UNDERSTANDING INTERVENTIONS

that Broaden Participation in Science Careers

Volume VII

Daryl E. Chubin and Anthony L. DePass - Editors

Translating Research, Impacting Practice

2015

UNDERSTANDING INTERVENTIONS
THAT BROADEN PARTICIPATION IN RESEARCH CAREERS

VOLUME VII

Translating Research, Impacting Practice

SUMMARY OF A CONFERENCE
SAN DIEGO, CALIFORNIA, MAY 15–17, 2015

Daryl E. Chubin and Anthony L. DePass, Editors

Funding for this conference was provided by
the National Institutes of Health (NIH)

With in-kind support from
Long Island University (LIU)

Co-chairs:
Daryl E. Chubin, Independent Consultant, Savannah, Georgia
Anthony L. DePass, Long Island University, Brooklyn

Consultant Writers: Steve Olson and Amelia Apfel

Cover Design:
Carol McDonald, Barefoot Creations

Conference Website:
http://understanding-interventions.org

Please go to http://understanding-interventions.org for information regarding earlier conferences and summary reports.

Printed in the United States of America.

Conference Staff

CO-CHAIRS

Daryl E. Chubin
Independent Consultant
Savannah, GA

Anthony L. DePass
Long Island University–Brooklyn

PLANNING COMMITTEE MEMBERS

David Asai
Howard Hughes Medical Institute

Phillip Bowman
University of Michigan

Goldie Byrd
North Carolina A&T University

Bradley S. Duerstock
Purdue University

Lorenzo Esters
Kentucky State University

Barry Komisaruk
Rutgers University

Kelly Mack
Project Kaleidoscope
American Association of Colleges and Universities

John Matsui
University of California, Berkeley

Richard McGee
Northwestern University
Feinberg School of Medicine

Michael Nettles
Educational Testing Service

Clifton Poodry
Howard Hughes Medical Institute

Claudia Rankins
National Science Foundation

Laura Robles
California State University, Dominguez Hills

Alberto I. Roca
DiverseScholar

CONFERENCE PLANNING TEAM

Shanta Outlaw
Long Island University–Brooklyn

Carleta Joseph
Long Island University–Brooklyn

Alma Clayton-Pedersen
Emeritus Consulting Group, LLC

Karen Kalla
Association of American Colleges and Universities

Daryl E. Chubin
Independent Consultant, Savannah, Georgia

Anthony L. DePass
Long Island University, Brooklyn

Contents

Preface

Since the first conference on Understanding Interventions that Broaden Participation in Science Careers was held in 2007, the Understanding Interventions community has been growing, diversifying, and broadening its purview. As the movement begins its tenth year, the community is entering a new era of expansion and outreach. As just one example, for the first time this year, the conference summary has been adapted for the web, with the summaries of individual sessions available from a hyperlinked agenda on the Understanding Interventions website.

As described in the preface of last year's conference report, the receipt of a major grant from the National Institute of General Medical Sciences of the National Institutes of Health has made it possible to execute several actions that were years in the planning. Key among these is the evolution of the Understanding Interventions website (http://understanding-interventions.org) to a portal where members of the community can access a variety of resources to learn about new opportunities, build their professional expertise, and disseminate their work. We have assembled a hard-working team of researchers, technologists, and information specialists to develop the UI Index (which is described in Chapter 7 of this report). Sections of the UI Index already unveiled include searchable databases of (a) peer-reviewed literature from across the sciences on interventions to broaden participation in science careers, (b) journals that publish interventions research, (c) reports from major organizations related to the status of training and diversity in science, and (d) published work on evaluation measures related to interventions. Sections under development will provide searchable access to the Top 50 cited articles for a variety of topics related to Understanding Interventions. Planning has begun to bolster our capacity for real-time dissemination of Interventions research as well as evaluation and program development originating in the UI community.

The Understanding Interventions conference took place for the first time on the West coast—in San Diego, California, on May 15–17, 2015—and attendance was the highest it has ever been at nearly 250 people. The conference schedule contained more talks than ever before, with more than 40 hours of presentations and discussions, and the break areas and poster sessions were thronged with people networking and building collaborations. The vitality of the UI community testifies to the wisdom behind the original intention of the conferences: to provide opportunities for researchers, practitioners, evaluators, and other experts to learn from each other and combine forces to study how interventions can be made more effective.

