
- Expanding charter schools
- Enhancing readiness for college and work

In addition to these ideas, Nettles mentioned several others that bear examination. One is to focus more attention on the schools that already exist and could benefit from new ideas. For example, strengthening the community focus on education could greatly benefit existing schools. Nettles described a project being conducted by the National Urban League in Pennsylvania and Tennessee to engage the community in the education reform movement. "What we have learned," he said, "is that people don't have the language or the knowledge about schools or what is happening in schools to be able to engage their Commissioner of Education, their school district superintendent, or employees, including teachers, about such issues as common core state standards, rigorous curricula, and teacher effectiveness. We have a huge education challenge in the country to get the population educated about these issues."

Nettles also discussed promise zones as an innovative way of bringing resources to poor school districts. The Striker family, in Michigan, started the first promise zone in 2005, pledging the earnings from $250 million to the Kalamazoo school district to pay for students to attend college. Research on the
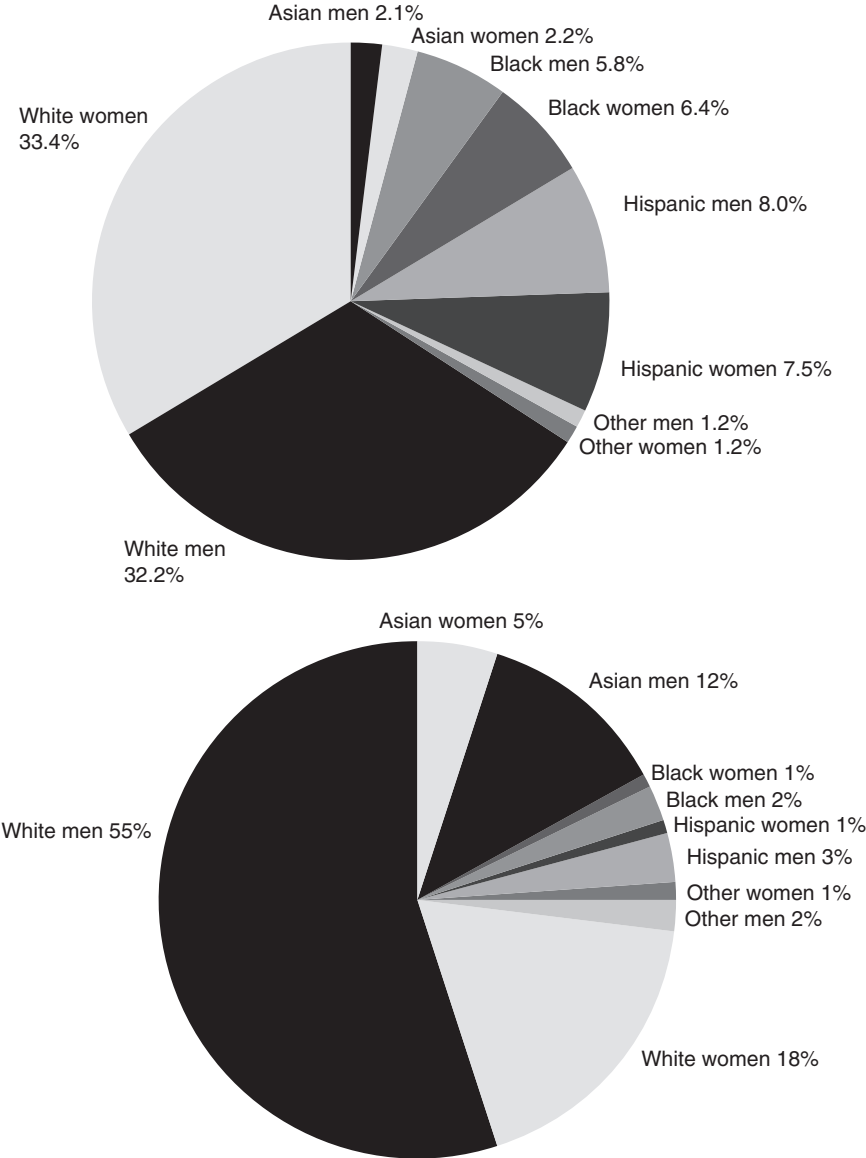
FIGURE 1-7 The resident population of the United States (top) has significant differences from the representation of groups in science and engineering occupations (bottom). SOURCE: Women, Minorities, and Persons with Disabilities in Science and Engineering, 2011.

Percent
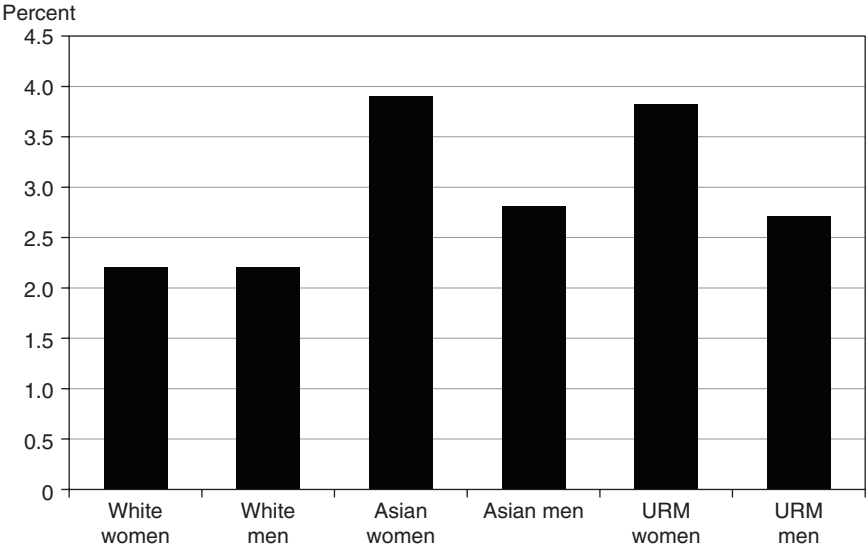
FIGURE 1-8 The unemployment rate for white scientists and engineers is lower than for nonwhites. SOURCE: Women, Minorities, and Persons with Disabilities in Science and Engineering, 2011.
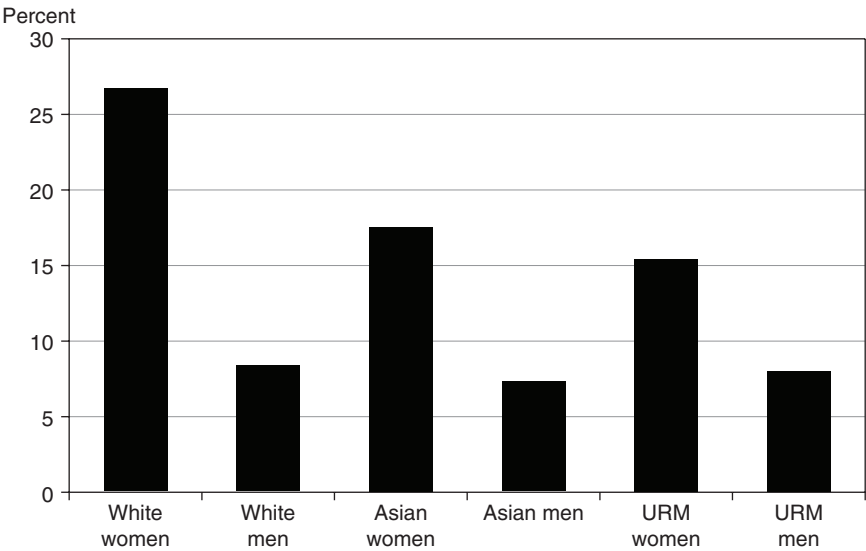
Percent

FIGURE 1-9 The part-time employment rates of women scientists and engineers are significantly higher than for men. SOURCE: Women, Minorities, and Persons with Disabilities in Science and Engineering, 2011.
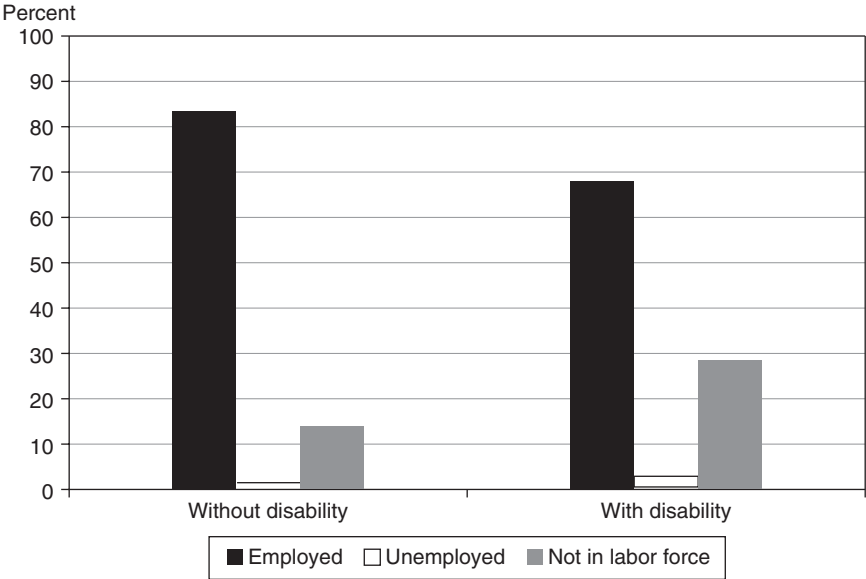
Percent

FIGURE 1-10 Nearly 30 percent of scientists and engineers with a disability are not in the labor force. SOURCE: Women, Minorities, and Persons with Disabilities in Science and Engineering, 2011.

promise zone shows declining dropout rates, increasing college attendance, increasing property values, and movement from the suburbs back to the city. Based on this success, the Michigan legislature adopted the Promise Zones Act in 2009 to build and maintain promise zones. Communities must meet a certain poverty threshold and then raise private equity funding for the first two years. After the first two years, tax increment financing pays for students to attend college. Similarly, in Pittsburgh, the University of Pittsburgh Medical Center committed up to $100 million to the local school district, promising to match every dollar raised by the promise authority with a 50-cent contribution. "This is an idea whose time has come," Nettles said.

Fiscal equity and accountability are also critical, Nettles said. He cited a recent victory for the nation's longest running school finance case, which challenged the New Jersey governor's decision to cut education funding in the state. The ruling preserved a decision made ten years ago requiring the legislature to grant extra funding to the 30 poorest school districts, bringing them up to the level of the richest districts in the state.

PROMISING INITIATIVES

Nettles also discussed several promising interventions. One is Strengthening Instruction in Tennessee Elementary Schools—Focus on Mathematics. With $10 million in funding commitments, ETS is partnering with historically

black colleges and universities and disadvantaged elementary schools to improve teacher preparation and strategies for mathematics courses. The project has shown promising results, Nettles said, which he attributed in part to the ability to compensate teachers up front. Many teachers, he observed, are not motivated to meet national or state standards and become discouraged by failing students rather than finding ways to improve their results. Compensating teachers for participation increases the chances of getting candid and informative feedback. He pointed out that it would be expensive to scale up the study, but doing so would be worthwhile.

In addition, Nettles described the Goldman Sachs Foundation project for the development of high-potential youth, which begins in the sixth and seventh grades. The program funds talented students to attend summer school and provides supplementary education during the school year. The goal, Nettles said, is to increase the number of students attending selective colleges and universities. Using IQ tests, the program identifies students in poor neighborhoods who are capable of performing at very high levels. The program has sent 70 percent of its participants to colleges ranked among the most competitive in the nation. A return on investment study showed that students involved in the program would have a $15 premium compared with students not in the program for every $1 invested in them. "These are the kinds of data that we are going to be called upon to ask for more frequently."

Esters, pointing to the fact that fewer men than women who start as STEM majors in public colleges and universities earn degrees, described a program being conducted by the APLU focused on minority males in STEM disciplines at APLU-member institutions. The overall objective of the M^2 STEM Initiative is to engage APLU member institutions in a comprehensive dialogue on the subject of minority males in STEM with the aim of providing institutions with the tools, information, and perspectives that will help them identify, retain, and graduate minority males in STEM fields.

COMBINING ANALYSIS AND ACTION

This summary of the fourth annual Understanding Interventions conference contains many more ideas for how to increase the participation of underrepresented minorities and women in STEM fields. The challenge is how to draw on past and ongoing research to create programs that are as effective as possible. At the same time, experience with past and ongoing programs provides a rich source of empirical evidence to shape and inspire research programs. This interplay between analysis and action has been a powerful motivating force throughout the Understanding Interventions conferences.

2

Theory into Practice

An underlying theme of the Understanding Interventions conferences has been that theory should inform practice, and most of the programs described at the conferences have had solid theoretical underpinnings. Several speakers at the fourth conference discussed specific programs from an explicitly theoretical perspective. These presentations helped create a theoretical framework for the other conference talks. They also reinforced the expectation that theory will be a prominent feature of the discussions at the conference.

A DECODER FOR TRANSLATING THEORY INTO PRACTICE

Social science theories, said Richard McGee, Associate Dean for Faculty Recruitment and Professional Development at Northwestern University, can be tremendously useful for informing and designing intervention programs in STEM. Often, however, the designers of intervention programs do not have the time to become experts on the sociological principles of such programs. The idea of an interdisciplinary approach is to give people enough knowledge about other fields to engage in a conversation and incorporate these principles into their work, McGee observed.

All interventions occur in a social environment. More awareness of that context is useful, allowing program developers to recognize patterns in student behavior and the principles behind those patterns. Even knowing parts of social science theories can bring another level of nuance to the development and evaluation of programs.

McGee, Lynn Gazley, a sociologist at Northwestern, and colleagues have created a research and development group that approaches interventions as an amalgam of theory, practice, and research. "It's a fascinating mixture of

both hypothesis generating and hypothesis testing," McGee said. "Part of what we want to do is give everyone enough language. How do we create enough decoding of language so that we can begin to talk with each other more productively?"

Social Science Theories for Natural Scientists

During a workshop on the first day of the conference, McGee and Gazley reviewed several social science theories of particular relevance to interventions for interdisciplinary practitioners. Four social science theories are particularly useful for interpreting interventions, said Gazley. An *identity perspective* is useful for looking at stereotype threat and at how a student develops an identity as a scientist and a researcher, as well as conflicts students may have with other aspects of their identity. *Social cognitive career theory* deals with career goals, self-efficacy, and career choice. However, neither of these is markedly useful for predicting which students will be successful. *Communities of practice* and *cultural capital*, the third and fourth theories, provide more insights into how students may become successful and accepted in laboratories and other scientific contexts.

The concept of communities of practice looks at learning in a social setting. It focuses on how individuals join, adapt to and become accepted as legitimate members within groups, and develop competencies common to members of the group. This is particularly helpful, Gazley pointed out, when studying how students join and participate in lab groups, research teams, or classrooms.

The concept of cultural capital centers on the knowledge, skills, and ways of being a person possesses, and how those assets contribute to both promotion and "fit" within a particular community. Cultural capital also draws attention to the power of dominant groups in an area to define the most valuable cultural capital in the field or community and to judge individuals' possession and use of cultural capital. In an academic setting, where promotions are granted based on perceptions of skills and knowledge, application of this concept is particularly apt.

Each theoretical perspective helps with different types of problems, Gazley pointed out. The trick is fitting research questions to concepts and using the theories to best advantage. Each set of theories also has many subtleties. For example, from the perspectives of both communities of practice and cultural capital theory, the definition of success can differ across lab groups and institutions. "There is this sense of fit between the individual and their actions in the social context, that neither one of them, by themselves, can fully explain," Gazley said. "What does the individual bring in, and how does the context respond to that individual?"

Communities of Practice

Several important concepts are embedded in the communities of practice model, Gazley observed. A community of practice must have three shared fea-

tures: the content area where members wish to become expert, a shared group identity, and a repertoire of practice. The legitimacy granted to an incoming member sets the tone for how that person interacts with other members of the community. Incoming group members often succeed best when granted and supported in a position of *legitimate peripheral participation*, where they are seen as, first, having a recognized community role and, second, as having responsibilities that are useful but not too difficult for a newcomer. As a result, she said, "graduate students or undergraduate students entering a new lab can face stumbling blocks. First, if they're not seen as legitimate, they can easily be excluded. Second, the students' project may be peripheral but has to be part of the real work of the lab."

Many things grant legitimacy in the world of graduate school. An undergraduate degree from a highly regarded institution might give an incoming student a leg up. Mentors also can contribute greatly to how students are perceived. "Thinking about labs as communities of practice, where a lot of voices go into creating these relationships, is a more useful model for thinking about scientific training than a traditional apprenticeship model," Gazley said. Social practices and not just lab skills help define the community as well. Students with children, for example, may turn down invitations to nighttime events or spend less time in lab than other members of the research team. This difference can be set up by the mentor and others as being perfectly fine, or it can be something that could marginalize a student as not fully participating.

Communities of practice theory classifies people within communities as either competent participants or outsiders. Discrimination, if it becomes a collective activity, can become a practice within the community. However, not all individuals seen as outsiders are the subject of discrimination. Some practices that seem discriminatory may be the result of misunderstanding rather than malice. Institutional climate also plays a role in how practices develop, and individuals may move between the two classifications. "As these groups change and develop over time, there's going to be a lot of movement. In any snapshot of a group, there's going to be a lot of blurring."

Science is a mentor-based system, McGee added. The ways in which students interact with their mentors and move from one community to another are highly variable. A mentor can give a student legitimacy but also can inhibit a student's success at adapting to new environments and communities. "Mentoring, and our reliance on mentoring, is one of the core issues that is probably preventing us from making the kind of progress we'd like to be making," he said. "Yet it is central to what we do."

Discussion

Predictability is an important underlying dynamic of a community, a participant at the workshop pointed out. It influences how quickly an individual can adapt and learn the implicit rules of that group. Unwritten rules are one thing that the researchers have been experimenting with, McGee responded. The implicit could be made explicit, in which case young scientists could metacognitively understand the social processes in play as they move into new research groups.

Multiple mentors, one participant suggested, can help buffer the variability of the mentoring experience for students and make students and communities less vulnerable to a poor rapport between student and mentor. Multiple mentoring is a useful practice, McGee agreed, but it is difficult to accomplish, especially in the early stages for lab sciences. However, he suggested that collective mentoring can contribute to a significant shift in perspective while also reducing the expectation that one mentor will have all the answers.

THEORY-DRIVEN INTERVENTIONS IN BIOSCIENCE PHD PROGRAMS

Not all students entering a PhD program have equal preparation or support, observed McGee during a presentation later in the conference. Students have huge differences in their prior experiences before beginning a PhD. They also have very large variations in understanding what will happen during the PhD and what to do with what they know.

Education professionals sometimes make the dangerous assumption that once students reach the PhD level, they no longer need intervention programs. However, disparities still exist, and students with less support and less understanding of program expectations may be at a great disadvantage when it comes to the quality of their experience and their continued academic success.

By applying social science theories to this period, he explained, "you can see that the starting point really matters." Cultural capital (including knowledge, skills, and norms) affects how students interact with mentors, how they deal with anxiety associated with the transition, and how their perception of others in the program influences their feeling of self worth. The mentoring system, he said, "poses the greatest risks and challenges for someone who is more of an outsider, someone coming in who is different from the group." The informal nature of mentoring, and the lack of other structure, can make the PhD experience difficult to navigate.

The System and the Individual

Some of the most important factors affecting the success of mentoring systems are subtle, McGee pointed out. For example, mentors may look differently at students from colleges they have not heard of, especially if they are used to dealing with applicants from highly recognized universities. "It becomes absolutely critical that a newcomer is seen initially and early as a scientist, because this is the mental model that people are looking for," said McGee. Using the example of a student presenting results at lab meeting, he demonstrated how anxiety or uncertainty can affect how others view that student. "The really good mentors and PIs mediate those. 'Wait a minute, let's give him time.' But that does not necessarily happen on a regular basis."

Some of the factors influencing a student's PhD experience are obvious, he said, like the amount of research experience, the clarity of research interests, and understanding of how the research culture operates. But many other

factors also come into play, some of which McGee captured in the following list:

- How far is a student achieving beyond family and early peers?
- How much positive feedback has been received in the past?
- How much negative feedback has been received in the past?
- What is the degree of development of identity as a scientist?
- What is the degree to which goals and identity are in conflict with other goals and identities?
- What is the general level of self confidence?
- To what extent is a student treated by others like a scientist?
- What is the level of "passion" for doing research vs. using the PhD as a route to teaching or other professions?
- What is the overall maturity and breadth of life experiences?

Just as there is cause for uncertainty at the beginning of a program, there can be a higher risk of failure or setting lower levels of aspirations later. Different lab groups have different practices, and students might deal mostly with postdocs, lab techs, or grad students, depending on who has the time to teach them. They may or may not be comfortable asking questions or pressuring mentors to teach them necessary skills. People are not malicious, McGee said. Rather, "the system has been set up assuming that certain things will come into play that don't always come into play. And some of the students who we're most interested in are going to be at the highest risk of things not working."

The solution, he argued, lies with the system, not with the individual. Administrators need to think about what they hope mentors will provide and take steps to incorporate those dimensions of mentoring into the system. This is especially critical in the early phases of graduate training when some students are catching up with others.

The CLIMB Program

The Collaborative Learning and Integrated Mentoring in the Bioscience (CLIMB) program at Northwestern University, which McGee directs with program and student support from assistant director Steven Lee, focuses on the first two years of the PhD, which is when students are most likely to find themselves marginalized. The program has undergone a gradual shift as researchers began linking theory to practice, he explained. "I wish I could say that it was built from the ground up around these principles, but no."

The three core elements that have crystallized over the evolution of the program center on the first six months of students' transitions, oral communication skills, and written communication skills. Oral communication, McGee pointed out, "plays a critical role in self perception and the perceptions of others. Every time you're opening your mouth, you're making an impression." Helping students understand and deal with that reality improves their self confidence, which eases their way through the program. Formal instruction on key elements of effective oral communication is provided through

the sequential building of a ten-minute talk. Practice within a peer group is decoupled from anything that "counts" within the PhD program.

Written communication is equally important, and for the same reason. The students practice writing in the context of a research proposal to make explicit the stylized practices of the scientific community. How peer review works and how it drives how and what scientists write are emphasized. In recent years, web-based tools have been created to demystify the process.

The CLIMB program seeks to create a new community of practice, McGee pointed out. Other communities, such as the program community and a student's lab group, can work effectively together with the CLIMB program. One element that has become particularly important in the program is a sense of collaboration and interdisciplinary work, which can instill in students an appreciation for cross-pollination.

The program brings in six new students each year from five bioscience programs at Northwestern, with funding provided for two years. The focus is largely on underrepresented minority students, but including only minority students led to negative stereotyping and stigmatization, which worked counter to what CLIMB was trying to accomplish. In 2009, the program opened its activities to any student who demonstrated interest, regardless of status. "Nothing we're doing here isn't likely to be valuable for other students," McGee pointed out. The group size is now about 25 to 30 students per year.

Designing activities to complement what students were already doing, he said, was important. Underrepresented and other atypical students are more likely to have less cultural capital with respect to research and science careers, so the program focuses on the transitions everyone experiences going from an undergraduate to a graduate student. It makes explicit the process of evolution as a scientist during the PhD and the steps along the way. It promotes and facilitates effective study groups to promote collaboration and decrease the risks of isolation. The program and activities are constantly being evaluated with extensive input. The program is based on the premise that all of its activities are voluntary, so "if people quit coming, we have screwed up."

The CLIMB leadership also works with faculty and graduate school leadership to evaluate criteria for admissions decisions, especially when dealing with students from minority backgrounds. McGee pointed out that in some cases, GPA and grades may not have the same meaning or predictive capacity for different students. If students are supporting themselves or helping to support a family, they may have to balance work with school, leading to lower grades. But being able to achieve both is evidence of a willingness to work hard against the odds, important attributes of successful scientists.

Discussion

In response to a question about faculty attitudes, McGee said that program leaders have not seen a lot of resistance from faculty. Also, program activities have not prevented students from developing rapport with mentors or a community in their labs. "We see relationships develop across programs that otherwise never would have happened," he said.

He also said that the program pulls back dramatically after the first two years, since by that time students have generally found a comfortable lab environment and a sense of community with their research group. "We don't want them to be dependent on us," McGee said.

CHRONIC STEREOTYPE THREAT AND THE
ROLE OF INTERVENTION PROGRAMS

Much of the research around intervention programs for minorities in STEM focuses on retention and academic indicators of success. Anna Woodcock, a social psychologist at Purdue University, discussed some of the psychological factors that underlie these indicators for minority students—specifically chronic stereotype threat—and her research into how intervention programs can help mediate psychological barriers to success.

The Effects of Stereotype Threat

Research implicates chronic stereotype threat as a major factor contributing to the loss of underrepresented minority students from the academic supply chain. Everyone has various identities, Woodcock explained, and some of those identities are subject to negative stereotypes. Stereotype threat, as proposed by Claude Steele in 1995, is the burden borne by individuals who fear that they might behave in a way that would confirm negative stereotypes. As Steele has written, "Despite the strong sense we have of ourselves as autonomous individuals, evidence consistently shows that contingencies tied to our social identities do make a difference in shaping our lives, from the way we perform in certain situations to the careers and the friends we choose."[1]

Studies show that stereotype threat can harm performance in many areas. In addition, scientists have proposed that stereotype threat could lead to a phenomenon known as "domain disidentification." Over time, the hypothesis says, individuals who experience chronic stereotype threat will begin to distance themselves from their identity as part of a group where that threat is present. For example, a minority student in the sciences may slowly stop identifying as a scientist and pull away from that career path in favor of other options.

Disidentification based on chronic stereotype threat has not been tested before using longitudinal data, according to Woodcock. "Despite a wealth of research concerning the moderators and situational mediators of stereotype threat, the long-term consequences of stereotype threat that is happening day in and day out have really received little empirical attention. It's difficult to study over time, it's expensive, and it's hard to do."

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[1]Steele, Claude. (2010). *Whistling Vivaldi: And Other Clues to How Stereotypes Affect Us.* New York: Norton.