Of the attendees at the 2015 conference, 46 percent were college and university faculty, and about 60 percent of those were from STEM PhD-granting institutions. Almost two in five were academic non-faculty, mostly postdoctoral fellows, and 11 percent were graduate students. Nine percent were from federal agencies, and six percent were from professional societies and nonprofits. Of all the attendees, 57 percent were attending their first Understanding Interventions conference, the largest number of newcomers ever. One third were travel award recipients.

Because the conferences are built up largely from abstracts submitted by potential presenters, with specific themes suggested by the conference organizing committee, the programs of the conferences and resulting summary reports differ from year to year. This year, the summaries of presentations fall into seven separate chapters.

Chapter 1: Opportunities to Increase Diversity
Chapter 2: Community Colleges
Chapter 3: Undergraduate Interventions
Chapter 4: Graduate and Career Interventions
Chapter 5: Mentoring and Coaching
Chapter 6: Gender-Based Interventions
Chapter 7: Tools for Interventions

For the first time this year, the conference summary also has been adapted for the web, with summaries and highlights of individual sessions available from a hyperlinked agenda on the Understanding Interventions website.

One of our favorite parts of the conference is the final plenary session, in which we invite participants to give us feedback on the conference and suggest ideas for future conferences. As usual, we received many excellent suggestions, including:

- Holding the conference in other parts of the country where it would attract new participants
- Conducting satellite meetings focused on particular themes such as mentoring, program dissemination, or training for program implementation and evaluation

- Using the UI website to discuss and agree on standards for collecting evaluation data
- Inviting teams from universities, perhaps with travel support, so that larger groups can be exposed to effective interventions
- Inviting more graduate students, postdocs, and junior faculty to the conference to provide additional perspectives on the issues discussed
- Inviting participants with expertise in marketing to help grow the community and disseminate its expertise
- Inviting reporters to help spread the ideas and stories discussed at conferences
- Making greater use of social media to involve more people in the community and disseminate ideas
- Providing experts from the Understanding Interventions community to speak at disciplinary society meetings or at institutions
- Devoting attention to the budgetary situation in research funding and education
- Further diversifying the disciplinary background of conference participants

The Understanding Interventions community still has tremendous room to grow. We would like to double the size of the conference—to 500 participants or more. We also would like to increase corporate involvement, especially since many graduate students will be going into the for-profit world and not into academia. Broadening participation in science careers is an issue that affects many sectors of government, academia, industry, and the non-profit world. All would benefit by becoming members of the Understanding Interventions movement.

Daryl Chubin
Anthony DePass

1

Opportunities to Increase Diversity

Regular attendees at the Understanding Interventions conference quickly become familiar with the theoretical frameworks that underlie many of the studies discussed at the meeting. Stereotype threat, implicit bias, self-efficacy, social cognitive career theory, cultural capital, a strengths-based approach, and many other concepts animate individual analyses and provide links among programs and practices. At the 2015 conference, two of the plenary speakers and several other presenters addressed the broad conceptual issues at the base of many interventions in science, technology, engineering, and mathematics (STEM) education.

SCIENTIFIC WORKFORCE DIVERSITY: OPPORTUNITY FOR ENHANCING RESEARCH EXCELLENCE

A diverse scientific workforce is a key contributor to research excellence, said Hannah Valantine, Chief Officer for Scientific Workforce Diversity at NIH, in her opening keynote address at the conference. Research has shown that diversity leads to better solutions to complex problems, such as those encountered in biomedical and behavioral research (Page, 2007). Moreover, a more diverse scientific workforce could broaden the scope of biomedical and behavioral research inquiry and narrow existing health gap.

"Diversity is also needed to ensure fairness. NIH controls a large amount of national resources," said Valantine. It needs to ensure that everyone can participate in research, and it has to recruit and retain the best talent into research. Given that minority groups also constitute the majority of the population in some states, drawing participants from those groups is essential. "If we're not pulling from our entire intellectual capital, we will not be ensuring that we have the right and the brightest people doing this research," Valantine said.