The Science Study

The Science Study, a nationwide longitudinal study of 1,420 minority science students, began in 2005, recruiting subjects from 45 U.S. colleges and universities. The study tracks two groups of students, one group from minority intervention programs and a control group that attends universities without those programs. Researchers focused on the Research Initiative for Scientific Enhancement (RISE) and the Minority Access to Research Careers (MARC) programs, both administered by the National Institutes of Health (NIH). Both programs are well established and well-funded, and their goals and strategies apply to many similar efforts, allowing researchers to generalize results to other programs.

When choosing a control group, Woodcock pointed out, the researchers did not want to pull students from universities with RISE or MARC programs, because "students self-select into these programs and are often cherry-picked by the program directors." Instead, the researchers pulled their control groups from nearby schools that were as similar as possible to the RISE campuses but lacked RISE programs. They then assigned students a propensity score based on gender, age, ethnicity, major, GPA, interest in research as a career, ESL status, transfer status, and first generation status. Propensity score matching, a technique for removing selection bias, is based on a logistic regression. The score represents a student's likelihood of being in a RISE program, and the researchers could pair students from the control group with students who had similar scores in the program group.

The final study population was majority female and African American with a large percentage of Latino students. The study pulled students from all biomedical sciences, but most came from the biological and natural sciences. Researchers collected data twice a year using an online survey tool. Woodcock explained that her data come from the first five surveys, but the study is ongoing, with 11 rounds of data collected so far. Although most students were undergraduates when the research began, with some graduate students, many have now graduated or left school.

Using a tailored panel management system, the researchers have managed to get response rates between 75 and 85 percent. Because somewhat different groups of students respond each time, the study has usable data from 96 percent of the survey population. "It's fine for us if they don't answer our questions every time, because the statistical techniques use a full-maximum-likelihood type of approach," she said. "We really don't need full data for everybody."

The questions included in the survey cover structural and contextual variables involved in retention of underrepresented minorities in the sciences, as well as the students' individual attitudes and motivations. "We realize it's the interplay between the individual variables and the environmental variables over time that is going to affect these outcomes," Woodcock explained. "So every wave, we ask about the hard-and-fast outcomes: What are you doing? Did you graduate? What was your major? How much research have you been doing? Then we ask them about their attitudes and their percep-

tions of the context that they are in. We ask them that consistently so we can track that over time."

Using a four-item scale with good reliability, researchers asked students about their perception of stereotype threat and about their identity as a scientist. The study had four main questions: how well minority training programs sustain interest in research careers, the extent to which minority students experience stereotype threat, whether the hypothesis that stereotype threat affects scientific identity and persistence applies, and whether minority training program membership influences the ability of students to cope with stereotype threat.

Reports of Minority Program Members

On a scale from 1 to 10, when students were asked to give their interest in pursuing a scientific research career, RISE students consistently had interest equal to or higher than their non-program counterparts, and they showed less of a downward trend. Students in programs and students from the control groups both reported experiencing stereotype threat, but there was no significant difference in the level to which the two groups felt that threat was present. "So simply being in a minority program doesn't buffer you from the experience of stereotype threat," Woodcock pointed out. "You are still going to your classroom. You are still going to your lab. It doesn't buffer you from the experience of stereotype threat itself. You are still reporting to us that you are experiencing it just as much as your non-funded matched twins."

The researchers also found that stereotype threat did increase the likelihood of disidentification, with increasing stereotype threat causing decreased science identity over time. This in turn decreased the likelihood that students would pursue a research career. However, the study showed no relation between stereotype threat and science identity among members of intervention programs. "You still experience stereotype threat," Woodcock explained, "but it protects you from that experience having an impact on your contingency, your self worth as a scientist, and then down the track, having that process lead you down a different path."

While the study showed clearly that programs buffer the effect of stereotype threat on disidentification, Woodcock said they still do not have a good idea why. She laid out some questions for future research, such as whether the experience is the same across ethnicities and contexts, and which program elements are most significant.

SUPPORTING THE SCIENCE AND MATH EXPERTISE OF UNDERREPRESENTED MINORITY STUDENTS

Gail Coover, Executive Director of the Wisconsin Louis Stokes Alliance for Minority Participation (WiscAMP), presented information about WiscAMP Excel, an eight-week summer program for underrepresented minority students majoring in STEM. This program was designed to support students' development of math and science learning self-efficacy. The purpose of the

presentation was to provide an illustrative example of how specific concepts from Bandura's theory of self-efficacy were translated into the program elements of WiscAMP Excel and to provide evidence in the form of qualitative data about the students' math and science learning self-efficacy.[2,3] The program focused on developing students' self-efficacy because self-efficacy expectations are predictors of interests, goals and actions.

Bandura identified four key components of any learning experience that are necessary for individuals to develop self-efficacy within a domain. In order of importance from most to least significant, these components are:

- Mastery experiences
- Vicarious learning
- Verbal persuasion
- Positive emotional states

Bandura noted that "successes heighten perceived self-efficacy; repeated failures lower it, especially if failures occur early in the course of events and do not reflect lack of effort or adverse external circumstances." This dynamic is particularly relevant to the experiences of students targeted for participation in WiscAMP Excel. The WiscAMP project involves an alliance of 22 institutions across Wisconsin that are collectively committed to doubling the number of underrepresented minority students who graduate with bachelor degrees in STEM. Given the relatively small size and the distribution of minority communities in the state, most WiscAMP students who receive their bachelor degrees in STEM do so in predominantly white institutions (PWI). In addition, only a very small minority of the underrepresented minority students at many of the PWIs in Wisconsin choose to major in STEM. Consequently, the vast majority of underrepresented minority students in STEM experience their academic careers within the context of being a double minority: an ethnic/racial minority on the campus as a whole, and a minority within their own ethnic/racial group with respect to their chosen major. This context almost inevitably leads to stereotype threat, thereby discouraging student persistence, weakening student performance, or both.

A Focus on Student Retention

As with the United States as a whole, the attrition rates for underrepresented minority students in STEM at UW-Madison are highest between freshman and sophomore year. WiscAMP Excel engages students whose class performance in the first year threatens their persistence in a STEM discipline. In particular, students who received a grade of B/C or C in calculus-level math, chemistry, biology, or physics are candidates for the program.

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[2]Bandura, A. (1986). Self-efficacy mechanism in human agency. *American Psychology* 37:122–147.

[3]Bandura, A. (2001). Social cognitive theory: an agentic perspective. *Annual Review of Psychology* 52:1–26.

The program involves eight weeks of summer school. Room, board, and a stipend are provided. In turn, students commit to participate fully in all classes and activities and to be on time. The program has classes Monday through Thursday, including a class on communication and study skills. Fridays feature enrichment activities and field studies.

In math, students are divided into groups to accommodate their different levels, thereby ensuring that students have ample opportunities to master content repeatedly and receive feedback on their performance. Students work individually and in groups, again ensuring that students have access to vicarious learning experiences. After eight weeks, students place on average one class higher on the math assessment compared with the beginning of the program.

The communication and study skills class emphasizes career and academic major advising. Students engage in independent projects such as developing their academic plans for declared and alternative majors, making a thoughtful response to a selected book, conducting an informational interview with a professional, reporting on peer best practices, and doing a juried poster presentation of a research project.

The curriculum is designed so that the task difficulty is slightly greater than students' current ability. Students are exposed to vicarious successes and role models, with opportunities to present successes and correct errors. Each student's performance gets honest feedback, with specific information about how to improve their skills and performance. Instructors and staff meet regularly to monitor students' work and to evaluate the qualities of the learning environment—specifically to ensure that the classroom and activities create a positive, supportive, and safe space for students.

Evidence of Developing Self-Efficacy Expectations

At the end of the eight-week program, students are asked to reflect about what is different for them compared to the beginning of the program. The following quotations provide some evidence that participation in the program did strengthen students' self-efficacy expectations in science and math. One wrote:

> I feel very prepared for my math and science courses next year, and for whatever challenges may come my way. The program really helped me to confirm my abilities and discover some that I never knew I had. I would highly recommend the program to any student that feels overwhelmed with their schooling and unsure about what steps to take toward accomplishing their academic goals.

Another wrote:

> The first and probably the most important was not to give up on engineering. Not because of the money I would lose if I had decided to switch majors, but because of the opportunities that I would lose out on.

Finally:

Most of all, I have become less discouraged by the mistakes I have made and more confident about the situation I am currently in because I have a plan for succeeding, and with that I can achieve any goals I have set for myself.

SELF-EFFICACY AND SCIENCE IDENTITY IN AN UNDERGRADUATE NEUROSCIENCE SUMMER PROGRAM

Brian Williams, who is a member of the research team for the Behavioral Research Advancements in Neuroscience (BRAIN) program, used the program as a case study to explore self-efficacy and science identity. The hypothesis behind the program is that a collaborative learning experience will positively affect student outcomes to the same or a greater degree than a traditional research apprenticeship. Expected outcomes include:

- Neuroscience research skills self-efficacy
- Mastery of neuroscience content
- Mastery of neuroscience process skills
- Progress in neuroscience related careers

The project's aims are to maximize outcomes for women and underrepresented groups and to cultivate the next generation of neuroscientists.

The Intervention Model

The BRAIN program contrasted a traditional apprenticeship of mentored research in an active lab integrated with ongoing research and resulting in an individual research report (the right brain model) with team-driven research that results in a mini-grant proposal based on collected preliminary data (the left brain model). The overall approach is based on Bandura's definition of self-efficacy as the belief in one's capabilities to organize and execute the courses of action required to produce given attainments.[4] According to Bandura, self-efficacy beliefs are constructed from four principal sources of information:

- Mastery experiences that serve as indicators of personal capability
- Vicarious experiences that affect efficacy beliefs through comparisons with others
- Social persuasions
- Physiological and affective states

Of the four sources of information contributing to an individual's development of self-efficacy, mastery experience is the most influential, Williams

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[4]Bandura, Albert. (1997). *Self-Efficacy: The Exercise of Control.* New York: W.H. Freeman.

reported. According to Bandura, mastery experiences contribute to the development of self-efficacy not simply through these experiences, but through an individual's *reflection* on, and *interpretation* of, these experiences. Furthermore, situational factors have an effect on an individual's interpretation of mastery experiences.

Many of the situational factors thought to influence the interpretation of mastery experiences are found in the BRAIN program, Williams said. Among these factors are:

- Persevering in the face of challenges and overcoming setbacks
- Modeling of successful strategies
- Cognitive simulations of successful performances
- Having mastery experiences organized in ways that are conducive to the acquisition of generative skills
- Support in cognitively processing performance

Improvements in Self-Efficacy Beliefs

In the study described by Williams, self-efficacy beliefs were measured quantitatively using an instrument developed by Martin Chemers.[5] Four students were asked to rate their confidence in their ability to generate a research question, figure out what data to collect, create explanations for the study's results, and relate results and explanations to the work of others. They then participated in semi-structured interviews focused on mentorship, scientific research, scientific communities, student confidence, and career goals and plans. Interview transcripts were analyzed to identify emergent themes, ideas, and patterns within and across students.

Quantitative data from the study indicate that increases in self-efficacy occurred for two of the students. However, the higher ranking students—a senior and a graduate student—did not see large increases in self-efficacy.

Regardless of these indicators, all students stated that they felt more confident in some aspects of their abilities related to scientific research at the end of the program. As one student said, *"I'm pretty comfortable with animal research in rats at least.* You know, I can learn research projects pretty easily and do tasks pretty easily. So it increased my confidence in technical skills."

Students also said that overcoming obstacles and challenges, such as unavailable mentors or having to solve a problem on their own, was integral to their growth. One said, "We spent hours arguing over almost everything, especially because one of our group members was a bit more on the argumentative side, which wasn't bad because she gave us points of view."

Finally, students identified several shifts in the ways in which they thought about themselves as members of the scientific community. According to one, "Before, I didn't include students in the scientific community, I don't think. Now, I definitely think that students are part of the scientific community."

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[5]Chemers, M. M., Hu, L., and Garcia, B. (2001). Academic self-efficacy and first-year college student performance and adjustment. *Journal of Educational Psychology* 93(1):55–65.

Remaining Questions

The study raised several new questions, Williams said. The two students who showed no improvement in self-efficacy on the quantitative instrument nevertheless reported improvements in confidence in their interviews, but the reasons for this contrast are not clear. Also, how can the BRAIN program support students' affective states regarding their ability to conduct scientific research effectively, especially when facing obstacles? Finally, how do factors and characteristics specific to individual students influence the ways in which they experience the BRAIN program, think about the experience, and change in terms of science research self-efficacy?

UNDERGRADUATE RESEARCH PARTICIPATION AND SCIENTIFIC SELF-EFFICACY

U.S. students have markedly low participation and performance in STEM fields, noted Frances Carter, a recent PhD graduate from the University of Maryland, Baltimore County. Only 35 percent of STEM PhDs granted in the United States are awarded to U.S. citizens, and less than 10 percent are awarded to underrepresented groups.[6] A quarter of U.S. STEM occupations are held by foreign-born scientists, and that number is bound to rise if the United States does not encourage and prepare more students, including underrepresented students, to pursue STEM careers.

Policy responses to the low participation of U.S. students in STEM fields have included improving STEM instructional methods, scholarships and financial assistance to STEM majors, intervention programs such as tutoring and mentoring programs, and undergraduate research and internship opportunities. Carter focused specifically on undergraduate research and its relation to student self-efficacy beliefs.

Why Undergraduate Research Works

Undergraduate research has many positive relationships with STEM student outcomes, Carter observed. It increases bachelor's degree completion, persistence in STEM majors, and pursuit of graduate and professional degrees. It also has professional, cognitive, and non-cognitive benefits related to the process of "becoming a scientist."

Carter looked at a non-cognitive benefit termed *scientific self-efficacy* and at a cognitive benefit called *scientific research proficiency*. Scientific self-efficacy she described as judgment of capabilities to organize and execute actions for science performance. Scientific research proficiency she defined as skills in conducting laboratory-based research in STEM fields. While scientific self-efficacy has been linked to positive student STEM outcomes, scientific

[6]Committee on Science, Engineering, and Public Policy. (2011). *Expanding Underrepresented Minority Participation: Science and Technology Talent at the Crossroads.* Washington, DC: The National Academy Press.

research proficiency has previously received little study and has not been applied to undergraduate research.

The study Carter described estimated the relationship of summer research participation with both scientific self-efficacy and scientific research proficiency. The study compared students undergoing a science research experience with a comparison group of students not participating in undergraduate research. The goals of the study included designing and implementing a survey instrument with scientific self-efficacy and scientific research proficiency scales as well as providing evidence of the psychometric properties of the scales. The study used cognitive interviews to pilot survey questions, two waves of online surveys, and focus groups to address the study's objectives. Wave 1 had 207 respondents and wave 2 had 127 respondents. The majority of respondents were underrepresented minorities split between the natural sciences and engineering and computer science.

Subsequent to the survey development, data collection, and psychometric analysis, difference-in-difference analysis was applied to one scientific self-efficacy factor and four scientific research proficiency factors that resulted from the psychometric analysis. The scientific self-efficacy factor was generally referred to as scientific self-efficacy while the scientific research proficiency factors were conceptualized as (1) the use and purpose of research literature, (2) scientific writing, (3) understanding of scientist career structure, and (4) research presentations. The difference-in-difference method estimated the main effect of participating in undergraduate research on the scientific self-efficacy and scientific research proficiency factors as well as allowing the analysis to account for unobservable factors.

The most notable effect of summer research participation was an increase in scientific self-efficacy, Carter reported. In contrast, research had far less of an effect on proficiency factors, including scientific writing, understanding of scientist career structure, and research presentations. However, certain characteristics of summer research had a more substantial effect on these two measures. For example, students who presented a poster experienced gains in both scientific self-efficacy and their understanding of the scientist career structure, and students who were given weekly tasks by their research supervisors gained a greater proficiency at making research presentations.

The focus groups with students supported previous understanding of scientific self-efficacy increasing via mastery experiences, physiological states, vicarious learning, and verbal persuasion. Positive experiences reported by students included presenting a poster, supervision by a researcher, developing an identity as a scientist, and developing an intention to attend graduate school. Negative experiences included not completing a research project.

Conclusion

Carter concluded that both scientific self-efficacy and scientific research proficiency are measurable constructs when applied to undergraduate research participation. However, the study did not produce strong evidence for an influence of summer research participation on these measures. The limited sample size produced relatively low power, and the lack of program

participant variability may have attenuated changes in measures of scientific self-efficacy and scientific research proficiency.

The benefits that were measured vary according to the characteristics of the research experiences. The presentation of research, the supervision provided, and training experiences all had influences on changes in self-efficacy and proficiency. Testing for different amounts and combinations of research participation, comparing different programs, including science identity measures, and continuing to control for unobserved differences would all help establish better relationships with research participation.

"PROGRAM"—THE FAMILIAR, REVISITED

Finally, John Matsui, cofounder and director of the Biology Scholars Program at the University of California, Berkeley, spoke about some of the aspects of intervention programs that influence research choices. The Biology Scholars Program has seen about 2,500 students graduate with grade point averages equivalent to majority students outside the program, even though 80 percent of the students in the program are first-generation, low-income students, 70 percent are women, and 60 percent come from underrepresented minority groups. "I'm very proud of those students," said Matsui. At the same time, their success provides insights into the larger conversation about how to diversify STEM education and careers.

Understanding What Works

The traditional list of interventions for undergraduate students, Matsui observed, includes mentoring, research experiences, financial support, tutoring and academic support, personal counseling and advising, career development information, and fostering community. Interventions for graduate students constitute a similar list, including fellowships, professional development, and mentoring. "The question I want to ask," Matsui said, "is, if it's as easy as implementing these lists, why does underrepresentation in STEM still exist? These lists have been out there for about 40 years, ever since affirmative action came on the scene. We have spent billions of public and private dollars establishing programs that essentially have these lists of things."

Matsui said that he has heard various reasons for the continued disparity, including lack of student preparation and motivation as well as overarching institutional inequities. However, framing the problem that way is not useful for implementing changes, since it focuses on circumstances beyond the control of most programs. "We need to go back to basics," he said. "We need to revisit the familiar and take a critical look at this notion of program. What do we have control over? What do we need to change in terms of what we are doing?"

Four Observations

Matsui presented four observations, with the goal of raising questions for further consideration.

First, the selection of students for diversity programs can be difficult, since program directors want both the student and the program to succeed. This often means choosing students who fit all the qualifications—grade point averages, test scores, commitment to service—that predict they will do well, and possibly ignoring students with potential who lack the traditional indicators. Establishing alternative guidelines, Matsui argued, could be beneficial, as would looking at how a program defines success outside of grade point average and degree accomplishments.

Second, programs generally agree on how to treat students once they are admitted, generally adhering to the list of successful program strategies. However, could working with students for short-term success compromise their long-term success, Matsui asked. "One of the things that I have learned is that the devil is in the implementation of the things from the list—the specifics of our treatment, who does it, how we do it, and the population of students to which we apply this list." He talked about the need to teach open-ended science, exposing students early to the possibility that experiments they expect to succeed may not succeed, or not in the way they have predicted. A one-dimensional approach to teaching, he said, even if intended to help students succeed, "ill prepares students for an open-ended life without a program." The message such instruction conveys is "Follow what I say. Don't think for yourselves. Do what I say you should do."

Third, students need to learn how to fail. According to Matsui, there are fatal errors and sublethal errors. "Failure with the appropriate safety net can actually help students realize that they don't have to depend on the program," he said. Instead, they can rely on information gathering, conversation with others, and problem solving to them get them through rough patches, which is a skill they need to learn.

Finally, failure can promote creative thinking, but it also can cause severe problems. In particular, students who are failing can become irrational. Matsui drew an analogy to poker, where a player is said to go "on tilt" when losing, becoming aggressive and choosing poor strategies in an effort to recoup past losses. Students who have a bad semester may try too hard to make up for it and lose focus. He recommended that program directors be aware of their own attitudes, and whether they are trying to win too quickly by emphasizing the selection process over how they treat students once they enter the program. "Finding the answers to these and other related questions, I believe, constitutes our challenge and is the work before us all."

3

Designing Effective and Sustainable Programs

In contrast to the theoretical perspectives presented in the previous chapter, several presenters at the conference took predominantly programmatic perspectives on interventions designed to increase participation of women and minorities in research. How can programs be designed, implemented, and developed to be effective and sustainable? What are the best ways to pool resources and tap diverse expertise? How can interventions be integrated so that together they have a greater impact than each would separately?

Partnerships were a theme of several of the presentations described in this chapter. Speakers talked about several types of partnerships, but all found that certain ingredients were crucial for a strong and sustainable relationship. Open communication is vital for effective collaboration, along with a willingness to modify programs as weaknesses come to light. Evaluation on a program-wide level is useful, but if many universities are involved there also should be individual assessment. All partners should have an equal say and be committed to the students, not just to the benefits institution receive. Cultivating this student-centered environment helps build community by providing students and faculty with the sense of belonging to a larger effort.

DESIGNING, IMPLEMENTING, AND DEVELOPING
SUSTAINABLE PROGRAMS

For intervention programs to be effective, they need to be sustainable. "We are all familiar with the scenario in which there's an initial champion of a particular cause and there's a lot of energy and effort put into a particular program," said Mary Boyd, Dean of the College of Arts and Sciences at University of San Diego. "But if the program is not designed with an inten-

tion to see how it will continue in the future when those initial energies are exhausted, then much good work can be wasted."

Boyd and Jodi Wesemann, Assistant Director of Higher Education at the American Chemical Society, collaborated on a book that presented strategies for designing sustainable programs that build the capacity of students, faculty, and institutions and can be adapted to all institutional contexts.[1] During a workshop on the first day of the conference, they described ten best practices for interventions programs developed from the Building Engineering and Science Talent (BEST) program.[2]

1. *Institutional Leadership*   The first design principle is a commitment to inclusiveness and excellence across the campus community at all levels. Examples of institutional leadership include:

- Including high-impact practices in excellence initiatives
- Providing seed funding and cost sharing for grants
- Coordinating efforts among campus units
- Creating positions or offices to coordinate undergraduate research activities
- Recognizing faculty efforts in evaluation, promotion, and tenure
- Generating support for high-impact practices as part of an endowment campaign
- Requesting funds for high-impact practices in grant proposals

"Anybody can be a leader in these efforts," Boyd said. However, people with lofty titles need to be on board. She emphasized the necessity of an institutional commitment backed by resources. "This is one of the more difficult, or more comprehensive, of the design principles."

2. *Targeted Recruitment*   Efforts to engage those who have not traditionally participated requires "thoughtful intentionality," Boyd said. What is your target group? Is it a particular demographic group? Depending on the type of institution, and whether there is an emphasis on research or teaching, that target group might vary. Establishing connections with local communities is one way to embody this principle, as well as reaching out to groups that have not previously been involved. Other examples of this principle in action are:

- Hiring faculty who can serve as role models
- Providing high-impact opportunities for first- and second-year students

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

[2]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.

- Linking research projects to community needs
- Extending invitations to become involved

3. *Engaged Faculty*   "A colleague of mine once said that faculty want only four things: time, money, appreciation, and love," Wesemann said. "My faculty are super smart, super committed, super talented, and super, super busy. If I want to ask them to take on another commitment or responsibility, I have to acknowledge that in a lot of different ways." Ways to invest in faculty and build capacity include:

- Hiring faculty with interests in research and student engagement
- Providing faculty stipends
- Providing reassigned time
- Aligning efforts via a coordinator or office
- Providing mentor training and resources
- Involving postdoctoral fellows and graduate students
- Including student outcomes as a rewarded faculty outcome

4. *Personal Attention*   One program or one office cannot provide students with all the resources they need to thrive academically, socially, and in their research endeavors. Teamwork and coordination are needed across a campus to make sure students have access to career advice, good role models, academic help, and mentoring. Examples of this principle in action include:

- Tapping into national programs
- Mentoring
- Tutoring
- Curricular reform
- Supplemental instruction
- Academic advising
- Career and professional advice

5. *Peer Support*   Opportunities for interactions with peers and near peers are needed to build networks and community. These opportunities can be provided by:

- Encouraging participation in national and local organizations
- Organizing community-building activities
- Establishing vertically-integrated student research teams
- Developing participant cohorts
- Using peer mentors
- Integrating student interpreters into laboratories
- Involving peer leaders in workshops

6. *Enriched Research Experiences*   "A large body of work shows the effectiveness of undergraduate research experiences—or even pre-undergraduate research experiences—for students, and the benefit it provides to students, to

faculty, and to institutions," Boyd said. "It has a broad suite of positive out-
comes." Examples of opportunities for enriched research experiences include:

- Collaborative projects
- Summer undergraduate research programs
- Academic year research
- Authentic research modules that replace standard experiments
- A research-rich curriculum

7. *Bridging to the Next Level*   Students need relationships that provide path-
ways through key transition points. This requires purposefully monitoring
and supporting transitions between high school, undergraduate, and gradu-
ate education. Valuable steps include:

- Establishing connections with other institutions
- Preparing for the next level
- Building relationships with role models
- Creating research and learning communities
- Offering mentoring that continues after transitions are made

8. *Continuous Evaluation*   For a program to be as effective as possible, it needs
to be continuously evaluated. Evaluation also provides a program with the
tools to demonstrate its impact, which is necessary for funding agencies, ad-
ministrators, and other stakeholders. Best practices include:

- Establishing goals and milestones
- Obtaining funds targeted for assessment
- Integrating support for evaluation into program structure
- Aligning impact measures with institutional data (for example, student
  outcomes, graduation rates, or matriculation into graduate school)
- Tracking students over time

Assessment requires time and resources, said Wesemann. Also, comparison
groups are one of the clearest ways to measure efficacy, but students must
self-select, since purposefully withholding a beneficial treatment brings up
ethical issues.

9. *Comprehensive Financial Assistance*   Financial support is often critical for
groups that have not traditionally participated. Some ways of obtaining such
support are:

- Obtaining funds for supporting high-impact practices
- Providing stipends
- Offering reassigned time
- Providing tuition waivers
- Offering financial aid packages
- Providing scholarships
- Establishing a continuum of programs to support students

"If people don't have the financial wherewithal to do things, it's not going to happen," Wesemann said. A further challenge is sustaining this support. "It's nice when you get the grant, but it often can be very hard if you haven't positioned yourself to sustain it with data and leadership along the way."