Yet diversity falls steadily from the undergraduate years through the professionals ranks. While the members of groups underrepresented in STEM fields constitute 30 percent of college age Americans, they earn only 18 percent of science and engineering bachelor's degrees and 7 percent of PhD degrees. The same process of attrition is seen among women in academic medicine (Figure 1-1).

This attrition is not inevitable. When she was appointed to the position of Senior Associate Dean at Stanford in 2004, Valantine instituted a comprehensive and integrated plan to increase diversity. The plan included active and early engagement with search committees, changing the composition of committees and applicant pools, expanding outreach, research awards, mentoring programs, women's networking, child care, and professional development (Valantine et al., 2014). Those interventions raised the percentage of women faculty members at Stanford above the national average and the average rate at peer institutions. Yet even with this improvement, it would take 28 years for women to achieve parity with men at Stanford, compared with 40 years for peer institutions and 48 years for national institutions. "Conventional approaches are necessary but not sufficient to get the change in pace that we want," Valantine said.

Changing Attitudes and Cultures

Going beyond conventional approaches, in part, requires changing people's attitudes and institutional cultures. For example, implicit bias and

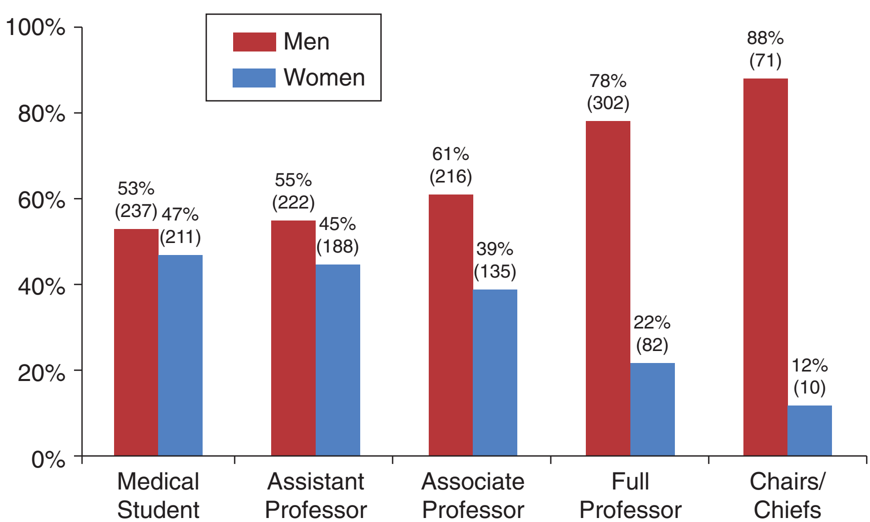

FIGURE 1-1 The gender gap in academic medicine increases at higher profession ranks. Source: Lautenberger et al., 2014.

stereotype threat can both lead to decisions that perpetuate inequities. Stereotypes often operate outside of conscious awareness, Valantine noted. For example, when CVs were sent to more than 200 eminent scientists and they were asked whether or not they were going to hire a person as a lab manager, the CVs with male names were more likely to be selected, and with higher salaries, than for CVs with women's names (Moss-Racusin et al., 2012). Valantine said, "these stereotypes are happening in terms of how people make their decisions about who is entering into science, as well as the individual's feeling a sense of belonging in the workforce and whether or not they fit into this great endeavor."

"Interventions are available that can help modulate such behaviors," Valantine stated. The Recruitment to Expand Diversity and Excellence (REDE) program at Stanford had department chairs or division chiefs deliver short talks in 40 departments and divisions to more than 300 faculty participants. Implicit Attitude Tests were completed before and after the talks showed that the intervention significantly reduced implicit bias for both men and women (Academic Medicine, 2016).