10. *Evidence-Based Approaches* "A lot of work has been done, and it's important to be familiar with the different activities other people have done so that you can just move forward with implementation without reinventing the wheel," said Wesemann. In that vein, it is important to write up the results of a program to contribute to the community and continue working toward a repertoire of best practices. Programs can be designed based on studies of:

- College retention and success
- Peer support
- Responses to identity and stereotype threat
- High-impact practices

Sustainable programs need to be inclusive, comprehensive, and aligned with institutional context, Boyd and Wesemann said. Building sustainable programs therefore involves designing and implementing plans, leading change, and maximizing investments.

Boyd and Wesemann also emphasized the importance of all the design principles, not just some of them. "It's not a menu. You can't just pick and choose," Wesemann said. "I suspect many of you have the components on your campus, but might benefit from weaving them together more cohesively."

Finally, they listed some of the ways to transform visions into sustainable programs:

- Be inspired
- Gather information
- Find collaborators
- Develop skills
- Be receptive
- Align efforts
- Set the agenda
- Anticipate changes

THE LEADERSHIP ALLIANCE

Medeva Ghee, Executive Director of the Leadership Alliance, pointed to the role of partnerships in building effective and sustainable programs. The Leadership Alliance ("the Alliance") is a national consortium of 32 institutions with the shared mission of developing underrepresented students into outstanding leaders and role models in academia and in the public and private sectors. The Alliance provides the infrastructure for institutional collaboration to implement programs in support of the academic and career development of young scholars, to conduct long-term assessment of program efficacy and monitor student outcomes, and to develop strategies that promote a collab-

orative environment. The organization has a diverse membership, encompassing leading research and undergraduate-focused institutions. Of the 32 member institutions, 22 offer summer research programs. Leveraging the resources of partner institutions, Ghee explained, is critical for maximizing the success of the program.

Summer Research

The Alliance's flagship program is the Summer Research Early Identification Program (SR-EIP), which began in 1993. The program provides research experiences for students in the biomedical sciences, physical sciences, social sciences, and humanities. In 1995 the Alliance began holding its Leadership Alliance National Symposium, which is designed to build community among students doing research at various institutions across the country and provide a national research presentation stage for SR-EIP participants and constituents of the Alliance network. The symposium also offers professional development, mentoring, and networking opportunities for students at each successive stage of the academic pathway. In 2008, the Alliance celebrated its first 100 doctoral scholars, alumni of the SR-EIP who have obtained a PhD or MD-PhD.

The SR-EIP is open to students from Alliance institutions as well as from other institutions across the United States. Approximately 60 percent of SR-EIP students come from Alliance institutions, while the other 40 percent represent over 100 unique non-member universities. The program recruits diverse undergraduates who are primarily, but not exclusively, underserved and disadvantaged and who have expressed an interest in research careers. Participants submit a common application to apply to up to three research sites. In addition to monetary support, research institutions commit to providing a high-quality research experience with top-notch faculty at some of the nation's most competitive graduate training universities. In support of these efforts, the Alliance seeks support from federal and private resources to fund these initiatives. "We all work together to provide the competitive research experiences," Ghee said, "as well as skills and professional development training."

Between 1993 and 2009, SR-EIP participants were 54 percent African American. Current program participants are 40 percent black and 39 percent Hispanic, with a 2:1 female to male ratio. At the onset of the program more than 150 students participated every summer, with that number increasing to more than 200 students in recent years.

A focus on research skills and communication skills combined with professional development are the core elements of the program, Ghee explained. These are incorporated in the ancillary training activities at every institution. Each university shares its activities at the Leadership Alliance National Symposium, contributing to a growing pool of knowledge.

The national symposium gives participants a supportive venue to present their research, a particularly important component of a program where the majority of students have never attended a conference. The symposium "is

where possibilities are realized," Ghee said, "because students come to this conference and they see others who look like them and who have a similar cultural background in academia and other career sectors. When students see others at advanced stages along the training pathway who are accomplishing goals similar to their own nascent goals, it helps to clarify and validate their decision-making processes and training goals. Within a supportive environment, students obtain advice from a trusted network."

Program Evaluations

The Alliance administers a yearly on-site evaluation of the symposium that collects both quantitative and qualitative data on student satisfaction and participation. Student satisfaction was assessed by the rating each student gave to a symposium program element on a five-point Likert scale that ranged from a high of "very valuable" to a low of "no value." Satisfaction rates are defined as the percentage of respondents rating the element in the top categories of "very valuable" and "valuable." Undergraduates, graduates, and doctoral students complete evaluations, but Ghee showed only data from the undergraduate students.

Workshops on applying to graduate school and expectations once in graduate school received high ratings. Satisfaction with role models was also highly rated. In 2009, 97 percent of students gave a presentation, and over 85 percent were satisfied with the experience.

Since 2001, the Alliance has worked closely with external evaluators to assess the efficacy of the processes at the various institutions as well as the outcomes in relationship to the initial goals of the SR-EIP. From 2002 to 2010, students reported high satisfaction with their overall summer experience, understanding of research processes, and understanding of graduate school requirements. On average, over 90 percent of participants respond to surveys, which Ghee attributes to careful tracking and efforts by the executive office and program coordinators.

Ghee pointed out that the Alliance is able to respond to evaluations, which provide both qualitative and quantitative data, by adapting workshops and panels to better meet students' needs. She also emphasized the importance of the Alliance's longstanding relationship with external evaluators, who have helped design specific questions to address each institution's goals. A constant dialogue among coordinators, she said, is important for developing a structured framework of data collection that best serves the program's needs. The feedback from the evaluations has been used to adjust and improve the program for a continuous quality improvement opportunity. Further, the assessments provided the consortium with examples of best practices that could be adapted and implemented at any institution. This provides a total quality management function for the Alliance by reinforcing similar core strategies throughout the Alliance programs. A third value of these formative assessments has been recommendations for the Executive Office to improve the focus and effectiveness of the Alliance. As an example, the Alliance is increasing its efforts to expose students to the idea of the program early on,

speaking to freshmen and providing programs that are appropriate for less experienced scholars.

In addition to the survey, evaluators hold focus groups at participating institutions throughout the year and report at biannual business meetings. This gives the Alliance a sense not only of overall successes and areas for improvement but of the specific evaluation of each university and its individual programs. Ghee also discussed efforts to establish a comparison group for evaluation to balance out reliance on self-reporting.

Overall, the summer research program has had great success. One-third of the students in the program are still in school; of the 67 percent who have graduated, two-thirds have gone on to a graduate program and 25 percent of those to a PhD. Many of the doctoral scholars return to SR-EIP institutions for their PhDs.

Continuous monitoring of students who complete the program is essential to fully understand the long-term impact of the program and the factors that increase entry and completion of graduate training. The Alliance tracks all of its alumni, Ghee said, regardless of where they do graduate work or what degree they are seeking.

The Alliance also works to place students interested in postdoctoral opportunities and faculty positions. As students progress, they can become mentors for the next generation of program participants. "This was part of the promise of the Leadership Alliance," Ghee explained. Once students become the next generation of leaders and role models, they are connected with the generation after them. "We're starting to see our doctoral scholars who are writing letters of recommendation for undergraduates who are applying to our program."

Prerequisites for Success

Ghee pointed out that institutional commitment on the presidential level is a requirement for the sustainability of the Alliance. Also, in promoting a collaborative environment, effective communication and shared values go a long way. Representatives from each institution participate in shared governance, she said, and everyone is an equal partner. Institutional representatives were tasked at the onset to work together as equals toward the Alliance's common goal. This principle of equality is critical to establishing an environment of mutual respect and trust that prevails as a galvanizing feature of the consortium. In this way, the Alliance benefits from a diversity of perspectives and shared expertise as well as continuous discussion of best practices and institutional transformation. Overall coordination is maintained by an executive office and dedicated staff headquartered at Brown University.

"The Alliance has an established partnership, but we are also developing new strategies to build and reinforce our solid network of distributed institutional relationships to cement the foundation of Alliance programs and secure our future of developing the next generation of leaders and scholars. We don't think we've figured it all out," Ghee explained. "We have seen some really good results, but we're still working to improve how we work together."

A PARTNERSHIP IN ACTION

Pablo Mendoza, Assistant Director of the Multicultural Center at the University of Missouri, presented preliminary findings from a doctoral dissertation on a particularly effective partnership between a predominantly white institution (PWI) and a Bureau of Indian Affairs (BIA) university. The partnership embodies many of the design features discussed at the conference and serves as an example of effective collaboration.

The two schools began their relationship in the mid-1980s, when administrators at the presidential and provost level at both universities began examining the possibility of working together. At the BIA university, the administrators and faculty members Mendoza interviewed were most interested in relationship building and compliance with federal guidelines. Federal appropriations come to the university annually from Congress, along with instructions on how the university can disperse that funding. The university, which was formerly a tribal school, now wants to move from a four-year college to a master's-granting institution, so it is looking to improve its status and is paying careful attention to compliance with grants.

The administrators and faculty members Mendoza interviewed at the PWI were concerned primarily with creating a real partnership between the universities. That was "refreshing to hear," said Mendoza, who had previously done research on the campus climate for Native American students in partnerships where one university was gaining much more than the other. The PWI established an Office of Diversity and Science Training in an effort to get students the most benefit and involve participants of all ethnic backgrounds. The university had a strong focus on individual students rather than emphasizing benefits to the institution, such as increasing diversity numbers.

Faculty members at the BIA were interested in preparing students to "be instrumentally autonomous within a predominantly white culture," Mendoza said. In that way, they would be able to go back to their tribes and contribute, not just learn to be functional within a particular institution or discipline. Mendoza referenced Tribal Critical Race Theory, which focuses on the legacy of colonization and how the remnants of that history in society create inconsistencies that disadvantage indigenous students.

Opportunities and Obstacles

The partnership created an opportunity for students from the BIA university to use high-quality research facilities and work with faculty members on cutting-edge scientific challenges. The BIA university is sparsely funded and has only one chemistry lab, one computer lab, and one biology lab, so its students greatly benefited from access to more extensive resources.

Faculty at the PWI were very interested in attracting students from the BIA university to master's and PhD programs. By giving students access to research opportunities, the interviewees said, they hoped to broaden students' perspective and show them the range of possibilities in the sciences.

Mendoza pointed out that the faculty and students at both institutions received very little cultural preparation. For example, one faculty member

with experience on both campuses reported working with students to prepare them for teaching assistant positions at the BIA university, since the students experienced some degree of culture shock when making the transition.

Overall, Mendoza found, the partnership has had different but related benefits for each group involved. The program gives students from the BIA university skills and confidence that they can bring back to their tribal entities. It also opens a window onto a wide range of research questions and science careers.

The PWI benefits from increased diversity and an influx of students to graduate programs. Many students return to the BIA university after graduate school and become role models there, which fosters the continuity of the program.

Mendoza recommended that PWI institutions seeking to enhance the cultural integrity of students partner with tribal councils to enhance cultural competence. He emphasized the importance of building collegiate relationships and avoiding the patronizing tone that can sometimes hamper such efforts.

THE ROLE OF PROFESSIONAL ASSOCIATIONS
AND SCIENTIFIC SOCIETIES

George Wimberly, the Director of Social Justice and Professional Development at the American Educational Research Association, described some of the roles of professional associations and scientific societies in enhancing diversity in science.

The American Educational Research Association is part of the Collaborative for Enhancing Diversity in Science along with the AAAS Center for Careers in Science and Technology, the American Educational Research Association, the American Sociological Association, the American Psychological Association, the Association of American Medical Colleges, the Consortium of Social Science Associations, the Federation of American Societies for Experimental Biology, the Institute for the Advancement of Social Work Research, and the Society for Research in Child Development. With funding from the National Institutes of Health and the National Science Foundation, the collaborative conducted a study to determine what professional associations and scientific societies are doing and could be doing to enhance racial and ethnic diversity in science.[3] The study drew on a survey of 250 professional associations and scientific societies. It also convened a retreat with about 100 leaders from 37 associations, organizations, federal agencies, and private foundations.

A key finding of the survey was that respondents indicated being concerned or extremely concerned about the future availability of sufficient numbers of scientists, particularly those from underrepresented minority groups. Most associations reported sponsoring some form of training or career development activities for scientists, with an emphasis on underrepresented

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[3]Consortium of Social Science Associations. (2008). *Enhancing Diversity in Science: A Leadership Retreat on the Role of Professional Associations and Scientific Societies, A Summary Report.* Washington, DC: COSSA.

students, beginning as early as high school and continuing to early career. Wimberly listed some of the capacity-building activities cited in the survey:

- Science fairs
- Test preparation
- Academic enrichment projects
- Internships
- Mentoring
- Networking opportunities
- Scholarships
- Travel awards
- Conference support
- Membership discounts
- Dissertation awards
- Fellowships
- Research awards

Recommendations for Association Leaders

The study uncovered several efforts recommended by professional association leaders to further enhance racial and ethnic diversity in science.

Recruiting and retaining underrepresented minorities in science requires incorporating diversity goals into strategic plans, along with improving the collection and evaluation of empirical data on underrepresented minorities. Research on program outcomes can guide program changes while building support for program successes. Societies and associations need to communicate with universities about the status of underrepresented minorities in science to raise awareness. They also need to demonstrate commitment and leadership in setting expectations and norms for behavior.

Mentoring underrepresented minorities requires an infrastructure to support long-term mentoring relationships and to develop a mechanism to evaluate the sustainability of these relationships. Mentors and mentees need resources and programs, such as professional newsletters and web resources, to understand goals and expectations. Students can be invited to annual meetings so that they can engage in scientific and nonscientific programming and networking opportunities. Organizations also can collaborate to develop definitions of program success and program evaluation metrics.

Federal longitudinal data collection strategies for underrepresented minority issues, and financial support for program evaluation, can accelerate the evaluation of diversity programs. In addition, a joint public statement that simply and coherently articulates shared diversity goals and encourages policy development to affirm those goals could build support for diversity initiatives.

Finally, professional associations and scientific societies should gather data to inform policy decisions and work together to identify best practices and common challenges to enhancing diversity in science. This may involve examining the social science research on the benefits of diversity, translating

research findings into action steps, and recognizing and supporting effective institutional practices

ESTABLISHING INTERDISCIPLINARY COLLABORATIONS

NSF has recently sought to identify collaborative strategies across three of its directorates—Education and Human Resource (EHR), the Social, Behavioral, and Economic (SBE) sciences, and the Mathematical and Physical Sciences (MPS)—that would broaden participation of underrepresented groups. In November 2010, representatives of the three directorates were asked to form a task group on broadening participation, and the task group, which consisted of Kellina Craig-Henderson of SBE (chair), Claudia Rankins (EHR), Caesar Jackson (EHR), and Morris Aizenmann (MPS), was charged with addressing the following questions:

- What are the most promising roles and approaches for NSF to take in investing in broadening participation?
- Are there new programmatic directions that could be developed across directorates to move NSF's impact on broadening participation to new levels?
- What kinds of outcomes are right for NSF in the broadening participation area?
- What kinds of systematic collaborations among the three directorates, and possibly others, could be undertaken in FY11 that would help advance efforts in broadening participation?
- Might the three directorates sponsor some events or activities in the coming months to advance and deepen the NSF-wide focus on how programmatic investments can address broadening participation?

After a series of meetings, it was determined that, given the scope of the questions, a workshop would enable the widest population of researchers from across the different communities to engage and seek solutions to these vexing questions. To carry out the workshop, the group decided to supplement an existing award provided to one of the Understanding Interventions conference organizers, Daryl Chubin of AAAS. Invitations to attend the workshop were sent to individual researchers and teams of researchers whose research and in some cases administrative experiences reflected their own success at effective collaborations as well as broadening participation. In addition, several conference participants attended the workshop because of their interests in collaborations and broadening participation.

The aim of the workshop was to identify and provide a forum for presentation of exemplary collaborative efforts that broaden participation in science and education. The workshop also featured a panel discussion of academics and administrators engaged in some aspect of collaboration and broadening participation in STEM, including Carlos Rodriguez from the American Institutes for Research, Ann Gates from the University of Texas, El Paso (by phone), Keivan Stassun from Vanderbilt University, Lorraine Fleming from

Howard University, Hank Frierson from the University of Florida, and Ken Maton from the University of Maryland, Baltimore County.

The Need for Collaboration

The organizers began the workshop by discussing the need for collaboration, especially across various scientific communities. Research is increasingly interdisciplinary, said Craig-Henderson, which opens many avenues for collaboration. Rodriguez added that innovative interdisciplinary efforts are needed to provide diverse students with the resources and expertise to succeed in STEM fields. "The United States is at a crossroads," he said. Innovation drives 60 to 85 percent of GDP growth, including innovation in STEM fields, and even jobs not technically belonging to STEM professions often require scientific literacy. Meanwhile, a gap has formed between job openings and the next generation of U.S. workers. Underrepresented populations are a pool of untapped talent that can fill that gap, Rodriguez said. Enough overlap exists between methods and approaches in research fields ranging from the social sciences to engineering to allow for effective collaboration. Curricula and research programs need to be reformed to prepare and retain students. "We are challenged to work with our populations, especially underrepresented populations, to create a different habit of mind," Rodriguez said. "That is going to take a social scientist, a natural scientist, and the entire system to get that done."

Gates agreed. "Innovation comes from diverse thoughts and perspectives," she said. "Collaboration is a key part of that." Equal return on investment is an important determinant of an effective collaboration, she added. Projects should add value for all parties, not just serve to meet a quota or requirement of some kind.

"You have to put time in to build a relationship," she said. Building a successful collaboration means establishing shared core values, developing a community, and identifying a purpose. Institutional support is important, especially when it comes to performance evaluation and promotion. If an administration does not recognize the importance of collaborative efforts, it is difficult to be productive.

Cooperative Learning

Gates explained that she works on two collaborative NSF-funded projects—the Computing Alliance for Hispanic-Serving Institutions (CAHSI) and Cyber-ShARE, which stands for Sharing Resources to Advance Research and Education through Cyberinfrastructure—that use a cooperative learning model. The model has five elements: positive interdependence, promoted interaction, practicing and teaching cooperative skills, reflection, and communication. "When you have positive interdependence," she said, "everyone understands their role in the project. It is all for one and one for all. The success of the project is not the success of one person but the success of everyone working together."

Recognition of individual contributions is important, she said, but should not be valued over the success of the group. The CAHSI team, for example, defined its core purpose early on, asking members as well as top administrators at participating institutions to sign a memorandum of understanding (MOU). The MOU, which has been very successful, asked for collaboration among faculty and funding for student research experiences, Gates said.

Challenges to Collaborations

Fleming talked about some of the challenges to successful collaboration. Fleming runs week-long workshops for STEM faculty designed to help them come up with ideas and strategies for interdisciplinary projects. The first obstacle for most faculty, she said, is deciding with whom to collaborate. "We show them that they can find collaborators in many, many different areas," Fleming said, suggesting that faculty look in education, psychology, communication, curriculum development, and other fields.

Another issue is how to work with people who think differently, she explained. "When you work with social scientists, you have to be friends. You have to like working together. You have to like sharing ideas and learning from them." Different disciplines have different communication styles, and team members may have varying ideas about how to map out a project. Social scientists rely on theoretical frameworks that may be unfamiliar to researchers from other departments. For example, scientists and engineers often have difficulty working with qualitative research, though it is an important component of social science results.

There are challenges within the social sciences, said Frierson. Funding is a major issue, as is the lack of sustained programs that promote collaborations. Many social scientists feel like outsiders in organizations like the National Science Foundation and National Institutes of Health, he said.

When STEM practitioners work with social scientists, both sides of the collaboration are enriched. Such collaborations can be encouraged by providing opportunities for departments to interact. Funding agencies also can prioritize interdisciplinary research. And administrators are more likely to give support if faculty are able to acquire funding or demonstrate that their collaborations are valuable, Frierson noted.

Models of Collaboration

Maton observed that there are various models of collaborative research. One of the most useful is insider/outsider research, where one collaborator has in-depth knowledge of a field and the other brings theories, methods, and knowledge of how to address a question within that field. For example, the insider may know what it takes for students to succeed in a field, while the outsider provides a different perspective and research methodology to create a more nuanced picture of success.

Trust is key in such collaborations, Maton pointed out, as is open-mindedness for both parties. In an ideal situation, the collaborators would

decide jointly on a hypothesis, study design, and data collection approach. The success of such collaborations can be assessed using research on collaborative models and team science, he said. Collaborative research should result in new insights, enhanced understanding, and improved methods. Future teamwork is another positive outcome. Successful experiences can generate momentum for such efforts in the future.

Tensions will arise, he pointed out. "All collaborations of this sort are going to have real issues with language and terminology." Spatial distances also can inhibit collaboration, but even informal interactions in a shared space can foster teamwork.

Involving Multiple Groups

Participants discussed the need for integration of disciplines at all levels, even at the undergraduate level. One brought up the necessity of forcing the conversation, to some extent, pointing out that interdisciplinary efforts may not begin naturally. Tenacity and leadership are crucial to sparking new endeavors and ensuring that they will continue. Gates agreed, adding that any attempt to promote collaboration will raise awareness.

At the University of Pennsylvania, said Marybeth Gasman, the provost brings together faculty in the sciences and social sciences as part of a committee once a month. "People are very committed," she said. She emphasized the importance of outreach, presenting to administrators, and following through with anyone who expresses interest. "It takes a lot of pushing," she said. It takes keeping it on the table constantly. I've seen wonderful, wonderful change."

A Manual for Collaboration

After breaking into groups, participants worked on outlining a manual for collaboration and subsequently shared their ideas with the other workshop participants.

It is important, one group said, for potential collaborators, and the general population, to have an awareness of the internal and external barriers facing underrepresented minorities in STEM. Important questions include:

- What would it take to promote effective collaborations?
- How would we promote effective collaborations?
- How do we evaluate interventions?
- What is really possible in a generational time frame?

Several groups emphasized careful coverage of best practices and a chapter or section devoted to case studies and examples of successful collaborations. Case studies should identify what has worked, what has not worked, and the headwinds facing best practices.

Building the right team was another area of emphasis. In particular, every team member needs to have the same level of commitment.

Most of the groups also focused on successful communication, and some discussed the importance of funding and resources.

Parting Comments

"We hope that you leave here with commitments to your newly formed and newly established partnerships and collaborations," said the NSF's Jackson, one of the workshop organizers. "We hope that you will draw on cross-disciplinary knowledge, capability, and skill that are necessary to address all aspects of the problems and challenges associated with broadening participation in STEM."

4

Programs Focused on Undergraduates

The most common target of interventions designed to broaden partici-
pation in research careers is the undergraduate student population,
and the majority of programs discussed at the conference involved
undergraduates. Only one presentation at the conference (described in the
first section of this chapter) focused on K–12 education. Presentations on
undergraduate education examined the experience of first-year students and
the retention of academically gifted African American students. A particular
emphasis at the conference was the effects of undergraduate research on un-
derrepresented students.

BROADENING PARTICIPATION OF TENNESSEE GIRLS IN STEM

As in the rest of the United States, recruitment, retention, and graduation
of women with STEM training are critical needs in the state of Tennessee.
Judith Iriarte-Gross, a chemistry professor at Middle Tennessee State Univer-
sity (MTSU), has been involved with Expanding Your Horizons in Science and
Mathematics (EYH), a girls-only conference designed to encourage middle
and high school girls across the United States and around the globe to pur-
sue STEM education and careers. Only 18.3 percent of women in Tennessee
hold a four-year degree or better. For that reason, said Iriarte-Gross, "girls in
middle and high school in Tennessee are a vast and largely untapped source
of STEM majors."

Iriarte-Gross has been a leader of the MTSU EYH Conference, which
was first held at Middle Tennessee State University in 1997. Since then it has
served more than 4,300 middle school girls, and a high school program began
at the university in 2007.

According to a survey of approximately 1,200 girls after their participation in the EYH conference, three-quarters judged the planning of future high school and college courses offered by EYH mentors to be useful or very useful. Slightly more felt the same about being introduced to careers they knew nothing about by EYH mentors and learning what a STEM professional does in a normal day. And more than 90 percent reported that EYH had increased their awareness that taking both science and mathematics courses is important for a successful career in STEM.

Factors Contributing to Success

Iriarte-Gross pointed to several factors that encourage girls to pursue STEM degrees. One is to recognize and make visible women involved in STEM fields, who then can act as role models and advisers. Girls tend to be particularly receptive to the message that a career in a STEM field helps people. Furthermore, there are many ways to connect STEM fields to everyday things that are of interest to girls.

Parents and teachers have the most powerful influence in sparking a child's interest in mathematics and science. Mentors and advisors also can have a major influence. A female STEM major at Middle Tennessee State University who had been active in the program wrote, "Encouragement is the key. I know, from my own experience, that the enthusiasm and encouragement that I got from my teachers and advisor helped me to pursue my passion." In that respect, a severe lack of mentors poses serious challenges to the future success and achievement of women in STEM fields, Iriarte-Gross observed.

She closed by quoting Nobel laureate Rosalyn Yalow: "The world cannot afford to lose half its people if we are to solve the many problems that beset us."

THE FIRST-YEAR EXPERIENCES OF HIGH-NEED, HIGH-POTENTIAL STUDENTS

William Wulf, former president of the National Academy of Engineering, once said, "without diversity, engineering cannot take advantage of the life experiences that bear directly on good engineering design." The concept of diversity as a contributor to the solution of complex social-scientific challenges is at the center of a program at Purdue University for high-need, high-potential students. Loran Carleton Parker, an assessment specialist with Purdue's Discovery Learning Research Center, spoke about the center's evaluation of the program, with a particular focus on the first-year experiences of students.

The Partnership for Recruiting and Retaining High-Need, High-Potential Students to Food, Environmental, Engineering, and Life Sciences (FEELS) program targets students in STEM-focused degrees in the College of Agriculture at Purdue. Students receive up to $10,000 in scholarship money to attend the university and participate in an articulated program to help them acquire the

professional contacts and credentials necessary for success. Selection to the program is competitive, with interviews, GPA, and essay requirements. The program recruits students in cohorts of 10 or fewer with consideration for the racial, ethnic, and socioeconomic diversity of the cohort. With three cohorts enrolled so far, 79 percent of the students have been ethnic minorities or first-generation college students.

Each year of the program has a themed seminar. In the first year, Parker explained, students learn about university resources and "grand challenges" in the life sciences and engineering, as well as about potential research opportunities. In the second-year seminar, students explore academic research. Business and industry are the focus of the third year, and students spend time making contacts and looking for internship mentors. They also are required to have an internship as part of their junior year experience. For the senior year seminar, the students will design a service learning project.

Support and community are important themes in a successful program. Core classes are scheduled together when possible. Social activities, community service events, and shared study time are a few of the ways that program directors attempt to create a beneficial community for program participants. Students also have mentors for the activities associated with each seminar, including a program manager, who serves as a core mentor; an academic mentor; a research mentor; and an internship mentor. In this way, students potentially graduate with four different people to whom they can turn with questions, concerns, and problems.

The program is designed to give each cohort a well-rounded experience and a full portfolio of activities. Comfort in both the academic and business world, Parker said, is key, so program directors want students to try different activities and acquire as many contacts as possible.

First-Year Experiences

Parker discussed data from the critical first year of the program. Researchers have surveyed students at the beginning, middle, and end of the year, asking questions about their comfort level, their confidence, and the strengths and weaknesses of the program. At the end of the year, students participate in a group interview. Parker explained that the researchers have done qualitative analysis of the interview questions and comparison of self-efficacy before and after the first year.

The primary goal of the program is to improve retention of minority students in STEM. Student responses to a Likert-scale survey showed no significant changes in the first-year intentions to remain in the major, though individual students moved in both positive and negative directions. Some students considered changing their major, but most remained committed to graduating from Purdue. "These students are coming in fairly certain that they are going to complete their college education, and their first-year experience isn't changing that," Parker said.

Some students reported decreasing confidence in math, although overall comfort levels in the classroom went up over the first year. The program's

support seemed to increase student comfort with interaction in the classroom and with faculty, Parker pointed out, but students still feel the difficulty of college math compared to their high school experience. Students also reported uncertainty in their ability to do well in science and engineering courses.

Building a community of belonging was the most significant benefit of the program, according to students. Meeting other people going through the same type of transition and academic support also were recurring themes in students' reported benefits of the program. In addition, students noted the benefits of learning time management and study skills and commented on the availability of resources.

Effects of Program Components

Parker and the other evaluators were particularly interested in the components of the program that contributed most to students' success. They therefore asked students to rank each component according to its beneficial influence.

According to these rankings, the program manager was consistently the most important component of the program, followed by interactions with faculty members. The third most important influence was the relationship with peers in the program. Parker pointed out the significance of these results when developing other programs. Program developers often focus on the curriculum, rather than the personnel involved in the program. However, the sustainability and quality of the people involved, rather than specific curricular structure of the program, may be the most influential factor in producing positive results.

Every cohort of students is unique, Parker observed, and programs must respond to the needs and interests of the group. Therefore, hands-on management is required. This can be a resource-intensive process, but programs must be able to adapt if they are to support students in the ways needed.

RETENTION OF ACADEMICALLY GIFTED AFRICAN AMERICAN STUDENTS

"What are the factors that most significantly impact the success of academically gifted African American students, particularly gifted and talented African American students, in engineering and computer science enrolled at Historically Black Colleges and Universities (HBCUs)?" That was the research question behind a study of African American students enrolled in engineering and computer science programs at the 12 four-year HBCUs in the nation that have ABET-accredited engineering and computer science programs. Felecia Nave, Associate Provost and Associate Vice President for Academic Affairs and Associate Professor, in the Department of Chemical Engineering at Prairie View A&M University, reported on the qualitative phase of the study, which was based on focus groups with faculty and students.

From the perspective of faculty, the following factors were identified as characteristics of academic giftedness:

- Value high academic achievement
- Innate giftedness
- Creativity and intellectual curiosity
- Share a love for learning
- Display initiative in exploration and problem solving
- Maintain student discipline and independence

As one faculty member said, "very gifted students, they might not have great grades, but you know from the interaction, the interaction between professor and students, you can see they are really gifted good students." According to another, "a lot of students do manage to get 3.0 and above, but a lot of students with this criterion plus an extra edge really have a lot of creativity and a lot of intellectual curiosity. So I think that's my viewpoint of gifted; they are beyond."

Barriers to Academic Success

Faculty members identified the following factors as barriers to academic success that are internal to students:

- Financial rewards as the motivating factor for pursuing engineering
- Sense of entitlement
- Lack of interest in engineering
- Materialism
- Negative social stereotype for engineers (e.g., a nerd or geek)
- Academic insecurity

In the external environment, they identified the following barriers to success:

- Lack of parental involvement, and support and stress due to family obligations
- Financial strain to pay for tuition and fees and basic living expenses like housing and clothing
- Academic unpreparedness for college mathematics and science courses
- Peer and social distractions
- Not using campus resources and support systems
- For women: stereotypical roles, lack of self confidence and practical experience, and few mentors

Finally, they identified institutional barriers to success:

- Inadequate teaching resources such as insufficient quantity of or inoperable lab equipment
- Deficient support staff for departments
- Limited access to federal funding for resources, programs, and professional organizations
- Ethical problems with leadership

As one faculty member reported, "I had my students do a hands-on laboratory-type assignment, and they're constantly complaining about the equipment, and how it doesn't work. . . . And even beyond that just having the right components, you know I give them a circuit to wire and I give them the part numbers and they go into the store room or stock room and look for it and it's not there."

Factors in Student Success

Faculty members also identified factors that contribute to student success. Factors internal to students include:

- Soft skills and attitudinal attributes like self motivation and perseverance
- Developing a strong study ethic, global thinking skills, and team skills
- Obtaining professional development
- Family background and environment
- Supportive community environment from the church, neighborhood, teachers, and counselors
- Positive interactions with faculty members
- Natural ability

One faculty member described gifted students this way: They "are better prepared; you can recognize them because they are more mature and responsible. Also, they are goal oriented and have better communication skills. I also say they are inquisitive and they take advantage of office hours. They also get involved with faculty's research, industrial experience, and professional advice."

At the institutional level, support systems that contribute to success include:

- Funded tutorial programs
- Quality resources for labs and equipment
- Small classes
- Financial assistance at the department/college level in addition to general university funding
- Student research opportunities with faculty members
- Student-focused environment
- Counseling center

Finally, with regard to faculty and peers, the following factors were cited:

- Financial contributions
- Presence of African American faculty
- Caring attitude and interest in student success
- Peer study sessions and study groups
- Peers provide social support and encouragement

- Peer networks gained and strengthened by participation in engineering and professional organizations

Recommendations

In light of these findings, Nave made a number of recommendations to enhance student success:

- Increase funding for physical and human resources
- Dedicate funds for gifted students only
- Provide research opportunities for students
- Connect alumni to the students
- Hire better qualified candidates for faculty positions
- Link students to a mentor early in their academic career

Faculty should have a genuine interest and dedication to the students' success, she said. They should challenge and maintain expectations for the students and help them develop realistic expectations for the engineering profession.

The study also identified a set of "ideal characteristics" for students, the institutional environment, and the faculty. For students, these characteristics are:

- Academic and social skills
- Maturity
- Strong communication skills
- Clear understanding, interest, and prior engineering experience
- Initiative, dedication, and curiosity
- Independence, confidence, and adaptability

At the institutional level, an ideal environment includes:

- Financial support
- Mentoring programs
- Study abroad opportunities
- More diversity at the HBCU
- Training for life and study skills
- Updated facilities to study on-campus
- Social activities tied to academic activities
- Research experiences
- Curriculum changes for increased global learning
- Required experiential (internship or co-op) component

Finally, the ideal situation for faculty members would be the following:

- Increased number of African American faculty members
- Increased number of modern telecommunication facilities

- Increased salary
- Increased acceptance rate for grant proposals
- Funding for professional development
- Fully equipped and sufficient labs
- Access to incoming student's skill level with weaknesses identified
- Departmental mix of experienced and new faculty combined with workplace and research faculty

Academic giftedness is a combination of cognitive abilities and personal characteristics, Nave concluded. However, early socialization helps foster the personal characteristics necessary for academic excellence, and learning communities help students manage their workload while providing them with psychosocial and academic support.

BEST PRACTICES FOR UNDERGRADUATE SUMMER SCIENCE RESEARCH PROGRAMS

The Amgen Scholars Program (ASP), a summer research program for undergraduates in STEM disciplines, is highly selective, drawing 10,000 applicants for 1,200 positions in the United States. The program, which brings participants to ten U.S. and three European universities for eight weeks of full-time research, workshops, and networking, has three objectives: (1) increasing learning and networking opportunities for undergraduates, (2) sparking interest and broadening student perspectives, and (3) increasing the number of students pursuing PhDs in a STEM field. Although the ASP was established relatively recently (2007 in the United States and 2009 in Europe), it already serves a large and diverse group, according to Courtney Brown, Senior Research Associate at the Center for Evaluation and Education Policy (CEEP) at Indiana University.

Brown's colleague Timothy Flowers presented the results of a longitudinal study of the program conducted by the CEEP. The evaluation collected data from participants, program administrators, and mentors through a variety of methods, including pre- and post-program surveys, focus groups, program director meetings, online surveys, and interviews. The study encompassed all four years of the program in the United States as well as the two years at European universities.

Who Are the Amgen Scholars?

Amgen scholars are current undergraduates with at least a 3.2 grade point average, although the average for participants was 3.75 in 2010. "The goal behind the Amgen program is to get the best and brightest and expose them to a summer of what a research career would actually be," said Flowers. Participants must be entering either their junior or senior year.

In the United States, Amgen scholars are 35 percent Caucasian and 26 percent Asian, Asian American, or Southeast Asian. Approximately 30 percent of participants come from underrepresented minority backgrounds (African American, Puerto Rican, Hispanic, Latino, Mexican American, and Native

American). Participants must be citizens attending a U.S. university, so an American citizen attending school in Europe is not eligible for the ASP in the United States. In Europe, participants come from 31 countries and 55 universities across the continent.

Impressions and Success

When asked to rate the success of the program, approximately 90 percent of students gave it high marks, either a 4 or 5 out of 5. The data show an upward trend from 2007 to 2010, with an average rating of 4.7 percent in 2010. In Europe, the average quality rating over two years was 4.5. Of participants and program directors, between 98 and 100 percent said they would recommend the program, and researchers found that ASP "consistently outperforms the participant expectations by an average of 10 percent."

The program is also successful by external measures. In the first four years of the U.S. program, 99 percent of ASP graduates have planned to obtain a PhD or advanced degree, and 41 have begun or are already in a PhD program. Of those, 71 percent are in STEM fields. In Europe, 75 percent of ASP students have entered graduate school, with 100 percent of those planning a PhD in STEM fields.

Best Practices

Flowers outlined three areas chosen for review of best practices: the program administration, the lab experience, and the out-of-lab aspects of the program, such as workshops and seminars.

For successful program administration, the study found that using various platforms to market the program was important for attracting applicants. Students at small schools tended to learn about ASP from the Amgen website or Internet research, while students at universities with high research activity were more likely to hear about the program from faculty or staff. A strong web presence, as well as alumni ambassadors and a good faculty network, were some of the best tools for getting the word out, said Flowers.

Another important factor was a consistent application process, with uniform deadlines and processes for every school. The evaluation recommended an online system capable of informing students who were not eligible and notifying applicants when the program received their materials.

The Lab Experience

Lab placement is another crucial part of the application process, Flowers said. Applicants should be able to rank potential research mentors with whom they would like to work so the program can effectively match student interest with faculty expertise. The program also should link students and labs as early as possible so they can begin communicating.

In the early years of the program, students and their faculty mentors sometimes would not see eye to eye about the substance or timeline for a

project. It is important to have expectations established before the program begins, Flowers explained.

In 2010, 67 percent of ASP participants rated mentor support as the most important aspect of their lab experience, with lab meetings as the second choice. Collaboration, Flowers observed, seems to be a highlight of the program, with only 8 percent of respondents saying they hoped to gain independence from the experience. "If that's their expectation, everything should be done to meet that expectation," he said. Program coordinators should make sure mentors can give enough time to their mentees, and mentors should ensure that someone in the lab is matched with the student and available throughout the experience. Flowers emphasized the necessity of helping both students and mentors get the most out of the experience by clearly defining expectations and checking in regularly throughout the program.

Mentors usually should set up a project before a student arrives. If students have to set up the project once they begin, crucial research time can be lost. Advance planning also enables students to prepare ahead of time, so that they arrive with as much knowledge as possible.

Out-of-Lab Experiences

Out of the lab, meetings and activities are most beneficial when based on student needs, Flowers said. Meetings should be well organized and announced ahead of time. Students need to receive career guidance, preparation for the Graduate Record Examination, and other useful experiences. Working alongside graduate students can be very helpful for undergraduates, as can workshops and materials on how to apply to graduate school.

Flowers discussed the difficulty of defining networking, pointing out that it is integrated in many experiences but that students may not recognize it as such—a perception that may be reflected in evaluations. One key, he said, is to use the term whenever it applies to help students understand that many activities are involved in networking. Alumni of the program reported networking and contacts as the most useful skill they gained from the program outside of lab work, and 99 percent of participants were satisfied with networking events.

A Culture of Evaluation

It is important to create a culture of evaluation at the beginning of a program, Flowers emphasized. Multiple data sources—focus groups, interviews of mentors and students, and measuring student outcomes—help to give a clear picture of the overall experience and allow the program to adapt. Both formative assessments for program improvement and summative assessments to gauge success are needed. Finally, it is important to maintain a database of participants that is updated regularly with contact information and future plans.

NEW PATHWAYS FOR BROADENING
PARTICIPATION: THE UPSTAR PROJECT

"When I say research, what vision comes to mind?"

That was the question behind a study to understand undergraduate science students' perceptions of their research experiences and to determine how those experiences shape their attitudes toward research, with the further aim of determining how those attitudes affect their decisions toward further education or a career in science. Lori Bakken, Associate Professor in the Department of Interdisciplinary Studies at the University of Wisconsin–Madison (UWM), presented the results of the study, which is known as the Undergraduate Perceptions in Scientific Training and Research (UPSTAR) project.

The pilot study held four focus groups with 14 undergraduates majoring in science at the University of Wisconsin–Madison. Using ideas from social cognitive career theory, which takes into account self-efficacy and outcome expectations as mediators of career goals and choice, the students were asked six open-ended questions during the focus groups. Their responses were recorded, transcribed, and analyzed.

The project focused on "understanding the learning experience," said Bakken. "My perception, as an educator, is that the learning experience is not just giving information and expecting it to happen. It's thinking about what kinds of activities are we engaging students in; how that is affecting what they know, what they do, and how they perceive that content area; and what they do with it."

Focus Group Results

Most of the experiences reported in the focus groups, Bakken explained, are related to their laboratory experiences, involving faculty mentors or graduate students. Students tend to see themselves as part of a team effort, and they describe projects in fairly general terms. Participation in lab meetings is an important part of the research experience, the students said, since it allows them to see firsthand the responsibilities and challenges facing upper level students, as well as to discuss the literature and other findings pertaining to their research.

When asked what research means to them, the students thought of people working alone in a lab for a long time and producing few results. According to Bakken, the students tended to view research as a frustrating and time-consuming career, requiring dedication and risk. "They see this as a really absorbing career pursuit, and they are not really sure if that matches what they want to do." Few of them connected research with any immediate benefit to society. Many students did not realize they could mix research with other pursuits, such as being a doctor. They tended to think that the academic benefits of research outweighed the benefits of a research career. "Research as a career is often seen as more focused, less stable, and therefore less interesting to those who want variety and stability," Bakken pointed out.

The students enjoyed gaining independence in the lab and acquiring skills that they knew would be useful in other courses. The idea of community-

based research also sparked their interest. "They were excited that there was even this option. When we bring this up, a lot of them are hearing it for the very first time."

The focus groups also revealed some gender differences in how students view a research career. Women were more likely to consider the difficulty of having a family and taking care of children while doing research full time. Other students were concerned with ethical conflicts. Many of the stories of ethical conflicts they cited were exaggerated or untrue, Bakken said, such as ones involving animals in research. Nevertheless, students' personal values are clearly influential in their decisions about human-oriented or animal research.

Conclusions

Tentative conclusions from UPSTAR are that research experiences do influence perceptions of research careers and what pathways students choose. Women's perceptions tend to differ from men's and typically feature relationships with others. Moreover, students' personal values may influence their desire to do human-oriented or animal research.

The study was limited by the specific views of the students involved in the research and by the influence their views may have had on others in the focus group. The researchers plan to increase their sample size, explore the experiences of transfer students from two-year colleges, look more closely at some of the gender differences they observed in the focus groups, and develop and distribute a survey to a large group of undergraduate students.

FROM PILOT TO PERMANENCE: EXPANDING RESEARCH OPPORTUNITIES FOR UNDERGRADUATES AT HARVARD UNIVERSITY

Former Harvard President Larry Summers' comments on women in science have had a positive impact on efforts to increase representation of women and minorities in the sciences at Harvard over the last several years, said Gregory Llacer, Director of the Office for Undergraduate Research Initiatives. The task force on Women in Science and Engineering set up after the furor generated by his remarks recommended that the university develop formative and substantial undergraduate research activities. That recommendation led to development of the Program for Research in Science and Engineering (PRISE), which recently obtained a permanent funding source after three years of pilot funding.

"Our focus is primarily on the development of community," Llacer said, though Harvard's size and complexity make community building a unique challenge. Because the university is so decentralized, connecting various research activities across the campus is a major focus of PRISE. Harvard has nine schools, nine teaching hospitals, and multiple affiliated research institutes. "For undergraduates, that's very daunting," Llacer pointed out. "Our research enterprises are disconnected. . . There could be somebody in the graduate school of education who's doing something very similar

to somebody in the school of public health, yet they don't even know each other."

The school recently opened an office in order to better track and understand the undergraduate interventions happening on campus. The object is to advance not just women in the sciences but underrepresented minorities and other target populations, such as students from disadvantaged socioeconomic backgrounds. Changing financial aid policies at Harvard have helped support students with fewer resources, requiring zero contribution from families making under $60,000 a year. Intervention programs also make an effort to relieve financial pressures on students so that research participants do not, for example, feel the need to prioritize work over school.

After a slow start, PRISE has taken off. The first year it had difficulty attracting faculty speakers, but the second year began with an overflowing calendar.

An Emphasis on Data

The program is participant-driven, relying on students to develop projects and write proposals within the provided framework. It also focuses on diversity in its speakers and staff. "We try to look at how we can demonstrate diversity and be able to make connections across every permutation of how the program is designed," Llacer explained. Program administrators do their best to encourage students to escape the isolation of lab work by sharing their experiences with the program community. "One day we went to a Red Sox game, and . . . I was listening to the two guys sitting behind me talking about their labs. I thought, 'Wow, I couldn't ask for much better than to hear about lab research at a Red Sox game.'"

The program emphasizes data collection, hoping to fill serious gaps in the university's database. Previously, data came most from exit surveys of graduating seniors, which were not as informative as other forms of information. Program administrators recently completed the first round of data collection for a longitudinal study last summer, with a control group of Harvard undergraduate researchers not affiliated with the program to compare the effects of community on students' experiences, and Llacer presented some preliminary data from the study. Of the more than 600 students who have participated in PRISE over the past six years, 90 percent rated their experience above 6 on a Likert scale of 1–7. Program participants had significantly different results from students in the control group on many questions, including connectedness within their discipline, choice of concentration, choice of laboratory, and view of science in general. The research also revealed greater connection among individuals who participated in an interdisciplinary research community, with underrepresented minority groups having the strongest connectedness scores.

Elements of Success

"You've got to shake some trees," Llacer concluded. "Let the participants drive the train, to the extent that's possible. Consider and implement creative funding models. And then, finally, have fun."

UNDERSTANDING THE IMPACT OF INTERVENTIONS ON STUDENTS IN SUMMER RESEARCH PROGRAMS

Undergraduates applying to graduate schools in STEM fields increasingly are expected to have participated in research. This expectation has contributed to a growing number of summer research programs in all fields, along with increased attempts to analyze the impacts of these programs. But do these programs simply reinforce a successful academic path for students who are already largely prepared for graduate school? Or do these programs truly broaden participation, and if they do, how can the impact of these interventions be measured? Anne MacLachlan of the Center for Studies in Higher Education at the University of California, Berkeley, addressed these questions in her presentation at the conference.

MacLachlan has been an evaluator for Berkeley's summer Research Experiences for Undergraduates (REU) program in cell, developmental, and evolutionary biology for the past six years. She has conducted interviews, observations, surveys, and follow-up contacts. Though important questions remain unresolved, her work has increased understanding of the effects of these programs on students and faculty.

Goals of the Program

The purpose of NSF's REU program is to expose students in real research, train them in many aspects of research, and introduce them to the culture of a research institution. Students become acquainted with graduate education (though not medical school) and receive information on successful graduate school applications procedures, sources of support, preparation for the Graduate Record Examination, and so on. Students develop professional skills such as scholarly writing, online research, public speaking, and designing PowerPoints. Importantly, the NSF summer research program is designed to attract first-generation underrepresented students from institutions lacking major research facilities.

Over the first six years of the program (from 2006 to 2011), 66 students were selected from more than 1,400 applications. Many of the large number of applications were not well matched to the program—students from research universities, with extensive research experience, who were not first generation, or who were not from an underrepresented group. Some unsuccessful applications were clearly committed to attending medical school, while others were missing basic course work or had a low grade point average. Reviewers of applications also asked whether there was an appropriate principal investigator for a student's interest. Students who were successful tended to have strong letters of recommendation and be in a position to benefit from participation. The program directors also sought to build a coherent and compatible student group.

Faculty members have cited a number of reasons for agreeing to have an REU student in their labs. They are engaged with teaching and mentoring undergraduate students. They think that their lab population and atmosphere are supportive of undergraduate learning and that their current research proj-

ects are amenable to a ten-week undergraduate project. Some say that they believe it is the right thing to be doing.

Students, for their part, also cite multiple reasons for wanting to participate. They say they are interested in learning about research and want to test their own interests. Some are interested in adding to a graduate school application portfolio. They may be interested in learning new skills or spending ten weeks in the San Francisco Bay Area with all expenses paid and a salary. Many cite combinations of most or all of the above reasons, MacLachlan said.

Characteristics of the Students

The 56 students accepted in the first five years of the program came from a wide range of institutions, from minority-serving institutions to major research universities. All had excellent high school grade point averages. Approximately half had already participated in a science program either in high school or college. Almost all had family, teachers, or others supporting their academic path. Notably, 27 of the 56 had one or both parents born overseas, and 12 were born overseas themselves.

Incoming students were excited about doing summer research, though there was great variation in their confidence to do work expected of them and their preparation for it. They varied greatly in their cultural capital and expectations and even in their personal styles. A small number were overwhelmed with the prospect of doing research, and some were overwhelmed to be at Berkeley. For some, their summer research experience was the first time they were away from a dominant ethnic minority environment, and they reported never having thought about being a minority before or feeling lost in a white institution. Additional concerns included negotiating living arrangements with other students, developing an identity as a scientist, and becoming a member of a research group.

Reinforcing a Career Path or Creating a New Path?

MacLachlan concluded that, for this REU program, summer research experiences contribute to student knowledge, confidence, and pursuit of clearer professional goals. According to student surveys, 91 percent were thinking about going to graduate school, though a smaller number (15 percent) reported that these plans were a result of the summer program. These results are roughly similar to those of other investigations of research experiences.

MacLachlan also discussed several reasons why knowledge of the effects of summer research programs remains incomplete. The measurement of individual student gains requires pre-testing or benchmarking against a baseline. Assessing impact is analytically challenging without knowledge of the achievement and academic socialization students bring to the program. It is usually based on the student's own assessment, which may be somewhat optimistic and differs from that of the principal investigator. Students may be affected by the desire to get a letter of recommendation for graduate school, while implicit bias may affect an investigator's judgment. There are very few

follow-up studies of what happens to the students after the program, and no consensus about what is a successful impact.

MacLachlan called particular attention to the fact that nearly half of the REU students were the children of immigrants. Also, 54 percent of the parents had associate's degrees, bachelor's degrees, or (in three cases) PhDs. With some exceptions, the students were already doing well in college and in science, and most did very well in the summer program.

For Berkeley's program, underrepresented first-generation students are unlikely to have enough academic capital to qualify, MacLachlan concluded. Relatively few applications from traditional underserved domestic groups meet the NSF guidelines for the program. Thus, NSF's goals for the program are difficult both to achieve and to document.

However, the program is successful in that students participate in research, including making a professional presentation on their research problem. It also is valuable in terms of their personal growth and development, even given that graduate school is not the universal destination of all students.

The impact of the program on students depends on what they bring to the program and the quality of their interactions with the principal investigators and mentors, and for a small number of students, their participation has been truly transformative. In both human and academic terms, MacLachlan concluded, the program has been a success.

5

Discipline-Based Approaches

Analysis of interventions in particular disciplines reveals fascinating commonalities and differences among student experiences, and these contrasts suggest approaches that could be much more widely applicable. For example, online courses being developed in mathematics may hold lessons for online teaching in other areas. The use of foreign-born graduate students as mentors, which has demonstrated its value in engineering, may benefit both students and mentors in other disciplines. And the use of computer programming to teach basic mathematical skills points toward ways to use student interest in information technologies to teach other subjects. This chapter looks at interventions focused on specific disciplines as a way of finding universally applicable principles for broadening participation in research careers.

REDUCING THE RISK OF ATTRITION IN UNDERGRADUATE ENGINEERING

As in other STEM fields, attrition in undergraduate engineering programs is greatest in the first two years, explained Elizabeth Litzler, Director for Research at the Center for Workforce Development at the University of Washington, and 30 to 60 percent of students leave engineering during their undergraduate experience. Much of the existing research presents risk of attrition as a continuous variable but breaks students into two groups for analysis: one with increased risk and one with less. Litzler described a study funded by the Alfred P. Sloan Foundation, part of the Project to Assess Climate and Engineering (PACE), that examined the risk of attrition without predetermined groups. Instead, researchers looked at groups that emerged with relation to

the construct of attrition and then examined the characteristics associated with those groups.