Another significant attitudinal and cultural issue involves faculty career flexibility and achieving and maintaining a work–life balance. More than half of faculty says that their institutions are not supportive of work–life balance, and this issue is the second most cited reason for considering leaving academia. At the same time, career paths have become very lengthy, so many biomedical investigators do not receive their first independent grants until their late 30s or 40s. To address these issues, Stanford conducted focus groups with 105 faculty members, gathered survey data, and did an ethnographic study of eight faculty members in 2010–2011. "The overall conclusion," said Valantine, "is that the problems have less to do with the availability of opportunities and more to do with a misalignment between those policies and with the culture of academic medicine." Among the core beliefs of academic medicine are:

- It's not worth the risk to stray from the established path.
- I always need to be advancing my career.
- I am most productive when I plan and document my goals.
- I always keep score because things that aren't measured don't count.
- Success is about individual accomplishments.

These beliefs make it difficult for faculty members to take advantage of programs that support work–life integration such as consulting days, paid sabbaticals, tenure clock extensions, family travel grants for conferences, part-time options, reduced teaching and clinical responsibilities, child care leave, and family and medical care leave.

To address this cultural mismatch, Stanford developed the academic biomedical career customization program, which establishes a culture that fosters work–life integration and development to recruit, retain, and advance the most talented physicians and scientists in academic medicine. A customized career tracks component, in-depth interviews, and a needs assessment were conducted to develop support mechanisms such as help for grant writing, career planning, and access to life coaches. A banking system component for faculty service was developed to ease work–life and work–work conflicts—for example, by providing support for clinical work, teaching, mentoring, and administration so that faculty can remain current in research. "The faculty really resonated with this," said Valantine. "There were reports of better work–life balance and less stress. As a pilot, this is something to be thinking about as we move forward to integrate our work and our lives."

NIH Programs

Valantine brought many of these innovations with her to NIH when she moved from Stanford. As in other areas of science, the workforce diversity for research project grants at NIH is low (Figure 1-2). The Advisory Committee to the Director Working Group developed 13 recommendations, including the appointment of Valantine as the Chief Officer for Scientific Workforce Diversity, along with the following:

Pipeline

- Systematic review and evaluation of all diversity programs.
- Develop interest in STEM in K–12 and beyond.
- Additional financial support for undergraduates.
- Assess reasons for disparity in grant awards.
- Establish a working group of the Advisory Committee to the Director.

Mentoring

- Establish a system of mentorship networks.

Peer Review

- More detailed explanation for unscored grant applications.
- Text-based analysis of grant review commentaries.
- Implicit bias/diversity awareness training for scientific review and program officers.
- Design experiment to determine effects of application anonymization.

Infrastructure

- Establish bold multiyear awards to enhance diversity at under-resourced institutions.
- Appoint chief diversity officer and establish office of diversity.
- More comprehensive search for tenure-track investigators.

The NIH Transformative Diversity Initiative achieves some of these recommendations by enhancing the diversity of the NIH-funded workforce