The research encompasses 22 engineering schools across the United States, 77 percent public, 55 percent with high research activity and 18 percent minority-serving institutions. The researchers oversampled underrepresented race/ethnicity and gender categories, so the respondents were 12 percent Hispanic, 11 percent international, 4 percent African American, and 45 percent female. The sample excluded students who had already left the programs, Litzler said.

Using a technique known as latent class analysis that identifies distinct latent groups with respect to a given construct (in this case, risk of leaving engineering), the researchers discovered three groups of students: those who are committed, committed with ambivalence, and at risk of attrition. The groups were found using three survey items, each scored on a rating scale of one (strongly disagree) to five (strongly agree). The survey items are: I have no desire to declare a non-engineering major; I can think of other majors that I would like better than engineering; and I intend to complete my engineering degree.

Of the more than 10,000 respondents, 52 percent were committed and 41 percent committed with ambivalence, leaving only 7 percent in the at risk of attrition group. A demographic breakdown showed Native American, Asian, and Pacific Islander students were overrepresented in the group at risk for attrition, as well as the committed with ambivalence group. Married students were the most committed, while Asian students had the highest percent in the committed with ambivalence group of any demographic group examined.

Experiences and Perceptions

Once the researchers established the classes, they performed a multinomial logistic regression to predict membership in each class. Student experiences and perceptions proved to mediate some of the effects of individual characteristics such as grade point averages and year in school. Students who were in the committed group had a greater sense of community and were more likely to feel valued by professors. They had higher academic confidence and a sense that they could contribute to society through engineering. Freshmen were more likely to fall into the at-risk group, and women were more likely to fall into the committed with ambivalence group. One of the most interesting findings was a higher sense of community among women in engineering compared with men.

The study has led to "some interesting conclusions and implications for the interventions that we use for retaining students," said Litzler. Personal experiences matter and mediate the effects of individual characteristics on the risk of attrition. Interventions such as community building and faculty–student interactions, she suggested, could contribute to positive experiences for students. Incorporating more socially relevant applications and multidisciplinary projects into the curriculum also could help retention, since some students leave engineering due to interest in another field.

During the follow-up to the PACE study, researchers asked each school to develop an action plan based on the research results, and funding from the Sloan Foundation will allow the researchers to go back and re-administer the survey to see if they can observe improvements in climate for undergraduate students within engineering.

CHANGING THE PLAYING FIELD FOR MINORITY STUDENTS IN BIOMEDICAL ENGINEERING

At City College of New York (CCNY), professor of engineering Sheldon Weinbaum, together with Phillip Payton, has developed a program in biomedical engineering (BME) that can compete with programs at the most elite institutions in the nation while defying the trend of a field where underrepresented minorities make up less than 3 percent of PhD students. "If we could do this in one department, why couldn't we replicate it in the rest of the college and then try to spread the word to other institutions?" he asked.

CCNY, which is located in Harlem, has the only engineering school in New York City. The students in the program are among the most diverse in the country, and many are first-generation. All but two of the junior faculty in the department are women or minorities. Wealthy CCNY alumni fund students from elite schools, such as Stuyvesant High School and the Bronx High School of Science, to attend the college. "The idea was to show that our underrepresented minority students could perform at the same level as very high achievers," said Weinbaum.

The biomedical engineering program started in 2002 with an NIH grant for Minority Undergraduate Education in the Life Sciences. Each year, 25 students with biomedical engineering as a major or concentration receive full tuition, a $6,000 stipend, and $4,000 in summer research funding. All of the students are required to do a research project. "The research expectation is extraordinarily high," Weinbaum explained. "They are doing research eight hours a week starting in their junior year and in the summer and in their senior year, because this is what it's like to be a graduate student. The idea is to get these students to go on to PhDs." Students must maintain a 3.0 average to stay in the program.

Mentors and Retention

Annual retention over the first three to four years was lower than the program wanted. When NIH renewed the grant in 2006, Weinbaum said, he made a significant change. He assigned each student a mentor, a PhD student in the engineering program, who would meet weekly with that student for all four years of their undergraduate experience. He intentionally chose mentors who were foreign-born, he explained, to increase the value of the experience for both mentors and mentees.

"In engineering right now, 70 percent of all our PhD students are foreign-born," he explained. "They have relatively little sensitivity to the problems of underrepresented minorities. These are the people who are going to be our

faculty. Unless we do something to create the sensitivity of our PhD students who will be our future faculty, we're going to have a very difficult time."

Retention was 54 percent before the mentorship program, over the first five years of the grant. After beginning the mentorship program in 2007, retention went up to 74 percent, with an average grade point average of 3.5. Retention for CCNY as a whole, Weinbaum pointed out, is only 37 percent. The students in the program became the highest-performing group in the department, and two of the scholars have been class valedictorians.

Students in the program spoke highly of the mentoring system. After the addition of the mentoring component, scholar satisfaction with the program jumped from 80 percent to 100 percent. Students also valued the research experience and support networks the program provided. A 2009 survey showed that roughly 60 percent of students—38 of 63—were planning to continue on to a PhD or MD program. Currently, only 500 PhDs in biomedical engineering are granted in the United States each year, and less than 3 percent of the recipients on average (roughly 15) come from underrepresented groups.

Success and Continued Challenges

Weinbaum explained that the mentoring program made the entire department more student-oriented. "It permeated the entire culture of the department and transformed it." Nearly every PhD student in the department is involved in the program, Weinbaum pointed out, so the entire biomedical engineering community is invested in the success of its undergraduates. The dean called it "a successful model," praising biomedical engineering as possibly the most student-centered program at CCNY.

Although the performance of the biomedical engineering department at CCNY is equal to that at the most elite schools, its rankings do not reflect the strides that the faculty and students have made. "This is really painful," Weinbaum said of US News and World Report rankings, which place CCNY's program at number 43. "They don't take you seriously. That's really what this is about. This is going to be a much longer, harder battle."

The program, despite its success, is also struggling for funding. Because NIH lacks the money to renew CCNY's grant a second time, Weinbaum is turning to alumni to at least see the current students through to graduation.

A FULLY ONLINE MATHEMATICS COURSE
FOR UNDERGRADUATES

Mathematics is one of the most difficult obstacles students face when they are interested in STEM fields. Many have to take developmental classes in college and are either delayed or drop out before they begin taking college-level math. Others struggle in their college-level courses, become discouraged, and switch majors.

Atma Sahu, professor in mathematics at Coppin State University, has tackled these problems by developing a fully online course in math. Today's students are much more technology oriented. By changing how they teach, professors can take advantage of this technological literacy to help students

succeed in math. The result is better retention of students, higher graduation rates, and enhanced productivity of STEM graduates in society, Sahu said.

Overcoming Isolation

One criticism of online courses has been that they are too isolating and reduce the interaction of in-person classes. Sahu has overcome this by retaining discussion sections and through the use of conferencing to increase interactions in online courses.

Sahu has used several programs to put together the course, including Blackboard, Tegrity (which is a class capture and sharing technology), and Mathematica. Campus-wide survey results indicate that 85 percent of students like Tegrity, with 67 percent saying it has a positive effect on learning and 78 percent saying that it helps them focus more and learn better. Half of the faculty surveyed expressed the view that its use helps keep students enrolled in the class.

Sahu also emphasized the importance of the discussion sessions, where students have an opportunity to ask questions. The online course also provides many online resources that students can use to answer questions. "The more things you have on the Web, the more students like it," said Sahu.

Finally, Sahu thought that the cost of online courses may be no less—and may be more—than traditional courses. Nevertheless, such courses have great potential to enhance learning, he said.

REMOVING BARRIERS TO LABORATORY SCIENCE

Efforts to promote inclusion of persons with disabilities have lagged behind other efforts focused on underrepresented groups. Persons with disabilities make up 10 percent of the overall workforce but less than 2 percent of employed scientists 35 years of age or younger. Though roughly equal percentages of able-bodied persons and persons with disabilities enroll in life sciences and engineering as undergraduates (about 18 percent), only 2.1 percent of persons with disabilities study science in graduate school (compared with 6.5 percent of able-bodied persons), and just 300 persons with disabilities earn science or engineering doctorates each year (compared with 28,000 such doctorates overall).

The Institute for Accessible Science (IAS), which is seeking to increase inclusion of persons with disabilities in the biomedical sciences, is a new project supported by a Pathfinder Award from the NIH Director. "We are going to need a lot of innovative solutions for the global challenges we are facing in terms of health issues," said Susan Mendrysa, the Assistant Director of the institute. "We can start to use diversity to our advantage to try to identify new ways of thinking about problems."

Widening the Bottleneck

The most drastic constriction of persons with disabilities in higher education occurs at the four-year college level (though not at the two-year level)

and coincides with the emphasis on lab-based science courses. Two types of barriers are responsible, said Mendrysa. The first is attitudinal, including lack of encouragement, lack of role models, and lack of institutional commitment to inclusion. The second is physical, including an inability to use facilities and equipment and directly engage in lab practices. As a result of these barriers, students at Purdue tended to stay away from hands-on occupations, including laboratory-based courses.

"For many of us who are doing science, it's important to get that spark, to understand that you can discover things and have opportunities to do things in the lab," Mendrysa said. "This particular group of individuals has frequently missed that opportunity and does not have that exposure."

The 1990 Americans with Disabilities Act targets public educational institutions and mandates equal access. But it does not necessarily require full inclusion. What this means, said Mendrysa, is that a student who is interested in science has to be provided an opportunity to get the same information from a laboratory-based class. They may be provided access to the laboratory and be allowed to observe the experiments, but universities are not required to go the next step to full inclusion.

Adaptations are expensive and target a small number of individuals, so it is difficult, Mendrysa acknowledged. But she observed that there are examples of full inclusion universities such as Wright State. What is needed is transformational change at the university level.

Institute Initiatives

The Institute for Accessible Science has the mission of connecting persons with disabilities with the information and tools they need to pursue and succeed in a career in biomedical science. It also seeks to empower persons with disabilities to advocate for institutional change.

New technologies can overcome many barriers. For example, the IAS*hub*, powered by the HUBzero® software developed at Purdue University, is an infrastructure for global connection and information exchange. Developed in 2002 from an NSF grant focused on computational nanotechnology, the HUBzero® platform combines web 2.0 concepts with middleware modules such as database management, social networking, wikis, an interactive simulation tool, animated presentations, and data storage. The idea behind the IAS*hub* is "to establish a virtual online community that can be used for developing and sharing knowledge and tools for accessible science."

Another institute initiative is the Accessible Biomedical Immersive Laboratory (ABIL), which provides a test space for removing barriers. In collaboration with the Discovery Learning Research Center at Purdue Discovery Park, ABIL provides wet lab training workshops for persons with disabilities, a three-dimensional virtual lab space, interactive lab training through IAS*hub*, lab adaptation for students with motor or visual impairments, and evaluations of the accessibility of lab space.

Finally, a summer undergraduate research program provides an opportunity for students with disabilities to participate fully and gain experience in

hypothesis-driven bench science. The program partners with existing summer undergraduate research programs and provides individualized support to students and faculty.

"We are missing an opportunity to harness the intellectual capacity of many of these individuals because their bodies may not be functioning as well as some of their able-bodied peers," said Mendrysa. "They have a lot of great ideas. We just need to be able to give them the opportunity to put those into action."

DEEPENING MATH AND SCIENCE UNDERSTANDINGS THROUGH INTEGRATION OF COMPUTATIONAL THINKING

"When I say understanding math," said Art Duval, professor of mathematics at University of Texas, El Paso (UTEP), "I'm not talking about just the procedural or memorization levels of understanding. I'm talking about a deep conceptual understanding that's going to help students advance in the sciences, engineering, and math. Without that deep understanding, those students are not going to become the doctoral students that we've been talking about at this conference." To further that deep understanding, Duval and Eric Freudenthal, associate professor of computer science at UTEP, have been incorporating programming into entry-level courses, both as a tool for applying math concepts and as a way of engaging students.

The use of programming to teach math has many advantages. It is engaging and can motivate students. Graphing calculators are common and cheap—"and students cannot use them to tweet," Freudenthal added. And programming instruction can support math and science classes that already exist.

Their initial motivation, Freudenthal said, was attrition among students in both math and computer science. Half of the students are lost in precalculus, and 50 percent fail their first computer science course.

Complex Versus Simple Problems

Initially, the instructors presented students with creative, artistic programming challenges, but they did not see much response. They then switched to more straightforward problems involving lines, curves, and graphs. "Even the liberal arts students were engaged," Freudenthal said. "Three-quarters of the students were interested in quantitative reasoning this way."

The problems incorporated into classes were loosely defined. Students are asked to draw a straight horizontal line, add a slope, and adjust various elements, which forces them to think conceptually about how to solve cumulative challenges. Introducing slopes using graphs helps students grasp the concept more quickly than teaching the theory on its own. Dealing with changes in slope also brings them closer to understanding derivatives, which are introduced in calculus courses. Students taught with this approach have demonstrated an understanding of mechanics that many tier 1 schools cannot claim of their graduates, Duval said.

The ultimate goal, the researchers said, is to use programming as a tool to improve students' performance in other STEM classes. "Incidentally," Duval said, "students have a better idea of what programming and computational thinking is about, and hopefully a better preparation and relevant experiences for making some career major and course decisions." Although programming skills were secondary to the math focus, the researchers observed that students in the course absorbed programming lessons in one or two lectures, rather than a whole semester.

Dramatic Results

The initial trials with high school and college courses have been too small to draw significant conclusions but have produced dramatic results. In one high school math course, 25 percent of the students signed up for AP Computer Science, and in a Pre-calculus course, 50 percent. Over half the students in a remedial Algebra I section satisfied the state requirements in only four months.

This fall, Duval said, 1,200 high school freshmen will enroll in Algebra I with embedded programming. Researchers hope to analyze their performance on state tests and their future selection of STEM courses. The curriculum is available on the web, but it is still being adapted for various courses. Freudenthal also pointed out that initial negative evaluations helped them quickly adapt the program for better results. "Listen to your evaluator," he said, because "depressingly negative results can be jewels." At present, the developers are taking a cautious approach, testing the program in schools where they have connections and can intervene if something goes wrong.

CHANGING ATTITUDES ABOUT COMPUTING SCIENCE AMONG AFRICAN AMERICAN UNDERGRADUATE STUDENTS

Many minority students are underrepresented in computer science just as they are in other STEM fields, said LaVar Charleston, senior research associate at Wisconsin's Equity and Inclusion Laboratory (Wei Lab). This underrepresentation has serious consequences for the United States' global competitiveness. "Computer usage cuts across diverse aspects of modern culture," said Charleston. "In a sense, it's at the heart of innovative technologies."

African American students, in particular, are more likely to have limited computer experience than the student population at large. African American Researchers in the Computing Sciences (AARCS) is part of the Broadening Participation in Computing (BPC) program, an NSF-sponsored effort to increase the number of U.S. citizens in computing sciences. The goal of the BPC is to engage the community in innovative methods designed to increase minority participation in the field. Since lack of role models is often an obstacle in attracting students from diverse backgrounds, the program also aims to support and encourage minority students who are interested in academic careers in computing fields.

Program Structure

The NSF grant specifies two types of programs: alliances and demonstration projects. Alliances consist of multiple institutions, while demonstration projects are smaller in scope and are treated as pilot programs for interventions that could later be incorporated into an alliance. Although AARCS began as a demonstration project, it has since merged into one of the alliance programs. The program is made up of targeted presentations, a future faculty mentor and research scientist program, and an annual conference.

During presentations, an African American professor or research scientist and a graduate student address students at HBCUs, attempting to dispel some of the myths around computer science. Administrators pair presenters by gender (one male and one female) to give students the most diverse possible picture. They attempt to address mental and psychological barriers students may have to the computing field and discuss what a career as a computer scientist could look like, including projected incomes for various degree levels.

The Future Faculty Mentoring Program targets African American PhDs and PhD students, helping them attain a research scientist or faculty position. Because participants come from across the country, they communicate mostly via telephone and internet, discussing strategies for navigating a PhD program, finding jobs, and building CVs. Some of the program participants are also able to meet in person at the annual conference, which includes graduate students, scientists, PhDs, undergraduates, and faculty and supplements the other aspects of the program by providing opportunities for networking, professional development, and community building.

Evaluation Results

In evaluating the project, Charleston and Jerlando Jackson, professor in educational leadership and policy analysis at the University of Wisconsin–Madison, asked what effect AARCS had on proposed intervention outcomes. The study investigated a number of outcomes, including interest in graduate school, negative views of computer scientists, and interest in becoming a computer scientist. The researchers also investigated the extent to which personal characteristics and experiences in college influenced those variables.

Their sample included students at both HBCUs and non-HBCUs, Jackson explained. The researchers found that students who participated in the program had increased interest in applying to graduate school and decreased apprehension about that transition. However, the effect size, which measures the strength of the relationship between two variables, was negligible for increased interest in a computer science career. Jackson suggested that a one-time intervention such as the targeted presentation is not enough to change a person's attitude about their career. "Clearly, sustained participation and engagement is necessary in a space like this, where you are asking someone to think differently about what they'd like to do."

Participation in extracurricular activities with a science focus positively influenced students' interest in graduate school, Jackson said, as did contact

with faculty. Participation in undergraduate research also helped students have a positive view of computer scientists, which was particularly significant given that the program was strongly targeted toward addressing negative stereotypes. However, the study showed that students who were involved in extracurricular activities were less likely to feel that graduate school was an option for them. Jackson explained that the study did not collect data on the quality and nature of the extracurricular activities, which challenges their ability to interpret the mixed results they saw when trying to measure the impact of those activities on student's perspectives.

When the researchers analyzed the data by institutional type and gender, they found that programs implemented at HBCUs had a higher effect for males, while programs at Predominantly White Institutions affected females more significantly. "It begs for us to look a little more deeply at how this implementation may need to be tailored by institutional type and messaging," Jackson said.

A Record of Success

The researchers concluded that the program was succeeding at overcoming some of the barriers preventing African American students from pursuing computer science as a career. In six years of data collection, they saw individuals move into graduate programs and faculty positions. The Future Faculty program also has seen good results, placing more than 95 percent of its participants.

Jackson added that the program may have a stronger impact if extended into elementary and middle schools, which would create a continuous and extended effort to nurture students' interest in computer science.

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The Effects of the GRE and MCAT on Minority Participation

Though graduate schools and medical schools use many criteria to evaluate applicants, the Graduate Record Examination (GRE) and Medical College Admission Test (MCAT) are significant hurdles that students must overcome to pursue biomedical careers. Three speakers at the conference discussed how these tests are used and their weaknesses in predicting student performance.

WHAT DOES THE MCAT MEASURE AND HOW DO ADMISSIONS OFFICERS USE IT?

The MCAT measures four things, said Karen Mitchell, Senior Director of the MCAT at the Association of American Medical Colleges (AAMC): applicants' knowledge of introductory biology, chemistry, and physics concepts; the way applicants use this knowledge to solve scientific problems; the way applicants reason about text-based information; and applicants' written communication skills. Students get one score for each of the four parts of the test. The first three subjects are scored from 1 to 15. The written portion is scored on an alphabetic scale. Mitchell's data focused on the numeric scores only, which are totaled for an overall result between 3 and 45.

Around 70,000 students take the MCAT every year, and 43,000 then apply to medical schools in the United States. Another 10,000 apply to Canadian universities. Other programs, such as veterinary schools and physician assistant programs, also use the MCAT. Overall, about 18,000 of those 43,000 applicants receive acceptances to one or more U.S. schools.

Factors Admissions Committees Consider

In 2008, AAMC began a multimethod research program to determine how admissions committees do their work. Project researchers visited admissions committee members, deans, and staff at eight medical schools in the United States and Canada, interviewing more than 75 individuals. They used this information to create a survey focused on admissions decision making, which they administered to directors at 142 schools.

The bottom line, said Mitchell, is that admissions committees use a wide range of academic and experiential data in deciding which applicants they want to interview. The top ten application variables cited by admissions officers when considering applicants for interviews are undergraduate GPA, MCAT scores, letters of recommendation, volunteer experience in clinical or medical settings, personal statements, community service, completion of required courses, medical or clinical work experience, leadership experience, and experience with underserved populations. Admissions officers reported using the same data for acceptance decisions, but they also placed higher importance on the information they gained from in-person interviews with candidates.

Many admissions officers review applications holistically by considering all the ways in which individual applicants might contribute to the learning environment and the practice of medicine, and AAMC has a Holistic Review Project to promote this approach. Holistic review is a flexible, individualized way of assessing applicants' capabilities and giving balanced consideration to experiences, attributes, and academic credentials, Mitchell said. Selection criteria are linked to school-specific missions and goals. Federal law says that race and ethnicity may be considered in admissions decisions when they are aligned with mission-related educational goals and are considered in a broader mix of factors. The object of holistic review is to identify a broadly diverse class of students, which helps enrich the learning and practice environments for everyone. In this way, faculty can train students to provide respectful, appropriate, and high-quality care to patients from all backgrounds and populations.

The Holistic Review Project provides publications about legal issues, tools to help institutions conduct institutional policy assessments on diversity issues, checklists for the admissions process, and a series of workshops. Many medical schools have participated in the workshop series, though Mitchell also pointed out that many institutions were practicing holistic review before the project began.

The Characteristics of Accepted Students

Mitchell also described the attributes of students who are accepted to medical schools. In 2008–2010, 92 percent of applicants with GPAs of 3.8 or higher and MCAT scores of 39 or above received acceptances to at least one medical school. "It is an interesting finding," said Mitchell, "because not all of them got acceptances. Eight percent of the applicants with those very attractive MCAT and GPA data did not get accepted by any of the medical schools

to which they applied." Acceptance rates for students with MCAT scores between 21 and 23 and GPAs between 2.8 and 2.99 were much lower—11 percent for the same three years. Overall, 45 percent of applicants were accepted over that time period.

Mitchell then broke down the data by race and ethnicity, pointing out that there was greater variety in the GPA and MCAT scores for accepted African American and Hispanic students than white students. "Admissions committees use MCAT and GPA differentially for different groups," she said. "In order to select a broadly diverse class, they look carefully at the information they get through the interviews, through the letters of recommendation, and through the accounts that students provide about their volunteer experience, work experience, community service, leadership, and experience with underserved populations." Acceptance rates are 48 percent for Hispanic and white applicants and 40 percent for African American applicants.

Admissions committees use a wide range of data to select students, Mitchell concluded. Some applicants with high GPAs and MCATs are not accepted, and some with more modest GPAs and MCATs are.

THE USE OF THE GRE IN THE ADMISSIONS PROCESS

David Payne, Vice President and Chief Operating Officer of the Higher Education Division at ETS, described the GRE and its use in graduate school admissions. The GRE measures three areas of academic ability: verbal reasoning, quantitative reasoning, and analytical writing. Around the world, 700,000 people take the test annually, and it is used by a range of academic programs. About 25 percent of people taking the test are outside the United States.

One major difference between the MCAT and GRE is that ETS, which is a non-membership organization, owns the GRE. Therefore, it is very important for ETS to have representatives of the graduate community serving in an advisory role, Payne said. The GRE Board, which determines the policies and standards surrounding the test and provides advice about how the test should be used, is made up mostly of graduate deans and professionals in educational assessment. ETS also invites members of the graduate community to join the Research Committee, the Minority Graduate Education Committee, and the Services Committee.

How the Test Should Be Used

ETS encourages graduate programs to look at percentiles for not only the overall population but also for those that represent specific disciplines. For example, distributions in the biomedical field are very different from those in the education field, he observed. ETS also suggests that admissions personnel use GRE scores as separate measures by considering the verbal and quantitative numbers independently, and that admissions departments conduct validity studies on their admissions and funding decisions.

ETS discourages giving too much weight to small differences in scores, since some error is inevitable in any educational assessment. "If you have two

candidates who only differ by a small amount on their test scores, those are probably not statistically significant differences or meaningful differences," Payne said. Cut scores, or setting a number below which applicants are automatically not considered, is another practice that Payne said is not beneficial. "We try as much as we can to root out bad practices that are having a negative impact," Payne said. "The real question is how do we, as an educational community, adopt practices that are appropriate for achieving the mission that we have. There are lots of tools out there. The question is how do you best use these tools to achieve your mission, and if your mission is to bring in a diverse group of students and have them succeed in your program, that is what I think all of us ought to focus on."

Looking at patterns for repeat test takers may reveal useful information, since ETS reports every score an applicant receives over the past five years. Also, data on differential results for various subpopulations are available for programs to consider. Some of the factors influencing differential GRE results, Payne said, relate to intended field, status as a first-generation college student, undergraduate GPA, and age. For example, older applicants tend to score lower on the quantitative portion of the test.

Increasing Fairness and Access

The GRE board has several initiatives aimed at increasing fairness and access to the test. A number of fee reduction programs help lower the cost of the test for students who meet requirements for financial aid or are unemployed. "It used to be a fee waiver program," Payne added, "but we realized that candidates getting a fee waiver were not showing up for their tests at a much higher rate than candidates who were paying." Increasing availability of high-quality and free or inexpensive test prep material also has been an initiative supported by the board. "We want the scores on the test to reflect the candidates' ability, not their ability to participate in expensive commercial test preparation programs," Payne said.

ETS conducts workshops with campus staff who help prepare undergraduates to take the GRE. Every test taker is entitled to the same conditions, and writers of test questions come from diverse backgrounds.

The GRE general test has been revised to better measure critical thinking and analytical ability. ETS wanted to ensure "that the skills we were measuring were more closely aligned with those skills that are required to succeed in graduate education," said Payne. The GRE board also has been working with ETS to find a way to measure skills that may not come through on a standardized test or transcript. The ETS Personal Potential Index (PPI) is a web-based tool designed to measure six skills known to be predictors of performance in higher education, including teamwork, resilience, and planning ability. Test candidates identify people who know them well, and those people receive a message that they have been chosen as evaluators. If they choose to do so, the designated evaluators can answer a short series of questions on the applicant, which are then available for graduate programs to access if the student wishes.

The PPI has been in use only for two years, but ETS has partnered with two states to use data from the test for validity research. More importantly, it is a first attempt to assess certain student characteristics in a standardized way, which can evolve as schools begin using the test and more results are available. "This is not the end of the day. This is moving the ball one step farther toward the finish line of having a better set of predictors that go across a wider range of ability levels," Payne said.

A meta-analysis of the GRE encompassing more than 1,700 independent samples of students showed good results for the test's validity in predicting student ability.[1] The analysis also concluded that the test is generalizable across academic disciplines and students of different age, background, and nationality. In addition, an ETS study of six different disciplines, focused on students in their first year of graduate school, also showed that high GRE scorers were more likely to achieve a 3.8 or higher GPA in their first year.

TEST SCORES AND STUDENT PERFORMANCE

"I am going to talk from the point of view of the consumer," said Roger Chalkley, Senior Associate Dean of Biomedical Research, Education and Training at Vanderbilt, "somebody who has spent a lot of time over a lot of years looking at issues of how to evaluate people who are applying to graduate school in the biomedical research arena." Forty years ago, most students had no research experience, and admissions were based largely on GPA and letters of recommendation. Chalkley said the strategy for admitting students has changed dramatically, with research now a requirement for an application to be competitive. Admissions officers are looking at candidates not just for their scores, he pointed out, but for the characteristics that will make them successful in the lab, including creativity, imagination, and an ability to learn from their mistakes and persevere through disappointment. "I don't think you can survive without drive and determination." These non-quantitative measures are particularly important for minority students, since in general they do not score as high on the GRE test as do majority students.

Correlations Between Scores and Performance

"At least for the applicants that we are dealing with, the community that we are working with, we are not getting a lot of predictive information from either the GRE or from undergraduate GPAs," explained Chalkley. Data gathered from more than 750 students in biomedical graduate programs between 1992 and 2010 showed little relationship between GRE scores and student achievement once they entered graduate school. GRE scores (separated by verbal and quantitative) and undergraduate GPA showed little to no correlation for either majority or minority students. Similarly, when measuring GRE

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[1]Kuncel, Nathan R., Sarah A. Hazlett, and Deniz S. Ones. (2001). A comprehensive meta-analysis of the predictive validity of the Graduate Record Examinations: implications for graduate student selection and performance. *Psychological Bulletin* 127(1):162–181.

scores against first year performance, no correlation appeared. "What it tells the admissions committee is that at least so far as the first year is concerned, GREs are not going to be a very profound guide," Chalkley said. Undergraduate GPA and first year GPA showed a slight correlation, about 10 percent for majority students and 15 percent for the minority group.

The researchers also observed no significant difference in GRE scores for students who remained in the program and students who chose to leave after the first year for both majority and minority students. No correlation appeared with the inclusion of successive years, and the GRE scores did not predict whether students would drop out, elect to finish an MA, or go all the way to a PhD. The time it took for students to complete a PhD also had no correlation with GRE scores.

Chalkley explained that although the overall attrition rate in the biomedical program is 15 percent, a greater proportion of minority students left between 1995 and 2002. However, this attrition tended to be among people with better GRE scores. "Minority students with better GREs, where do you think they had decided to go?" Chalkley observed. "Med school. They do a year in grad school in order to couch up their application dossiers for medical school."

Parent education level had less correlation than expected with student achievement, Chalkley pointed out, with a slight relationship showing up for the qualitative portion of the test and no significant result for the quantitative section. The strongest correlation the study found, he said, was between the number of underrepresented minority students in PhD programs in the biomedical sciences and the number of training grants at an institution. "As you know, you can't get a training grant unless you can satisfy the reviewers and then personnel at the NIH that you are making a strong effort to develop and maintain diversity in your programs, that you're making that to ensure retention, and that these students are being put onto the training grants."

Survey Results

For the last three years, Vanderbilt researchers have conducted a detailed exit survey of graduate students. To increase compliance, they put all participant names in a hat and award one randomly drawn individual a $1,000 prize. Questions on the survey ask about students' reasons for attending Vanderbilt, satisfaction with coursework and the style of the qualifying exam, and experience with mentors. Career plans also were an important component of the questionnaire.

Students leaving the university are looking at a wider range of careers than in the past. Whereas a large percentage of graduates used to aim for research positions at top universities, the numbers have decreased in recent years. "The interesting thing . . . is that if you now ask an incoming class, 'What do you want to do?' amazingly few of them want to be tenure track faculty in a research institution. [When] you ask them why, they'll say, 'Well, look at the faculty. They're not happy. They're writing grants all the time; they're stressed.' It's a big time issue."

When researchers asked students about their career goals, they noticed that students had a great deal of knowledge about different career options and research opportunities, more so than seven or eight years ago. "We spend a lot of time nowadays explaining what sort of career individuals who are trained to do research can actually have," Chalkley said, "and we're seeing that." Most students viewed a postdoctoral fellowship as a necessary step to a productive career.

In addition to the survey of students, mentors were asked confidentially to estimate the student's qualities in being a good scientist. Students' GRE scores had no relationship to whether they received a good evaluation. However, the study did find a relationship between those evaluations and recommendation letters from undergraduate mentors, which were included as part of each student's application to the graduate program. The findings suggest that recommendation letters have a stronger predictive value than GRE scores when considering student performance in Vanderbilt's program.

Maximizing Student Diversity

Vanderbilt has an initiative for maximizing student diversity (IMSD) program in which the primary focus is letters of recommendation from previous research mentors, in-depth research experience, and interviews, with a secondary focus on undergraduate GPA and GRE scores. Through this program, Vanderbilt researchers have been able to select a cohort of students admitted based on stellar recommendations from research mentors and observations of other factors, such as working to stay in school, that might have influenced their grades. Many of the students admitted in this experiment would not have gotten into graduate school based on their scores, Chalkley said. But of 20 students, 18 are still in the program, and none has failed the qualifying exam. "There are a lot of people out there who are really dedicated," Chalkley said. "They need a lot of mentoring, . . . but if they have that kind of research ability then they are going to be okay."

Chalkley also discussed the benefits the program has realized in having a psychologist available for students. "I think mental health, in terms of anxiety and depression, is not something that you hear very much about at a meeting like this," he said, "but I can tell you, it is definitely there, and if you can address it, you'll increase the stability of your population of students. You've got a class where everybody is pretty good. So someone who comes from a small school and has always been on top, suddenly they're struggling to stay out of the bottom, and all of these issues explode."

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Post-Baccalaureate Interventions

Interventions targeted at graduate students, postdoctoral fellows, and young faculty members can be even more influential in broadening participation than undergraduate interventions. Post-baccalaureate students have demonstrated that they can succeed in science. If they had the necessary support, such students would be more likely to make decisions that would increase the numbers in research careers. Presenters at the conference described a number of programs that can provide such support, from post-baccalaureate research programs that can prepare students for graduate school to summer programs for new faculty.

POST-BACCALAUREATE RESEARCH PROGRAMS FOR ASPIRING PHD STUDENTS: WHO CHOOSES THEM AND WHY?

Aspiring PhD students have multiple reasons for enrolling in a post-baccalaureate research program before beginning graduate school. Some want to try research to see if they like it; others are changing career trajectories. Some want to get into the best graduate programs, while others are seeking to reconcile their self-image or strong cultural ties with the culture of biomedical research. Robin Remich of Northwestern University explored these reasons using multiple social science theories in presenting the initial findings of a study of such students who had enrolled in NIH-funded Post-Baccalaureate Research and Education Programs (PREPs) around the country.

The study sample consisted of 53 participants from seven PREP programs. Forty-two percent were Latino, 47 percent African American, 4 percent American Indian/Alaska Native, 4 percent more than one race, and 2 percent each Asian/Asian American and white. Neither parent had a bachelor's degree for 47 percent of participants, while 17 percent had at least one parent

with a bachelor's degree as the highest degree, and 36 percent had at least one parent with a master's degree or above. Seventeen percent had no previous research in a biomedical field, 17 percent had one experience, and 66 percent had two or more experiences. With regard to graduate school preparation, 42 percent took the GRE before starting PREP, 25 percent had applied to graduate school, and 4 percent were already accepted to graduate school.

Building Skills

Remich identified a number of skills that students acquire on an idealized trajectory toward the PhD. As beginning researchers, they learn lab techniques and observe others. As they start to become independent, they design experiments, analyze data, present results, and follow protocols. When making connections, new researchers contribute in the lab, raise questions, look for literature, and write proposals. As they develop an identity as scientists, they complete independent projects, produce papers or theses, and network beyond the lab. The nature and quality of these experiences can be influenced by a large number of factors, including mentoring, personal support, messages about gender and race, and exposure to other researchers.

When students do not feel that they are ready to begin a PhD program, they may seek a program like PREP. The program consists of one to two years of mentored research on an independent research project. Additional activities include application guidance, GRE preparation, graduate classes, journal clubs, attendance at conferences, interview practice, and writing support. The idea is to prepare students to succeed in graduate school.

Remich looked at several different kinds of students for whom PREP is valuable and explained their differences using social cognitive career theory, identity development, and cultural capital as analytical frameworks. *Interest testers* want to try research. As one such student said, "I wanted to pursue an MD, but I never knew what research was all about. . . . I really didn't pursue it much, until my senior year. I started working in the lab, and that really sparked my interest. Some of the teachers held PhDs, and they told me about real research, not just you and a rat and a crazy dark room. So I just decided to try out the PREP program." From a cultural capital perspective, such students need experiences to build knowledge of practices, norms, and expectations of real research. They want to test a new interest and then decide if and how research will become part of their long-term career goals.

Career changers want experience for a new career intention. According to one such student, who was formerly interested in medical school, "I knew I wanted to get my PhD . . . So I knew I needed research . . . hence, the PREP program, which is a one-year post-bac research experience that prepares you for grad schools. It fit 100 percent. I needed that to get to grad school. I needed the research to say I did it, I can survive, this is what I want to do." Such students may have experience with research in another field and know that they want to get a science PhD. Their goal is to prepare for a new field while gaining awareness of options and steps toward biological science ca-

reers. They can be confident because of mastery gained in another field but also know that they have deficits in science research that they need to remedy.

Confidence builders want to be sure before they make a commitment to a PhD. As one said, "even though chemistry was my major, I was on the biochemistry track. . . . I knew I liked biology. So I was, like, 'Well, I don't want chemistry for graduate school, but I'm not sure exactly what area I want. . . . Maybe I should consider a program like [PREP]. I'll get to see research pretty much every day for a more extended period of time than the summer programs, to see if this is really what's right for me." These students are not ready to commit based on inconsistent experiences. PREP allows them to clarify future goals and feel more secure about their identity as a researcher.

High shooters want to get into the best programs and hit the ground running to excel. One student said, "in my final year of undergraduate studies I wanted to really invest all of my time and effort into keeping my GPA up," and PREP gave the student a chance to excel in research as well. Minorities in this situation may feel pressure during senior year to complete work at a high level and "work twice as hard because racism still exists." In this case, enrolling in PREP is a strategic decision to help them achieve their high goals.

Big thinkers need to reconcile their self-image as scientists with the culture of biomedical science. One said, "I couldn't talk the talk and walk the walk . . . in front of those professors. I got really nervous. . . . So that's one of the things that I'm looking forward to through PREP, is to be able to explain things more clearly." Such students can be vulnerable because of inflated confidence in their ideas, especially when they are challenged to focus and explain their ideas. PREP allows them to build credentials for graduate school, integrate into a lab community, and practice talking about their science.

Finally, *cultural straddlers* need to reconcile strong cultural ties with the culture of biomedical science. They may be attracted to research if it is related to their own culture and have difficulty envisioning a future if research conflicts with cultural expectations. As one such student said, a home culture "is something that you grow up with . . . for your whole life, and then you kind of get removed from it. It's kind of hard to function, I guess. I need to go every now and then just to hear the music and meet some people."

Multiple Needs

PREP can meet multiple needs, Remich observed. It offers a breadth of experiences to move toward the PhD. Knowledge of why different students seek PREP can help programs consciously design services or select only students they are prepared to assist.

PREP also helps students come to terms with their own needs. They can get credentials, GRE preparation, graduate courses, and experience with research.

In the future, said Remich, the program plans to use exit interviews to study the impact of PREP on scholars and their decisions. It also will use the data from PREP scholars to analyze their longer-term outcomes toward PhDs and careers.

THE FISK-VANDERBILT MASTERS-TO-PHD BRIDGE PROGRAM

Fisk, a highly regarded historically black university, and Vanderbilt, a research-focused institution that also has a strong academic reputation, began building the Fisk-Vanderbilt Masters-to-PhD Bridge program seven years ago with the idea of developing a model for such partnerships. The program links the universities, helping students transition from one to the other and combining resources to enhance their experience at both schools. "We wanted to do this in a way that honors and respects and capitalizes upon the rich cultural complementary aspects of the two institutions," said Keivan Stassun, a professor of physics and astronomy at Vanderbilt and co-director of the program.

Since 2004, the program has enlisted 50 students. Of those, 44 came from underrepresented minority backgrounds, and 33 have completed their master's and begun a PhD. Like PREP, the program identifies students who are completing or have recently completed undergraduate degrees in science and engineering fields and who aspire to a PhD but for a variety of reasons are not ready to jump into a PhD program. Stassun explained that recruiting is a large part of the program. "We work very hard in this program to identify students with promise and potential," he said, comparing the task to that of an athletic scout. Program administrators solicit applications, searching for students with raw talent who they think will thrive under the Bridge curriculum. The retention rate is 94 percent.

The Master's as Preparation for the PhD

The Bridge program uses the master's degree as a stepping stone to the PhD. Students are initially admitted to a two-year program at Fisk, and then to the PhD program at Vanderbilt. The program provides full funding for the master's degree, and hands-on research training. Some GRE preparation is included, but administrators strive to help students develop a rich portfolio, with qualifications that diminish the importance of the GRE as a metric. Once students complete the Bridge program, they have fast track admission to a PhD with full support.

Stassun emphasized the importance of master's degrees in preparation for a doctorate. Between 1987 and 2006, the number of minority-serving institutions with a terminal master's degree in physics, computer science, and engineering increased by nearly 80 percent, and the number of underrepresented minorities earning those degrees went up 533 percent.[1] Research at the University of Washington that sampled over 80,000 students found that underrepresented minorities were much more likely to move from a baccalaureate degree to a master's before getting their PhD and were likely to

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[1]Stassun, K. G., S. Sturm, K. Holley-Bockelmann, A. Burger, D. Ernst, and D. Webb. (2011). The Fisk-Vanderbilt Master's-to-PhD Bridge Program: Recognizing, enlisting, and cultivating unrealized or unrecognized potential in underrepresented minority students. *American Journal of Physics* 79:374.

complete all three degrees at different institutions[2]. The students have been making this path for themselves, Stassun said. The Bridge program is there to give it support.

Stassun called the master's degree a "safe rehearsal space" for students. "It's important that the students have an opportunity and a space to build up to that quality of performance, where they feel safe to make mistakes, where they feel safe to look dumb, where they can learn from their peers. And then they make their debut before their eventual evaluators, looking like they're really on the ball."

However, the program does not encourage minorities to go the master's route rather than directly to the PhD. "What we did not want to do," Stassun said, "was to build a program where we said, you're not ready for our PhD program, so go earn a master's degree and call us in two years. This is intended to be a path to the PhD from day one."

Students begin the program with a joint advising committee consisting of one faculty mentor at Fisk and one at Vanderbilt. Ideally the faculty are collaborating in research to some degree, which makes the transition even smoother. Courses required for the master's also fulfill some of the PhD requirements, so students can enter with advanced standing. Thesis research for the degree must be conducted in either a Vanderbilt lab or a Fisk lab that collaborates with a Vanderbilt lab, so that students get to know the faculty and become recognized. Also, students are required to take at least one PhD level course at Vanderbilt while completing their master's. The students in the program have built a strong community, although the early years without a critical mass of students were challenging, Stassun said.

Faculty also meet with the students to discuss hidden aspects of graduate school culture that may not be otherwise apparent. They are explicit about expectations and what is required to do well and impress advisors and mentors.

The program has been very experience based, Stassun said. "With our social science colleagues, we're beginning to name the core precepts of the program, in terms of theoretical mechanisms, so that other people can try to understand what really is important about what we're doing and why."

Careful attention to the students is critical, Stassun said. Because the program strives to consider qualifications beyond grades and other paper metrics, faculty have had to name the attributes and characteristics they are looking for: passion, persistence, an entrepreneurial spirit, creativity, commitment. "It has been profoundly impactful for us to write this down and say the words and breathe on them and give them significance, because it forces us to stay focused on these qualities," Stassun said.

With this in mind, recruiters have developed a protocol for what they ask in interviews. "We know that the students who go through our program are about to undertake what is probably the most challenging and rigorous academic experience of their lives." Interviewers look for people with mental

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[2]Lange, S. E. (2006). The Masters Degree: A Critical Transition in STEM Doctoral Education. PhD Dissertation, University of Washington.

toughness and "a certain level of grit" who have demonstrated that they have the inner strength and external resources to survive.

Measures of Success

Vanderbilt has seen an increase in underrepresented students applying for a PhD, due to an interest in the program and the realization that people at the school are committed to students' success. Money is another measurement of the program's success. "We all know graduate education is a very expensive proposition," Stassun said. Funding comes overwhelmingly from research grants, not training grants. This speaks to the quality of the junior faculty at both universities, Stassun pointed out, many of whom received large NSF CAREER awards over the course of their involvement in the Bridge program.

The Bridge program draws primarily from minority-serving institutions but also has proven attractive to students at top undergraduate colleges. Not all students choose to complete their PhDs at Vanderbilt. One graduate is on track to become the first African American woman to earn a physics PhD from Yale. The partnership also has generated institutional benefits for both universities. Since 2006, Fisk has been the top producer of African American master's degrees in physics, and one of the top ten producers of those degrees for all U.S. citizens. "This is not just a feeder program," Stassun emphasized. "There are real, substantial, lasting capacity-building benefits for the HBCU partner in this case—and tremendous bragging rights."

A challenge in sustaining the program has been sustaining the individuals who are working to keep it going. "This is exhausting work and it is incredibly rewarding, as you all know," Stassun commented. But he also cited Charles De Gaulle's dictum that graveyards are full of indispensable men. Programs need to be sustainable beyond the efforts of the heroes who created them.

The Bridge program does more than enhance the overall quality of the practitioners in science and engineering research, Stassun concluded. "It makes the face of science appear more like the face of America. We meaningfully touch lives that extend into deep and long histories. It is a profound thing to remember and to realize."

GRADUATE AND NEW FACULTY INTERVENTIONS AT UMBC

A successful intervention for the University of Maryland, Baltimore County (UMBC) has been the use of a dissertation coach, said Renetta Tull, assistant dean for graduate student development at UMBC and Director of PROMISE: the National Science Foundation's Alliance for Graduate Education and the Professoriate (AGEP) for the state of Maryland. In 2005 UMBC's then-Associate Dean of the Graduate School (and current Dean and Vice Provost for Graduate Education) Janet Rutledge learned about Wendy Carter-Veale, owner of "TADA: Thesis and Dissertation Accomplished," a small higher education company that specialized in helping students complete

degrees through workshops and distribution of course materials on the topic. With funding from NSF through PROMISE, Maryland's AGEP, and the Council of Graduate School's PhD Completion Project, UMBC hired Carter-Veale on a part-time basis to bring her expertise in-house. In 2005, Rutledge, Tull, and Carter-Veale learned about Sonja K. Foss' Scholar's Retreat at the University of Colorado–Denver, where graduate students paid to attend a two-week writing camp designed to help them complete their dissertations. The idea of combining UMBC's new in-house dissertation coach as a prominent feature of the annual PROMISE team-building retreats, which began in 2004, grew from that example.

The first PROMISE retreats, with graduate students from UMBC, the University of Maryland College Park, and the University of Maryland Baltimore (UMB, the founding campus that houses the medical school) took students to West Virginia for three days. Other weekends have taken place in various parts of Maryland, but most of the sessions for the Dissertation House are now on UMBC's campus, running in four-day blocks from 9 to 5 each day. Students sign up for one-on-one coaching sessions and spend the rest of their time listening to mini-lectures, participating in interactive exercises, and writing. The dissertation coach provides encouragement, guidance, and direction, giving talks on professional development, time management, goal setting, stress management, and overcoming writer's block. All students are required to set measurable goals for their time at the dissertation house. Since the dissertation coach has a faculty background, Tull said, she can help students understand the faculty perspective, acting as a liaison between students and advisors. Between 15 and 18 students participate in each session, and the campus holds two to four sessions per year. The coach also provides a 1.5-hour workshop on thesis and dissertation completion for UMBC's graduate school community each semester and holds office hours either in-person or through video chats. Students receive invitations to participate in the Dissertation House via a university listserv and campus intranet. Students also receive invitations through their subscriptions to the website and blog for the Dissertation House and through the social media presence that PROMISE maintains on Facebook, Twitter, and LinkedIn.

Role of the Dissertation Coach

"The dissertation coach is a cheerleader for the student, an advocate for the student, a leader, a teacher, a colleague, an administrator, and a mentor," said Tull. The coach serves as each student's "counselor and confidante." The dissertation coach may give a student advice on navigating the job market, public speaking, and preparing for a thesis defense. An online community is also part of the program so that students without physical access to the retreat can participate. Students blog throughout the year using the website for the Dissertation House to continue to share daily goals with each other and to have a regular, virtual connection to the coach.

Tull emphasized that the dissertation coach is not a replacement for the advisor, but a supplementary mentor for the students and someone who can

work alongside the advisor to make sure students have all the resources they need to complete their program. "Unfortunately, not every advisor is a great mentor," Tull pointed out. "Sometimes they think that the students are just going to get it, or that they will learn from the others in their lab or the others in their group. But it doesn't always work by osmosis, and some students need someone else to be alongside them to help."

Each department has different format and presentation requirements for a dissertation, but some errors are common across disciplines, Tull said, and can be targeted without worrying about specifics. The dissertation coach also does a session for students early on in their graduate seminars, to help them prepare for the coming years. Students can participate in the dissertation house as early as their first year, although the program gives priority to any student graduating with a PhD in the next six months and those recommended by faculty members.

Tull referred to "raw drafting" as a useful exercise for students to keep them from getting stuck in the writing process. Based on a writing process that Ben Dean of MentorCoach, LLC, introduced to graduate students at College Park, students in the Dissertation House are guided through the process to write for a specified period of time without stopping, regardless of what their results look like. "You write without stopping to correct your spelling, without stopping to correct your grammar," said Tull. "Even if you draw a blank and you can't think about what the next thought should be." Although the task is intimidating the first time, she reported that many students became very efficient at producing work under those conditions. The program also holds public speaking workshops, allowing students to practice presenting to an audience. "This gives them an opportunity and a safe environment with people who are going to be supportive to talk about their research," Tull said.

"PhD completion is a process, and it doesn't always have structure," Tull said. "Students don't really see the end of the road, so they're not able to understand it." The dissertation coach helps students develop a schedule and move from one step to the next, and follows up with those who drop off the radar. "We want to make sure that if they're demotivated, they're not just in a depressive mode, sitting and not doing anything," Tull said. In the years since the program began, the dissertation coach has also served as a counselor, helping students with personal issues they may not have shared with their advisor.

At UMBC the dissertation coach splits her time between coaching and program evaluation, and funding comes from grants and some institutional resources. Currently, the budget does not allow for a full-time position, so the coach works 60 percent at the university and fills the rest of her time consulting for other schools.

The Summer Success Institute

Tull also spoke later in the conference about the PROMISE Summer Success Institute, which is an intervention to ease academic transitions for STEM graduate students, postdoctoral fellows, and faculty of color. The Summer

Success Institute is a conference held every August. When it began in 2003, it was focused on graduate students, but it has expanded to postdoctoral fellows and young faculty because the alumni of the program were interested in continuing to participate.

Through plenary presentations and breakout sessions, the institute is designed to help participants move to the next level. "Originally we wanted to make sure that our graduate students were going to be prepared particularly for their proposals and for their dissertation defenses, because we noticed that a lot of our students had a lot of knowledge and a lot of intellect, but they weren't always able to communicate it effectively," said Tull. The institute also provided students with strategies such as sitting in the front of the classroom, going to office hours, and communicating with faculty.

Given the success of the original institutes, the program was expanded to other groups. It now has talks on such subjects as faculty interviews, understanding tenure and promotion, and the use of social media. A recent speaker was Dr. Randall Pinkett. "He was the winner of *The Apprentice* in the early years," said Tull. "He also has a PhD in STEM fields, so he is an engineer. But he came to talk to us about taking the road and what do you do when no one has gone before you: You keep on walking and you just keep on moving forward, even when no one has traveled the road before you."

The institute was originally held on college campuses and two weeks long, but that did not work well. Now it is held at a central hotel and has two days of programming, and that model is working well, according to Tull.

The institute has a family environment for faculty or graduate students with children. Evaluations have been overwhelmingly positive. In recent years, the institute has expanded to the social sciences. "That was one of the best things we ever did," said Tull. However, a major and continuing challenge has been covering the expense of the event, which has ranged between $7,000 and $15,000.

MENTORING, NETWORKS, AND INTERVENTIONS FOR PREDOCTORAL MINORITY SCHOLARS

There have been few systematic examinations of the effect of the social capital of graduate advisors on the post-PhD career trajectories of minority scholars. Social capital encompasses social networks and connections in gaining access to knowledge, institutional resources, and other support, and graduate school and early-career mentoring is a key process by which exposure to these social networks takes place. In more measurable terms, mentoring can create conditions for success in graduate school and beyond by increasing scholarly productivity, grant funding, service to the discipline, and progress toward tenure and promotion.

Jean H. Shin, Director of the ASA Minority Affairs Program, presented the results of a NSF-funded study by Roberta Spalter-Roth, Olga Mayorova, and Shin. This study examined whether mentoring by white male advisors (the dominant group in academic disciplines) has a significant effect on the career trajectories of participants in the American Sociological Association's (ASA) Minority Fellowship Program (MFP) when compared with two other

groups—awardees of the NSF Dissertation Improvement Grants in sociology, and a control group of PhD graduates in sociology, when other factors are held constant. The study population included PhD cohorts from 1997 through 2009.