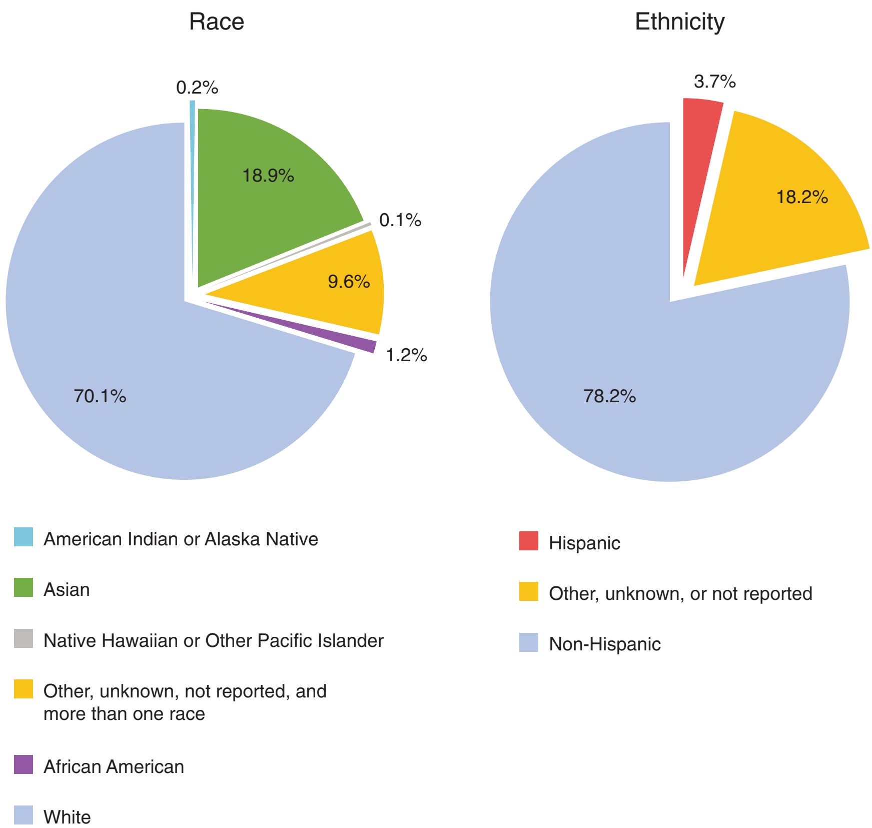

FIGURE 1-2 The diversity of the NIH-funded research workforce is less than that of the population at large. Source: Research Project Grants, 2014.

with the Building Infrastructure Leading to Diversity (BUILD) program, the National Research Mentoring Network (NRMN), and the Coordination and Evaluation Center (CEC). Other initiatives include ensuring fairness in peer review and increasing engagement by all NIH leadership. Awards were made in October 2014 for the NIH Transforming Diversity Initiative, with total funding of about $30 million per year for five years. The BUILD program is being funded at ten sites, including several minority-serving institutions; the NRMN is based at Boston College; and the CEC is based at the University of California, Los Angeles. "We can take all of that wonderful theory and translate it into action very much in the way that many of you are doing in your programs here," said Valantine.

The mission of Valentine's office mission is to build a diverse trans-NIH scientific workforce that will serve as a model for capturing the most talented biomedical researchers both in the intramural program and in the extramural program, with an early focus on the intramural program. The initial focus is to establish the intramural research program at NIH as a hub for innovation in scientific workforce diversity, centering on each transition stage of the career path. It will create climates of inclusion and a sense of belonging for the scientific workforce in the intramural research environment. And, it will assemble an interdisciplinary and diverse team to define and execute a robust research agenda for discovery and implementation of the science of diversity.

Valantine concluded by discussing a national strategy to enhance the diversity of the scientific workforce, which will produce rapid changes by creating interventions that address the barriers at key career transition points. "As you look through the career pathway of training from undergrad right through to the tenured scientist to leadership, you see that there's attrition all along the way," she said. A coordinated national initiative could create strong networks and an infrastructure to support career transitions seamlessly across career pathways. Essential components would include strategic partnerships, investments in the science of diversity, implementation and scaling, tracking and evaluation, and organizational commitment. The goal would not only create academic researchers but also produce trained scientific investigators for industry, government, and the community. Valantine added, "My real hope is that we will turn discovery into health, ultimately, for everyone."

STEREOTYPE THREAT AND IMPLICIT BIAS IN THE ACADEMY AND IN BUSINESS

In some respects, the corporate world and the academic world are very much alike, said plenary speaker Lydia Villa-Komaroff, who was the third Mexican-American woman to earn a doctorate in the United States in cell biology. Any institution has an identity that transcends the people who constitute that institution at any given time. Also, the interests of the institution and the interests of the individual can sometimes be at odds in both academia and the corporate world.

But the corporate and academic worlds also are very different, she added. A chief executive officer runs the company. When a CEO says "we will do this," "this" begins. In a university, the president, the provost, and the leadership set a tone and they have an important role in defining the culture of the institution. But when a president, dean or department chair says "we're going to do something," that is usually when the conversation begins.

In addition, projects in the corporate world are determined by the bottom line. If a project is not going to contribute to the bottom line, it is not going to continue. Projects in academia are determined by the interests of the investigator and the availability of funding. Also, projects in academia are subject to a number of rules and regulations, such as those covering animal care, human safety, and students in the laboratory, and in the face of limited institutional resources more and more of these are added to the responsibilities of the individual investigator.

These differences are an important consideration in helping students decide what they want to do after they graduate. Academia is of course close to the hearts of faculty members, Villa-Komaroff acknowledged, but there is not enough room in the academic world for all of the students being produced. "If that's the only aim we have for our students, then we will be in deep trouble."