A study database was created including information on demographic, institutional, and employment characteristics, professional association activities, publications, grants, and tenure status. This information came from ASA and NSF records, on-line curriculum vitae, and Google searches. Names of dissertation advisors and dissertation topics were found in the ProQuest theses and dissertation database.

Specifically, the study examined graduate mentors' roles in significantly increasing the likelihood of pursuing an "ideal" career compared to an "alternative" career. This "ideal" career path starts at a research I graduate program, leads to employment in a tenure-track position and tenure at a research I institution, and involves scholarly productivity in the form of peer-reviewed journal articles and books as well as scholarly presentations and external grants, all leading to increasing prestige in the discipline. The "ideal" career path is assumed to be the model for graduate training. "Alternative" careers include employment in applied non-academic positions, employment at minority-serving institutions, or employment at teaching-oriented or non-research extensive institutions. An "alternative" career can be a matter of choice or a matter of failure to successfully pursue an "ideal" career.

Findings

According to Shin and his colleagues, the three groups are not precisely comparable. Members of the NSF awardee group are most likely to have attained their PhDs at a research I institution (97.7 percent did), are almost entirely white, and are more likely to have graduated more recently than the other two groups. Therefore, this group would be expected to do better than the MFP or control groups. Members of the control group are also more likely to be white, while the MFP group includes only non-white racial and ethnic minorities. The MFP group, however, is more likely to attend graduate school at research I institutions than the control group (81.5 percent compared to 69.6 percent).

The descriptive findings from the study suggest that participation in MFP by itself does not "level the playing field." MFP scholars, in general, do less well than the NSF awardee group and about the same as the control group in terms of attaining successful "ideal careers." They are less likely to obtain post-PhD appointments at research I schools than either the NSF group or the control group (11.1 percent compared to 15.2 percent and 36.8 percent, respectively). They are less likely to have tenure-track positions than the NSF awardee group but equally likely to have this status compared to the control group (60.2 percent, compared to 71.8 percent and 61.4 percent, respectively), and they are more likely to be employed in "alternative" career positions, especially at minority-serving institutions, compared to the NSF awardee group and the control group (18.5 percent compared to 5.6 percent, and 10.1

percent, respectively). In terms of scholarly productivity, they publish fewer peer-reviewed journal articles than the NSF group, but the same number as the control group (with a median of five articles compared to three articles). They are less likely to receive at least one major NSF research grant than the NSF awardee group, but are more likely to do so than the control group (9.2 percent compared to 16.8 percent and 9.2 percent, respectively).

Regression Results

Shin reported that the success of the MFP group improves significantly when they have access to the social capital of white male mentors. According to the results of logistic regression analysis, having such a mentor has a direct effect on attaining a position at a research I university for MFP PhDs. Holding other variables at their means, MFP Fellows with white male advisors are about three times as likely to obtain this type of position as MFP Fellows without white male advisors. Having a white male advisor does not have a significant effect for the NSF awardee group or the control group. This may be because the NSF awardee group is already on the track to have an "ideal" career and members of the control group are less likely to be at graduate programs that have white male mentors with the most social capital. This finding suggests that MFP Fellows require the social capital that white male mentors can provide in order to obtain "ideal career" positions at research I institutions.

Once positioned through white male advisors at a research I institution, the career paths of former MFP Fellows continue to follow an "ideal" career trajectory, although having a white male mentor is no longer a direct effect. Employment at a research I university is positively and significantly related to publication rates, regardless of the comparison group, with former MFP Fellows less likely to publish in the three top journals in sociology. This failure to publish in the top three journals may be because former MFP Fellows are less likely to submit to these general sociological journals, perhaps because they regard them as less likely to publish on topics that MFP Fellows consider important to broadening the discipline such as race and ethnicity, gender, and minority health disparities. Both former NSF awardees and former MFP Fellows are more likely to participate in disciplinary leadership activities than the control group, seemingly as a result of their status at research I schools. White male mentors once again have a direct effect for obtaining tenure on time. Having a white male mentor in graduate school has a direct positive effect on receiving tenure within seven years after graduating while holding other variables constant. There is no statistically significant difference in the likelihood that NSF awardees and MFP Fellows will receive tenure within this standard time frame compared to the control group. Given that white male mentors do not appear to have significant influence on the number of publications, NSF grants, or section leadership, additional research will be necessary to understand their continued importance for the earning of tenure.

Shin further noted that more former MFP Fellows than former NSF awardees or members of the control group work at HBCUs and other

minority-serving institutions, and MFP Fellows and control group members are somewhat more likely to be employed in non-academic positions than former NSF awardees. Graduate training at research-intensive or doctoral universities and having minority male and female advisors are positively related to pursuing an "alternative" career trajectory. Other factors such as writing a dissertation on race or ethnicity issues do not have a significant effect on career attainment.

Conclusions

Shin drew several conclusions from this report. Early-career minority PhDs in the scholarly pipeline may not have similar resources, professional opportunities, supportive environments (especially if they are the only minority faculty member in a department), and protection from perceived negative behaviors as their white peers, especially those who have been awarded NSF Dissertation Improvement Grants. Participation in MFP gives minority doctoral students a leg up compared to minority students who are not part of the program. But MFP, by itself, does not appear to be sufficient for pursuing "ideal" careers. High-status white male mentors are instrumental to MFP Fellows in securing academic positions at high-status research I universities. This is partly because there are proportionally fewer minority faculty members in high-status positions with the social capital to move their students into "ideal careers."

Shin went on to note that former MFP Fellows are more likely to pursue "alternative" career paths. These career paths may be choices for those who do not wish to pursue careers in the academy that emphasize extensive academic publication and grant-based research as criteria for advancement, but may wish instead to pursue careers with stronger connections to teaching, applied research, public policy, sociological practice, or service to minority-serving institutions. In fact, minority graduate mentors may encourage such careers for MFP Fellows who are likely to have backgrounds that include research or employment in areas including health care services, health disparities, drug abuse, domestic violence, and HIV/AIDS prevention. These Fellows may wish to continue to serve predominantly minority communities with the added expertise of their doctoral-level sociological training. Shin noted that the study authors are not fully confident that these "alternative" careers are clear choices or the result of the lack of social capital that leads to "ideal" careers.

The researchers plan to enlarge the study sample by adding three more cohorts so that the intersectional analysis between fellows and mentors becomes more valid. They also plan to add data on publications and the grant status of mentors to further understand the effects of the mentoring relationships. And they will examine co-authorship patterns to see if NSF awardees and MFP Fellows are more likely to be part of professional networks than the control group.

MODELING WOMEN'S CAREER CHOICES IN CHEMISTRY

Although money and resources have been devoted to improving the recruitment and retention of women at research-intensive universities, women remain underrepresented in these institutions. What is attracting women chemists to some careers—teaching and industry, in particular—over careers in academia? That question was addressed by Megan Grunert of Iowa State University, who with George Bodner of Purdue University has been examining the career decision-making process for graduate women in chemistry.

From 1999 to 2003, 32 percent of chemistry doctoral graduates were women. But over this same period, only 18 percent of applicants for tenure-track academic research positions in chemistry were women. In 2009, women held just 17 percent of the faculty positions at the top 50 funded chemistry departments. Women tend to be at smaller schools with less emphasis on research, in non-tenure track positions, or serving as instructors or lab coordinators.

Questions that Drive Motivation

Grunert described a study of six research faculty at three institutions, four teaching faculty at three institutions, and ten graduate students at two institutions. The institutions encompassed low, medium, and high percentages of women faculty.

With the graduate students, narrative analysis allowed individual voices and experiences to be heard, while cross-case analysis allowed for comparison across narratives. With the faculty, a constant comparative method allowed for data from each interview to be compared, while thematic analysis identified commonalities across interviews.

Women in chemistry ask themselves many questions as they consider career options. Among the questions listed by Grunert were:

- What career options are available?
- What do women I see in different careers tell me about what that career is like?
- How well does a career fit with what is important to me?
- Do I have what it takes to be successful?
- Does this work yield results that are meaningful for me?
- What stressors are involved in success in this career?
- Do I have to worry about a partner, children, elderly parents, etc., when making this decision?
- How congruent is my ideal self with my possible self in different careers?
- What career choice is most congruent with my ideal self and best fits my needs?

Grunert especially emphasized the four areas of expectation of success, personal values, career outcomes, and the cost or stress to self. These factors are weighed against each other when making a decision, she said.

Qualitative Results

Grunert cited representative statements from graduate students and faculty members in each of these four areas. In the area of expectation of success, respondents said:

> I don't think I could do it. . . . I could do the teaching. [But] come up with the . . . new idea, that next big thing that really has the flavor of originality? While I might be able to get there eventually, I don't think I would get there soon enough to establish a program before tenure.

> I'm not really very creative. I don't have the big research ideas, and I don't think I could survive in that environment, to have those big ideas and push them and do the grants and that kind of thing.

In the area of personal values, typical statements included the following:

> I think being able to touch people is something that research, I mean, you can touch people with research, but being able to have that one-on-one contact . . . being able to see people respond . . . helping them understand a concept for example, that's a reward that I see a lot that I don't necessarily get from research.

> Research really for me is constant problem-solving . . . that's a great challenge. You never get bored; there are always new questions . . . the challenge to my brain, every day's different, new problems all the time.

Regarding academic research career outcomes, students and faculty said:

> I think everybody kind of comes into the science field thinking they're going to discover the one thing that's going to change the world and then you realize that's just not going to happen. That you're not part of the small fraction of people that's going do that, and I'm now okay with that and I've learned to kind of think of other things that I want to do and where I feel more comfortable with my skills.

> One of the problems I've had with even majoring in science and chemistry is that I couldn't see the relevance of it, you know, why is this important, why are we doing this, how does this relate to everyday life?

Finally, with regard to the stress or cost to self, typical statements were:

> It takes so much time out of your life to do that kind of research, that if you start talking about, you know, having kids or having a family, juggling that on top of trying to get tenure and, you know, trying to do really good science . . . just seems impossible . . . you see your boss and you're just like, 'that's not the life I want.' I'm not that great scientist, and I don't want to pretend that I am and I don't want to put in 20 hours a day or 18 hours a day, you know, I don't want to think about science all the time.

I like the fact that it's not really a nine-to-five job. So I can set my own hours, and in fact, generally I work more than a nine-to-five job. . . . I like the idea of having like a little bit more freedom.

Conclusions

Both graduate students and faculty members recognize the challenges inherent in academic faculty life and success in a chemistry department, including time commitments, pressures to publish and obtain funding, and challenges balancing family and personal life. However, graduate students often fail to identify the primary rewards and career choice motivators reported by research university faculty, and they tend to overlook the positive outcomes from academic chemical research. Graduate students may lack confidence in their ability to be a successful academic researcher, and they may perceive that academic research is incompatible with their family and personal goals.

Grunert suggested giving graduate students more information through candid conversations between women faculty and graduate students and mentoring relationships between women in the department outside of the advisor–advisee dynamic. She also suggested making explicit the relevance and impact of chemistry research and providing professional development opportunities for graduate students.

In addition, chemistry departments need family-friendly policies that are supported and accepted, such as tenure clock stoppage and maternity/paternity leave. Dual-career couples receive such supports as job placement and recognition that both members of a couple are working. Departments also need to provide support for a balanced life and lower expectations regarding the amount of time spent in a lab.

The take-home message, said Grunert, is that career decision making for women in chemistry is complex and multifaceted. Women are making active choices, not "leaking from the pipeline." There is a lack of visibility regarding the lifestyle of women in academic research, and the resistance to academic research careers among women reproduces the culture of academic research departments. Critical points in the decision-making process need to be targeted for interventions if more women are to be attracted to academic research careers.

8

Medicine and Science

Academic medicine has a long history of programs aimed at increasing diversity. More than 60 percent of the full-time faculty at U.S. medical schools are physicians, and academic physicians receive nearly half of the research funding awarded by the National Institutes of Health (NIH). Yet according to 2010 data from the American Association of Medical Colleges (AAMC), only 12.3 percent of physicians in the U.S. come from underrepresented minority backgrounds (African American, Mexican American, Puerto Rican, or Native American).

An entire session of the conference focused on factors influencing disparities in the physician workforce. Debt was a recurring theme, as was exposure to research opportunities throughout undergraduate and graduate school. The presenters also addressed the usefulness of integrating social science techniques into disparities research and the role of community organizations in policy development.

THE ROLE OF MEDICAL SCIENTIST
TRAINING PROGRAM FUNDING

Debt is a heavy burden for many medical students, and it plays a significant role in whether graduates of combined MD-PhD degree programs plan to pursue clinical or research careers, explained Donna Jeffe, research associate professor in the School of Medicine at Washington University in St. Louis. In work supported by the National Institute of General Medical Sciences, Jeffe and her colleague Dorothy Andriole investigated the role of Medical Scientist Training Program (MSTP) funding in the educational outcomes and career plans of MD-PhD program graduates of U.S. medical schools accredited by the Liaison Committee on Medical Education (LCME).

The MSTP, established in 1964, supports students in pursuit of biomedical research careers or careers in academic medicine through provision of institutional grants to support MD-PhD joint degree programs. NIGMS awards MSTP grants to institutions, which are then responsible for selecting trainees and running the programs. The grants provide institutions with funding for trainees for a maximum of six years of support, including a stipend, tuition allowance, and budget for travel and supplies.

The number of U.S. medical schools with MSTP funding has grown from three in 1964 to 42 in 2010, though more than 120 schools currently offer MD-PhD programs. Using de-identified student records from the Association of American Medical Colleges (AAMC), Jeffe tested two hypotheses: first, that certain pre-matriculation characteristics of MD-PhD graduates would differ based on whether their medical school received MSTP funding, and, second, that medical school MSTP funding would be associated with educational outcomes and career choices of MD-PhD graduates.

Using information from about 3,150 MD-PhD graduates who had matriculated in medical school from 1993 to 2000, the study considered multiple variables, including academic performance data—MCAT scores and United States Medical Licensing Exam scores from the first step in the exam sequence—and data from the AAMC's Graduation Questionnaire, including total debt at graduation and career-setting preference at graduation. Jeffe and Andriole separated career-setting preferences into full-time clinical practice, undecided/other, non–research-related career settings, and research-related career settings (including both full-time university teaching/research positions and non-university research scientist positions). They also obtained students' self-identified race/ethnicity and gender data from the AAMC's Student Record System, as well as the Carnegie classification of students' undergraduate universities to distinguish research universities from baccalaureate colleges, master's colleges, or other institutions.

The study identified three groups of medical schools: those with longstanding MSTP funding (at least six years from 1993 to 2000), those with recent MSTP funding, and those with no MSTP funding at any time from 1993 to 2000. Using logistic regression models, the researchers compared predictors of enrollment in longstanding–MSTP-funded versus non–MSTP-funded schools, recent versus non–MSTP-funded schools, and longstanding versus recent–MSTP-funded schools.

MD-PhD graduates who were women, who were underrepresented minorities, and who had higher MCAT scores were more likely to have graduated from longstanding MSTP-funded schools than from non–MSTP-funded schools. Findings were particularly notable regarding race/ethnicity; URM MD-PhD graduates were 4.3 times more likely to have graduated from longstanding MSTP-funded than from non–MSTP-funded schools. There were also big differences in the debt levels reported by MD-PhD graduates according to where they had gone to school, Jeffe emphasized. Nearly 50 percent of MD-PhD graduates of non-MSTP schools reported having at least $50,000 in debt compared to only 19 percent of MD-PhD graduates of schools with longstanding MSTP funding and 22 percent of MD-PhD graduates of recent-MSTP funded schools. The percentages of MD-PhD graduates of longstand-

ing MSTP-funded schools and recent–MSTP-funded schools having no debt (43 percent and 41 percent, respectively) were much greater than the percentage of MD-PhD graduates of non–MSTP-funded schools who were debt-free (21 percent).

When it came to career intentions, 87 percent of MD-PhD graduates of longstanding–MSTP-funded schools preferred research-related career settings, as did 79 percent of MD-PhD graduates of non–MSTP-funded schools. MD-PhD graduates with $50,000 to $99,000 of debt were twice as likely to indicate a preference for a clinical practice career setting than a research-related career setting, and those with at least $100,000 in total debt were 3.6 times more likely to indicate preference for a clinical practice career setting than a research-related career setting. Those MD-PhD graduates with at least $100,000 of total debt were also twice as likely to prefer other types of careers (non-research) or to be undecided about their career setting preferences compared to preferring research-related career settings. After controlling for total debt, there were no significant differences in career intentions by gender, by race/ethnicity, or by whether or not the graduates had attended MSTP-funded schools. "The important variable here seems to be debt," said Jeffe.

Increasing Tuition and Fees

Jeffe pointed out that between 1989 and 2009, tuition and fees at public and private medical schools increased steadily, while the amount of MSTP funding oscillated, showing little net increase over that time span. This leads students to depend more on school-based aid and less on MSTP funding.

The results of the study suggest both the importance of MSTP funding in promoting diversity in the physician-scientist workforce, and the role that such funding plays in minimizing debt, which can help sustain MD-PhD program graduates' interest in pursuing research-related careers. Jeffe also pointed out that many MD-PhD graduates had debt despite having attended MSTP-funded medical schools and recommended further interventions aimed specifically at reducing debt levels.[1]

MEDIATING RACIAL AND ETHNIC DISPARITIES IN ACADEMIC MEDICINE FACULTY APPOINTMENT

Although epidemiological techniques are generally associated with risk factors for disease and death, the principles apply to other arenas as well. Dorothy Andriole of Washington University in St. Louis used epidemiological models to study medical school faculty appointments and tease out some of the factors that lead to racial/ethnic disparities in faculty appointments among U.S. medical school graduates.

With funding from the National Institute of General Medical Sciences, Andriole and her co-investigators, Donna Jeffe and Yan Yan, developed a

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[1]Jeffe, D. B., and D. A. Andriole. (2011). A national cohort study of MD-PhD graduates of medical schools with and without funding from the National Institute of General Medical Sciences' Medical Scientist Training Program. *Academic Medicine* 86(8):953–961.

medical education outcomes database that includes every person who matriculated at Liaison Committee on Medical Education (LCME)-accredited medical schools in the United States between 1993 and 2000. They obtained longitudinal data about this population, made up of almost 130,000 individuals, from the Association of American Medical Colleges (AAMC), the American Medical Association, and the National Board of Medical Examiners.

"There is this very widespread perception that once you get your foot in the door in medical school, you're set. That's just not true. The pipeline is actually very leaky through medical school and beyond, and we need to understand this far better so we can address it," Andriole explained.

Predictors of Withdrawal from Medical School

After controlling for MCAT scores, pre-medical debt, and undergraduate institution, Andriole and her colleagues identified several predictors of academic withdrawal/dismissal from medical school. Nonwhite race was associated with significantly greater risk of academic withdrawal/dismissal—almost three times greater for underrepresented minority students and one-and-a-half times greater for Asian/Pacific Islander students compared to white students. The only educational factor the researchers found beneficial in preventing academic withdrawal/dismissal was participation in a college research lab apprenticeship.[2]

Andriole pointed out that although many faculty members may feel they have failed when a student leaves a lab for medical school rather than graduate school, it is important to note that the lab experience has important benefits for the student in the long run. It increases the medical student's ability to realize the professional goal of graduating from medical school; furthermore, it increases the likelihood that the graduate will be appointed to a full-time faculty position in academic medicine.

Analysis of the database reveals troubling racial and ethnic disparities in appointment to full-time faculty positions. Eighteen percent of white graduates eligible for faculty appointment had held full-time positions, as had 19 percent of Asian/Pacific Islander graduates, but only 14 percent of underrepresented minority graduates did so. "Importantly, that gap existed during a period of efforts by medical schools and all sorts of funding organizations to very actively promote the greater recruitment of underrepresented minorities to medical school faculty positions," said Andriole.

To try to identify variables that could be targeted for intervention to reduce this disparity, the researchers examined eight potential mediators of these racial/ethnic disparities in full-time faculty appointments using two models: one model compared white graduates to underrepresented minority graduates, and another model compared Asian/Pacific Islander graduates to underrepresented minority graduates; they controlled for gender, parent

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[2]Andriole, D. A., and D. B. Jeffe. (2010). Pre-matriculation variables associated with suboptimal outcomes for the 1994–1999 cohort of U.S. medical-school matriculants. *Journal of the American Medical Association* 304:1212–1219.

occupation, and graduation year in each model. A higher proportion of underrepresented minority graduates than white graduates had participated in research during college and research electives during medical school. However, a lower proportion of underrepresented graduates than white graduates reported authorship on manuscripts submitted for publication during medical school and were less likely to participate in a year or more of research during residency training. Both of these variables were found to be significant mediators of the association between race/ethnicity and full-time faculty appointment.

Attendance at a research-intensive medical school and intention at graduation to pursue an academic medicine career also mediated the observed race/ethnicity disparities in both models. Finally, Andriole noted, "Whatever intention you leave medical school with is very predictive of what you're going to do. Students planning to pursue academic medicine careers at the time they graduate from medical school are much more likely to have a full-time faculty appointment compared with students with other plans. This is really important."

Getting in Good Labs

Overall, the researchers found that variables amenable to intervention accounted for a significant portion of the observed disparities in full-time faculty appointment—86 percent of the disparity between Asian/Pacific Islander and underrepresented graduates, and over 70 percent of the disparity between white and underrepresented graduates. The findings highlight the importance of informing students about careers in academic medicine and providing productive research opportunities.

"Medical-school faculty and administrators can work to send students to labs that provide supportive, productive research environments," Andriole concluded. "And we need to make sure students are getting placed in good labs."

ARTICULATING THE EXPERIENCES OF MINORITY STUDENTS IN THE BIOMEDICAL SCIENCES

Although quantitative research on the experiences of underrepresented minorities in medical training programs is plentiful, few qualitative studies have focused on the experiences of the students in those programs. Gina Sanchez Gibau, Associate Professor of Anthropology at Indiana University–Purdue University Indianapolis, brought the perspective of a social scientist to her analysis of two programs at the Indiana University School of Medicine: Bridges to the Doctorate, which facilitates the transition of master's students to PhD programs, and Harper Scholars, which funds underrepresented minority PhD students enrolled in biomedical science programs.

Her findings generated dialogue about not only the benefits of the programs, but also the challenges faced by both participants and administrators. There is a great deal of integration between the two programs and the stu-

dents they serve, so although much of the discussion was centered around the Bridges program, Dr. Gibau's findings reflect on both.

The main goal of Bridges and Harper Scholars is to provide underrepresented minority students with mentors, funding, and research opportunities to increase the number of students graduating from PhD programs in the biomedical sciences. Gibau chose to focus on the experiences of individual students, analyzing interviews conducted by external reviewers over a five-year period. Although only 17 students participated, some gave multiple interviews, bringing the total number of transcripts to 24. The goal of her analysis, she said, was to see how well the experiences of students aligned with the goals laid out by the two programs to inform continued program development.

The Bridges initiative at the Indiana University School of Medicine is a formal partnership between Jackson State University, California State University–Dominguez Hills, and Indiana University. Other institutions across the country also run Bridges programs, which are funded by NIH. Master's students attend the university during the summer to facilitate their transition to doctoral programs. From 2000 to 2008, ten of the 18 students enrolled in the Bridges program at the Indiana University School of Medicine went into doctoral programs, and in 2010 that number increased to thirteen. Two of the three students in the first cohort have PhDs, and six of ten who graduated between 2003 and 2009 are funded by NIH grants associated with the program.

Some of the key program strategies Gibau emphasized were summer research opportunities, funding paths, and mentoring on multiple levels. The university strives to give students access to strong administrative and peer support. Students also have the opportunity to be mentors themselves. "Their interaction with other PhD students and postdocs, and also their ability to mentor others, is very important to their socialization as scientists," Gibau said.

Interview Themes

Several themes emerged from the interviews that pointed to the value of central tenets of the program. Students praised the availability and quality of lab space and equipment, as well as the exposure to minority role models in the form of successful visiting scientists and other students graduating from the program. Gibau pointed out, however, the frustration one student expressed at the prevalence of Ivy League backgrounds among visiting minority scientists—an experience not shared by most of the program participants. The interviewees also emphasized the significance of mentoring and their exposure to a range of different research areas.

One particularly interesting response to the interviews was the feeling of students that participation in the program highlighted their minority status. Gibau quoted one student on this topic: "I was always referred to as either a minority student or whatever grant, like everyone knew what grant number I was associated with. I didn't like that too much."

"How do we highlight the successes but also not engage in an activity which would make [students] hypervisible in a situation where hypervisibility causes stigmatization?" Gibau asked. Changing the culture of science overnight is not realistic. A better approach may be to change the cultural lens so that students are not categorized primarily as minorities but as scientists who happen to come from a minority background.

Gibau expressed her hope that the integration of social science with science departments would continue given the benefits of such partnerships in understanding disparities in the sciences.

REDUCING CANCER DISPARITIES THROUGH COMMUNITY ENGAGEMENT IN POLICY DEVELOPMENT

Cancer is the second leading cause of death in the United States and a source of large racial and ethnic disparities in population health. Policy Development (PD) is a powerful but sometimes overlooked public health tool for reducing cancer burden and disparities. Along with other partners in the public health system, community-based organizations such as local cancer councils can play valuable roles in developing policies that are responsive to community needs and in mobilizing resources to support policy adoption and implementation. Local cancer councils are voluntary partnerships formed by community organizations to pursue common interest in PD activities. The cancer councils bring community members together to discuss policy solutions to disparities in cancer risk, prevention, diagnosis, and treatment. Michael Preston of the University of Arkansas discussed the function of these councils, their importance in the community, and their potential to influence policy development.

Each council has between 10 and 15 members, and six councils are currently active in Arkansas. Cancer councils unite a large swath of the community, including representatives from health care and government, cancer survivors and family members, community organizations (including churches and faith-based groups), nonprofit organizations, and education professionals.

Preston and his colleagues did a descriptive and formative study to examine the current and potential roles played by local cancer councils to reduce cancer burden and disparities. "We wanted to look at the current and past experiences in cancer policy development, the types of policy issues addressed, the array of policy decision-makers with which council members interact, and the types of methods used to inform policy discussions within these communities," Preston explained.

Survey Results

Researchers surveyed 77 council members. Of that group, 86 percent responded to questions about their background, experience in health policy, and perceptions about the effectiveness of their work with the cancer councils.

Membership for the six community cancer councils in Arkansas includes elected or appointed officials of a state/local government (6.1 percent), rep-

resentatives of church or other faith-based organizations (9.2 percent), health care professionals (6.1 percent), hospital or health care organization employees (6.1 percent), and business owners or chamber of commerce members (5.1 percent). The majority of these cancer council members are from the Arkansas Department of Health (27.6 percent) and community-based organization (39.8 percent).

Preston emphasized three areas targeted by the survey: knowledge, skills, and resources. By asking respondents about their perceived knowledge of health policy, as well as whether they felt they had the necessary resources to carry out policy development activities, the researchers were able to more clearly gauge the potential of cancer councils to influence policy development. Awareness of and exposure to health policy issues were high among council members, with 88 percent reporting experience in PD activities. Among the members with experience, 81 percent discussed cancer prevention and screening. Policy self-efficacy was high among council members, with 85 percent reporting the necessary knowledge to talk with a local official about a health issue. Additionally, 73.2 percent of respondents indicated that they have the skills to support their interest in changing a health care issue. Alternatively, only 41.5 percent believe that there are available resources to support their interest in providing a change in health care. Nearly a quarter of respondents believed they needed assistance knowing who to speak to on specific policy concerns.

Potential for Greater Influence

Cancer council members are engaged in frequent PD opportunities on a variety of cancer policy issues. Their current engagement occurs more often with governmental policy stakeholders than with influential private sector interests such as chambers of commerce, medical societies, and hospitals. "These findings also provide evidence that cancer council members have high perceived self-efficacy but need resources and technical assistance to support Policy Development," Preston said. Community engagement through local cancer councils may inform and improve the PD processes within public health systems. Findings may be used to develop interventions to enhance community engagement in policy for the population studied.

"To have the greatest impact, you have to have some tool or mechanism," Preston said. "Responsive public health systems require vehicles for communities to engage in policy development. These particular cancer councils provide a promising model of engagement for these particular activities." Untapped opportunities exist for enhancing policy development through cancer councils, such as expanding targets of engagement to include private-sector stakeholders and expanding methods of engagement.

Many of the councils are located in poor and underserved areas of the state with large health disparities, and one of their strengths is their ability to shape council membership according to the specific needs of each community. Further study of such councils will continue to help refine and enhance their influence, Preston concluded.

9

Evaluating Interventions

The theory driving program evaluations is a significant component of the theory behind interventions in general, and several speakers specifically addressed evaluation methodologies and theories, including the data gathered to support these theories. Theory-driven evaluations may direct attention to the economic, personal, or social effects of an intervention. All are important in conducting a full evaluation.

ECONOMIC MODELING AND INTERVENTIONS RESEARCH

Large amounts of resources are devoted to increasing diversity in science and engineering, said Samuel Myers, Roy Wilkins Professor of Human Relations and Social Justice at the University of Minnesota. "There's not much dispute in an audience like this about the value of those investments," he said, but to justify that value to other audiences, a structured, quantitative evaluation process is necessary.

Approaching evaluation from an economic perspective is valuable, since economists are concerned not only that a program has the desired outcome, but also that the process is as efficient as possible. In particular, economists look closely at the market value of benefits—not just the intrinsic benefits to a student, but the value of those benefits to society. "As much as we are concerned about issues of fairness and equity, the evaluation methodology is not about that," he said. "It's about efficiency, about did you help the people you were supposed to help, did you help them at a cost that is lower than alternative costs, and does it do what it's supposed to do?" Careful attention to these factors is necessary, he added, at a time when opposition to interventions exists and the resources available for funding them have declined.

Methodological Designs

The most informative type of evaluation is a randomized experiment. Such experiments have the ability to establish causal relationships between interventions and outcomes. They also are more likely to be replicable and have strong internal validity. However, because the design requires that students in equal positions have different levels of support, ethical issues are involved. The logistics of studying interventions can prove both difficult and costly as well. Attrition and retention issues complicate long-term studies, and creating a double-blind experiment is difficult if not impossible.

A quasi-experimental design, Myers said, has some of the benefits of a randomized experiment. Instead of randomly assigning individuals to a control group, researchers use statistical techniques to create a program group and a control group that are almost the same. Matching techniques also can help compensate for some of the problems faced by longitudinal studies, and quasi-experimental design is cheaper than a randomized experiment. However, Myers pointed out, quasi-experimental design has some disadvantages. It is difficult to establish causality. Selection bias is an inherent issue, and by correcting for selection bias, the validity of the results declines. Researchers also have to consider counterfactual problems, Myers said, or the "what-if?" factors that can complicate a study. He offered the example of a scholarship program, where the sample is every student who qualifies. One counterfactual would be students whose parents send them to the treatment school using their own funds, thus introducing an individual who is not part of the sample but is participating in the same program.

Several quasi-experimental designs are useful. Regression discontinuity designs measure the effects of a program above and below a threshold. This type of analysis works best for disaggregated effects, such as changes in the GPA requirement for program eligibility. An interrupted time series design measures aggregate effects, where a discrete intervention occurs at a point in time. An interrupted time series study has several waves of observations, occurring before and after the independent variable is imposed.

An Example from Chemistry

The *ceteris paribus* method, which assumes all factors other than those under study remain constant, is another possible option. If offers easy-to-compute counterfactuals and "what if" considerations. It also is a potential starting point for more expensive experiments.

Using chemistry as an example, Myers explained how a *ceteris paribus* study might try to measure the impact of affirmative action interventions in the 1970s. The expectation of the intervention was an increase in diversity among chemistry PhDs. Chemistry employment data from 1968 to 2009, Myers explained, show a dramatic change—from 90 percent white males in 1968–1970 to 48 percent in 2007–2009. Building on a labor supply model, the dependent variable measures the probability that eligible workers will be chemists. The independent variables are predictors of whether or not people will become research chemists, including age, race, gender, wages, and

state of residence. The intended outcome of the intervention—PhD degree earned—is included as an independent variable.

The underlying question, Myers said, is what would have happened to the relative representation of women and minorities in chemistry with a uniform increase in post-baccalaureate education. The representation ratio is measured by the probability of being employed as a chemist for a particular group divided by the probability of being a chemist overall. A representation measure equal to one means proportional representation, while less than one symbolizes underrepresentation and greater than one means that group is well represented. By measuring the elasticity, or responsiveness of that ratio to changes in the intervention, researchers can draw conclusions about the effectiveness of the intervention.

The study uses data from the Integrated Public Use Microdata Series of the Current Population Survey (CPS). White males show over-representation, but with a declining trend, while white females have an upward trend, from 0.2 to 0.65, but never reach a representation ratio greater than one. African American numbers rose and fell with no consistent pattern. "It depends a lot on who's the president of the university, what's going on at NIH and NSF, what's going on with respect to the Supreme Court cases. There's a highly variable impact with respect to variable social conditions," Myers pointed out.

He highlighted the fact that the first time period studied—1970 to 1979—was the only one that showed a significant effect of the intervention. After 1979, no significant impacts were apparent. However, wage effects, he said, are statistically significant in recent years. "One of the takeaway points here is be concerned about wages," he said. The relative wages in competing industries and employment in alternative skilled professions affects representation. Also, representation ratios are not elastic with respect to changes in post-baccalaureate education. He recommended incorporating a measure of market wages in assessments of outcomes and controlling for different geographic market areas.

This kind of analysis is particularly suited to thinking about what types of experiments and measures to use, Myers said. It can point research in a useful direction and help make choices among various research questions.

Medical School Versus Graduate School

Many students in the chemistry intervention programs ended up in medical school, Myers observed. "I'm not going to argue about whether or not it's a good or bad thing for people to go to medical school when they're 'supposed' to go to PhD programs in chemistry," he said. "I'm just going to make a clear case that money that you spend trying to increase the skill set in order to increase the supply of chemistry PhDs—that's the pipeline model, like the post-baccalaureate model—is money that has a potential unintended market effect. Although you spend your money on trying to create chemist PhDs, you in fact might expand the pool of people who qualify to go to medical school."

The same thing happened at the American Economic Association, Myers explained, where attempts to increase the number of PhDs in economics led

to an increase in students attending business school and law school, in part because the salary of people in business schools and law schools is much higher. Nevertheless, he emphasized the net benefit to society. "I feel very uncomfortable with this idea that there's something wrong about making an investment that pays off in another field," Myers said. "However, I want the people who participated in that summer program to know that the investment we made in them helped contribute to where they are right now. There has to be some sense of accountability and responsibility on the part of the beneficiaries of the investment."

A SYSTEMS APPROACH TO MODELING AND MEASURING CAREER ADVANCEMENT IN ACADEMIC MEDICINE

Joan Reede, Dean of Diversity and Community Partnership at Harvard Medical School, spoke about a new model Harvard is developing for data collection and analysis of career advancement. In her 20 years at the school, she said, faculty diversity has increased. However, a better understanding of faculty experiences and the best places for intervention would greatly improve diversity programs. Diversity research is scattered across the university, without much connectivity. Moreover, assessment is often limited and not systemic or systematic. "Oftentimes," she said, "when you are running a program for minorities, you have information on the minorities in that program, but there is a lack of controls and comparisons, and there are many confounding factors where you have little information. It is astounding to me the ways in which we collect data but do not know what we are actually collecting, and we do not track over time."

As someone in a leadership role, Reede said, she has found this lack of complete information to be especially frustrating when developing policies and practices. Diversity programs become an effort to increase numbers rather than an integral part of an institution's mission. Also, it becomes much more difficult to attribute success, especially when applying for funding to support diversity initiatives.

A New Diversity Inclusion Framework

An NIH award for innovations relating to diversity advancement allowed a group at Harvard to begin building a new framework for data collection. The system, called Pathways, acknowledges that diversity programs "are embedded in a larger system that relates to the education, research, and service," said Reede. "How is diversity actually included and embedded in our organization? And what do we gain from it?"

The system contains profiles of all Harvard Medical School faculty. A dynamic set of algorithms is used to automatically update data on demographics, education, years at Harvard, academic rank, department, affiliation, publications, and so on from multiple existing institutional and public data sources. Pathways utilizes the tools created for the Harvard Catalyst Profiles by Griffin Weber. Harvard has already shared the Profiles tool with several other institutions, Reede said.

The Profiles system collects data automatically, pulling information from PubMed, MedLine, and Thompson's Web of Knowledge. There are several factors that need consideration. It can be difficult to disambiguate names, which might appear differently in the various databases. Prioritizing data based on usefulness, timeliness, cost, and accuracy is also important. Although some data exist at an institutional level, other critical information such as individual faculty CVs is found at the departmental level. Currently, the effort focuses on demographics, degrees, publications, teaching, and grants: who is applying for grants, how successful they are. "In promotion," Reede explained, "grants are critically important."

The study also explores other elements of career advancement, looking not only at progression from one academic rank to another but also taking into consideration other aspects of advancement such as leadership appointments and recognitions. How do traditional indicators of performance relate to these other types of advancement? What other indicators, such as social networks, can be used to understand the career pathways of diverse faculty?

Profiles allows researchers to examine connections among faculty members, where they do their work, how it shifts over time, and with whom they collaborate. "You can understand where an individual works across institutions, across departments, across disciplines," Reede explained. Each person in the system has a network, or reach, which increases as a faculty member rises in the academic hierarchy. Preliminary work has shown that the average publication reach differs across disciplines, and also by gender and race or ethnicity. Males and females stay on a similar track until age 35, where the reach for men continues to increase and the reach for women goes up at a slower rate. Blacks and Hispanics show a similar slower rise beginning at the same age.

"Do we understand the patterns of the networks that people have yet? No," Reede said. "Are there lots of things to take into consideration? Yes. Minorities tend to be more at the lower ranks than the senior ranks. Women tend to be more at the lower ranks than the senior ranks. Women and minorities tend to be in one discipline more than another discipline. But how do you start to tease this out so that we can understand where we need to intervene with our faculty?"

One advantage of having such a large pool of data, she said, is the ability to focus on individual departments and to compare trends across institutions to see if the data show similar patterns. "There are new kinds of questions we should be asking," she said. Researchers are also beginning to look at the findings of difference and considering adding other types of qualitative data as research questions develop.

Extensions of the Database

Harvard aims to expand Pathways by gathering data from a wider range of sources. "Our hope with this is that we can interrupt the usual assumptions people make," Reede said. She recalled disagreeing with a senior researcher about the amount of research done by faculty members. "Wouldn't it be nice to have some evidence? How you move from anecdote, from this is my

personal experience, to actually understanding what's going on within an institution?" By using institutional data to inform policies and progress, she said, diversity can be linked to the goals of the institution and to how the institution responds to community needs.

Reede said that it is an exciting time to be doing diversity work. "After 20 years, I can finally start to tease out what's actually happening. Is there equal representation of participation in these training level programs and other supplemental programs? How might they impact the career trajectory of a person—not just do they get promoted, but are they publishing differently? Are they collaborating differently? Are they appearing more often in grants as a co-investigator or a co-PI?"

A THEORY-DRIVEN APPROACH TO EVALUATE UNDERGRADUATE RESEARCH PROGRAMS

Four common models are applied to undergraduate research experiences (UREs), explained Omolola Adedokun, Assessment Coordinator for the Discovery Learning Research Center (DLRC) at Purdue University: apprenticeship, mentor-colleague, hierarchical, and contractual.[1] The apprenticeship model is most common, where a student is able to learn research skills by working closely with a faculty member. With a hierarchical relationship, a graduate student will typically supervise the undergrad, a postdoctoral fellow will supervise the graduate student, and the faculty member is more removed from undergraduate research. A contractual model emerges when a faculty member defines his or her needs in advance and then searches for a student for a specific task or project. A mentor-colleague relationship involves more of a one-on-one interaction and may lead to the student doing graduate work with that faculty member.

These models are important for consideration, Adedokun said, when designing evaluation plans for undergraduate research programs. She pointed out that many URE evaluation designs lack structure, fail to account for differences in models, and focus on outcomes with little to no attention paid to processes. Theory-driven evaluation is a framework that could address some of those gaps. It uses formal descriptions of the theory-based or logical processes through which program components are presumed to influence outcomes and the conditions under which these processes are believed to operate.[2] It emphasizes development of a program's theory and testing and refinement of the program model. It considers both the processes that connect the program with outcomes and conditions that moderate the relationship between processes and outcomes. Adedokun also added that theory-driven evaluation seeks to understand the relationships among program outcomes as well as links between participant characteristics and outcomes.

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[1]Landrum, R. E. and L. R. Nelsen. (2002). The undergraduate research assistantship: an analysis of the benefits. *Teaching of Psychology* 29:15–19.

[2]Donaldson, S. I. (2001). Mediator and moderator analysis in program development. In S. Sussman, ed., *Handbook of Program Development for Health Behavior Research and Practice* (pp. 470–500). Thousand Oaks, CA: Sage.

A program's theory can be empirical, descriptive, or a mixture of both. It may use existing literature or implicit theories of how the program should work. And it must be logical, Adedokun explained, perhaps drawing on observations of the program over the years or on information from the lived experiences of the program participants.

Evaluation of an Undergraduate Research Program

Using Purdue University's Discovery Park Undergraduate Research Internship (DURI) program as an exemplar case, Adedokun discussed the applicability of theory-driven evaluation for UREs. Purdue has multiple discovery-to-delivery research centers that promote the development of discoveries made on campus into business ventures and employment opportunities, and the DLRC, through the DURI project, helps match students with research projects in those centers. STEM fields dominate the program, but Adedokun said the projects tend to be interdisciplinary. Students participate in a seminar that incorporates peer-led discussions, research reports, and journals. The evaluation design consists in part of a faculty survey where faculty mentors rate students on 23 different items. The students also rate themselves on the same scale and take a follow-up survey that helps researchers track their activities after graduation.

Adedokun and her colleagues conducted exploratory research to test assumptions about how the program was operating. In developing the program's theory, the researchers expected that its components would lead to short-term goals, including interest in research and a desire for hands-on experience, which in turn would improve students' research. Students in a successful program will aspire to graduate education and research careers. At the same time, the evaluation recognizes that some factors, such as personal variables, preconceptions of science careers, and interactions with faculty, are beyond the control of the program. After testing the reliability of the instruments measuring research self-efficacy, understanding of research processes, and research skills, the researchers used path analysis, a statistical technique employing multiple regressions, to identify dependency between variables. From four separate exploratory studies, the researchers found that most relationships were as predicted. Aside from the lack of a direct relationship between research skills and the desire for a research career, the predictions were accurate. Adedokun and her colleagues observed that understanding the research process improved research skills, which increased research self-efficacy. Greater self-efficacy in turn increased students' desire for a research career. However, research skills had no significant effect on students' desire to pursue a research career. "There are lots of inter-variable relationships going on that we can't fully explain," Adedokun pointed out. Clarification of career options was a recurring theme, but it, too, is difficult to measure.

Pathways to Graduate School

Researchers also conducted qualitative studies to examine how the URE experience influenced students' path towards graduate education and ob-

served three main categories. One group answered that increased awareness of career options led them toward graduate school, while a second group pointed to development of research confidence and identity that helped clarify their career interests. A third group credited the experience with enhancing their credentials, giving them resources for graduate school or medical school applications.

Another component of the study looked at how students viewed the experience before beginning the program. "The first thing that came out was very interesting," Adedokun said. Because the sample was undergraduate science students, the researchers did not expect them to have stereotypical preconceptions of scientists and science. Yet students said they expected a lab straight from a science fiction movie, with white lab coats and bubbling chemicals. "The experience was really a learning experience for them."

Some students reported surprise at how long it took to learn lab skills, while others, who had not expected to be trusted with high-level tasks, were surprised to find themselves doing meaningful components of an experiment rather than washing dishes all day. Many also had preconceptions about the degree of team versus independent work and found that instead of every member of the team working on one task together, each person took on a different part of the project. All of the students expected more faculty supervision, instead of postdoctoral or research assistant mentors.

Theory-driven evaluation has greatly helped with program implementation and evaluations, Adedokun concluded. After further tests, the researchers hope to be able to replicate successful elements of the model in other contexts.

COMBINING PROGRAM EVALUATION AND THEORY-DRIVEN EXPLANATION

Phillip Bowman, Director of the National Center for Institutional Diversity at the University of Michigan, discussed the benefits of using theory-driven explanations when conducting program evaluations. Focusing on two exemplary intervention programs, he outlined the results of a mixed method study that is examining factors that both enhance and impede the success of such programs.

The Summer Research Opportunity Program (SROP) is a nationally recognized intervention for underrepresented minority students. The Committee for Institutional Cooperation, a consortium of 12 major research universities and the University of Chicago, developed SROP in 1986, and the program has served approximately 12,000 students since then, with more than 3,000 going on to graduate education. At the University of Michigan, the Undergraduate Research Opportunity Program (UROP) models that success on a smaller scale, giving students an academic year of research experience in hopes of advancing their skills and promoting research as a career.

Researchers designed their evaluation as a social-psychological study, combining record analysis with a quasi-experimental method that allows researchers to test theory-driven hypotheses and measure the efficacy of the programs. Both programs share certain components, including hands-on

research experience, skill development workshops, research reports, presentation opportunities, and faculty mentoring. This unique theory-driven intervention study is funded by the National Institute of General Medical Sciences.

Dimensions of the Evaluation and Theory-Driven Analysis

Preliminary studies of SROP have demonstrated the efficacy and impact of this exemplary program, Bowman said. His more rigorous outcome evaluation will collect data for four years, measuring responses from program participants against those from a comparison group of students who applied to the program but did not participate. That group is broken into multiple control groups, encompassing students who did not participate in SROP but participated in a different summer research experience and those that did no research.

The five main questions posed by the study focus on (1) the adverse effects of financial and academic role barriers on program outcomes, (2) the impact of differential engagement of formal program components on participant benefits, (3) the influence of informal support from faculty-mentors, program staff, and co-participants, (4) supportive roles of family support and a network of friends on program outcomes, and (5) whether mentor–participant relationships play a role in determining what path students choose. The researchers targeted several variables, including academic performance, choice of major, graduate school plans and short-term and long-term plans for STEM careers.

Bowman also discussed two doctoral dissertations in more detail that dealt with similar questions. While evaluation studies have supported the overall efficacy of pipeline interventions, less is known about the factors that *impede* and *enhance* the success of various program participants. Accordingly, both dissertations focus on better understanding of the mechanisms by which interventions promote positive outcomes for underrepresented students of color in the sciences. Guided by a strength-based role strain and adaptation model, one dissertation seeks to better clarify how financial and academic barriers, as well as students' adaptive strengths, affect the efficacy of an innovative pipeline intervention on STEM career–related plans.

The role strain hypothesis proposes that objective barriers and related distress experienced by underrepresented students in highly valued social roles may impede successful outcomes in exemplary STEM interventions. Financial and academic barriers are focused on as objective aspects of student role strain. However, this dissertation goes beyond existing research, which focuses primarily on the negative relationship between objective financial and academic challenges and student outcomes. In addition to the negative impact of objective barriers, this intervention study also examines how students' subjective reactions to financial and academic barriers (for example, self-blame and discouragement) may further impede their STEM career–related plans. As a result, this research provides a more theory-driven analysis of how both *objective* and *subjective* student role strain can deter positive intervention outcomes. Furthermore, unlike other studies, this research investigates how

students' cultural strengths (including extended familial and personal resiliency) may offset the deleterious effects of student role strain on successful intervention outcomes. Overall, this theory-driven analysis seeks to better understand how student role strain and multilevel strengths interplay within the context of an exemplary pipeline intervention to influence underrepresented students' STEM-related career plans.

A second dissertation will look at the impact of formal and informal support on STEM outcomes of program participants, focusing on differential benefits experienced by students in the program. Beyond the actual intervention, this dissertation also focuses on the relative benefits of several formal program components, including financial assistance, research project, graduate school workshops, and faculty career orientation activities. In addition, the analysis will investigate how student engagement of such formal program elements combine with informal support from faculty mentors, staff, and peers to influence underrepresented students' STEM-related career plans. With an open systems approach to program organization, this theory-driven study will further clarify how formal program components and informal support from various program stakeholders combine with multilevel cultural strengths to improve intervention outcomes. Given that students come from a variety of backgrounds, Bowman pointed out, the study is also concerned with examining how pre-intervention support influences students' experiences in the program. "Students are spending the summer at a particular campus, but they may come from historically black colleges, from other minority-serving institutions, or from other universities around the country," he said. "It's also a question about how family, best friends, and faculty at their home school may make a difference, the kind of outside support they receive, and the differential benefits they receive from the program itself."

Researchers developed a formal scale for measuring the effects of mentor–participant relationships, defining various aspects of the interactions between students and faculty. Mentors can serve as role models, friends, and coaches—among many other roles—and Bowman described how the study is looking at the possible impact of those roles on differential outcomes for students in exemplary pipeline interventions.

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From Conference to Community

In the final session of the conference, Daryl Chubin, Director of the Center for Advancing Science & Engineering Capacity at the American Association for the Advancement of Science (AAAS), and Anthony DePass, Assistant Vice President for Faculty Research Development at Long Island University–Brooklyn, led an informal session with the goal of informing future conferences and the development of a community focused on improving interventions. "What has left an impression on you about what you just experienced in the last couple of days?" asked Chubin. "What thoughts do you have about this community going forward?"

Since the initial 2008 conference, presentations have expanded away from a strictly hypothesis-based format, said DePass. At the same time, said Chubin, networking, which has been a goal of all the conferences, has brought together program directors and researchers from an increasingly large variety of fields. As a result, the conference has evolved from a research-focused event to a gathering of people motivated to translate research into practice.

Chubin and DePass acknowledged the difficulties that many conference participants have in deciding which conferences to attend. Many researchers have to limit their travel due to a lack of resources and time. However, conference participants also stated that the Understanding Interventions conferences fill a niche not covered by any other event. Often, DePass pointed out, diversity work ends up on the margins of a professional society or is limited to the social and behavioral sciences. "That is the unique space this conference is designed to fill, where people who are either learning to be researchers or are already social scientists but moving toward informing their research with practice can interact with each other, along with those who are running programs."

Part of the discussion in the final session centered on whether to hold the Understanding Interventions conference annually or every two years. Some researchers who have presented at the conferences do not feel that they make enough progress in a year to revisit their results. But approximately two-thirds of the attendees at each of the four meetings have been first-timers, Chubin pointed out, and the disciplinary and organizational representation has been steadily increasing. "How do you satisfy the needs of all those participants?"

Chubin noted that the pre-conference survey had 44 percent of participants in favor of an annual meeting, while 56 percent wanted a biennial conference. However, several attendees at the final session said that they had changed their minds over the course of the conference. One participant suggested that two years was a long time to go without reinforcing the connections made during the conference. Other attendees suggested that having the conference at a university enhanced networking opportunities, which in turn made the conference valuable enough to have every year.

A participant noted that many of the presentations given at the conference are worthy of being published, but it is unclear where they belong. Chubin agreed that finding an outlet for interventions research is a continuing challenge. "That leads to the question of what a community has to do, as opposed to what a conference has to achieve," he said. Peer-reviewed journals are one component of a successful community, giving scholars a place to put their work in the public sphere, collaborate, and earn professional recognition.

DePass said that the vision of the conference organizers is to use the conference website as a portal to gather resources in a central location and publish findings online. In addition to bridging the gaps between conferences, this strategy would fuel the evolution and collaborative nature of interventions work.

Finally, long-term funding for the conferences is a major goal, DePass said. Such funding would enable the conference to transition from being a periodic gathering to an ongoing vehicle for building community. Inviting private industry might be a good move, one participant commented, because many jobs exist in that sector. Another brought up the possibility of bringing students, which Chubin said was something to consider. "If we can't enlist the next generation in this work and learn a little from them, we are being shortsighted," he said. "A lot of the issues that we are taking on are not going to be solved in at least my lifetime."

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