Villa-Komaroff argued that well-trained students can do just about anything. "The PhD needs to be thought about as a degree of opportunity, not a degree of limitation." The path from basic research to a product is a complex network, not a linear progression, and students can work at any point in this network (Powell, 2005). The life sciences ecosystem includes biotech companies, universities, private research institutions, government, pharmaceutical companies, venture capital, and many other entities, and scientists can work on anything from biotechnology to finance. "As you work with your students, they need to be aware of this and to know the skills that they bring to these endeavors."

The Massachusetts Life Sciences Center

The Massachusetts Life Sciences Center, which is a quasi-public institution in the State of Massachusetts, exemplifies many of these features of the life sciences ecosystem. The center originated in a small 2005 grant from the Boston Foundation to found the Massachusetts Life Sciences Collaborative, with an organizing committee that included the leaders of all Boston areas' major universities, teaching hospitals, life-science companies, and venture capital firms. This committee helped promote the passage of legislation in 2007 that established a 10-year, $1 billion investment to strengthen the state's leadership in the life sciences. The Massachusetts Life Sciences Center (MLSC) was given a broad mandate to encourage basic research, development, and commercialization in the biosciences; ensure the preparation of a skilled workforce to meet the needs of the state's bioscience industry cluster; and build stronger collaboration between the sectors of the local and international life sciences community. As chief executive officer, the board selected Susan Windham-Bannister, a woman of color who had a PhD in public health but had spent much of her career in marketing. She recruited a small but very talented and extraordinarily hardworking team of people with a variety of skills, including a talented scientific advisory board to review proposals.

The center identified its subject matter as biotech, pharma, medtech, diagnostics, and bioinformatics. Its mission was innovation-driven economic development and job creation throughout the state. Among its programs were:

- Creation of novel infrastructure and consortia to accelerate the pace of innovation
- Grants for translational research and industry-academic partnerships
- Investments in entrepreneurship and early-stage companies
- Grants for translational research and industry-academic partnerships
- Public-private funding partnerships to leverage investments
- Workforce development programs
- International collaborations

These programs often involved working across institutions, Villa-Komaroff noted. For example, it helped educate people about what they needed to do to take the next step in a project. In one case, the center helped the University of Massachusetts, Boston, to increase the amount of research done there through a partnership with the Dana-Farber Cancer Center. In another, companies can find partners in any country in the world and forge joint projects.

As of June 2014, the company had invested more than $500 million in projects, with about $1.5 billion in additional funding received as a result of these investments. One thing this investment has bought is equipment for community colleges, high schools, and middle schools, allowing students to be introduced to the technologies used in the life sciences. As Villa-Komaroff pointed out, many students enter into jobs in the life sciences directly from high school or a community college (Figure 1-3). She also pointed out that people with PhDs make up only about one in six of the employees in the Massachusetts Life Sciences Cluster (Figure 1-4). "It's not necessary to have a PhD in order to get a very well paying job in this field," she said.

The center has played a minor direct role in attracting big pharma and medtech to Massachusetts, but it has played a major role in encouraging the development of small, innovative firms. In turn, the proliferation of these small firms has attracted a number of global companies to Massachusetts, including Pfizer, Novartis, Johnson & Johnson, Sanofi, Abbott Labs, Bristol-Myers Squib, and Merck (Bluestone and Clayton-Matthews, 2013). "These

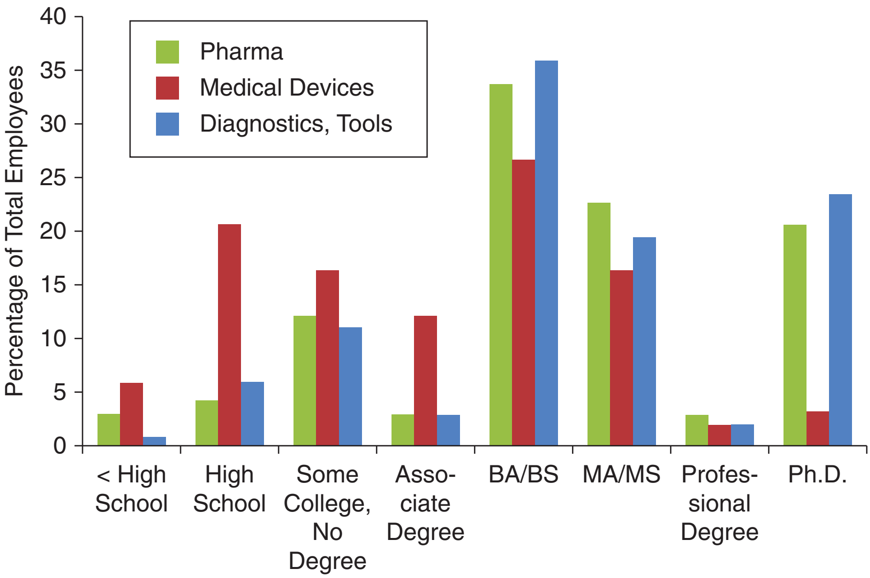

FIGURE 1-3 Many of the employees in the Massachusetts Life Sciences Center have less than a bachelor's degree.

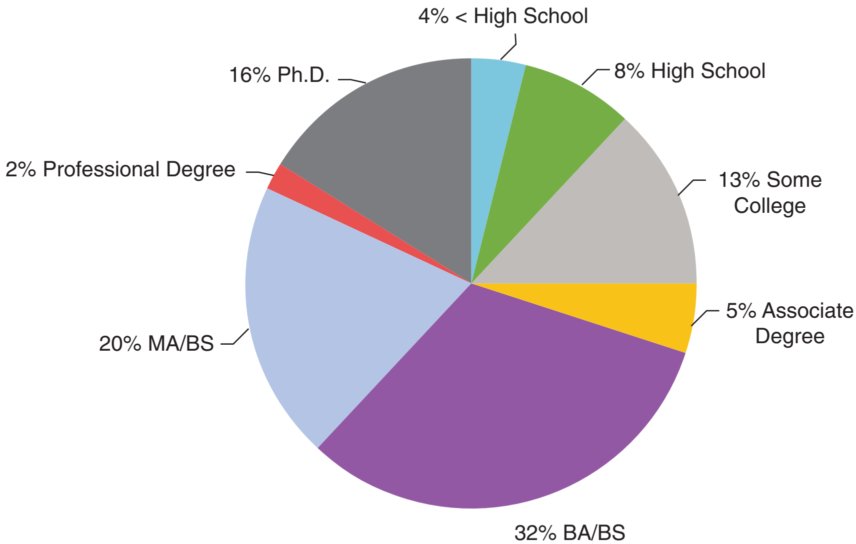

FIGURE 1-4 Only about one-sixth of the employees in the Massachusetts Life Sciences Cluster have a PhD.

big companies want to be in touch with these little companies, because that's where their new [innovations] are coming from." This process also builds and strengthens the life sciences ecosystem, creating employment opportunities for students with a wide range of educational backgrounds.

Thinking Systems

The question remains, said Villa-Komaroff, which students are able to take advantage of these opportunities. Even before college, many students are lost to these opportunities. "Children decide extraordinarily early, before they are aware of it, what they can do. They look at the world, and if they see no one that looks like them, they close that door." Villa-Komaroff said that one reason she became a scientist is because of Star Trek, where the diverse crew demonstrated that color made no difference. The show "provided an example that allowed to me to conceive of the possibility."

People respond to such cues in part because of what are called heuristics—relatively hard-wired, simple, efficient rules that humans use to make decisions. Though scientists in the "hard" sciences have been resistant to the notion, psychologists and other social scientists have long recognized that humans make systematic errors in judgment. As Kahneman (2011) says in his book *Thinking, Fast and Slow*, "As we navigate our lives, we normally allow ourselves to be guided by impressions and feelings, and the confidence we have in our intuitive beliefs and preferences is usually justified. But not always. We are often confident even when we are wrong." As he points out, two systems of thinking have evolved in humans. The first, which he calls system 1, operates automatically and quickly, requires little or no effort, has no voluntary control, and runs all the time. The second, system 2, allocates attention to effortful mental activities, is orderly and deliberative, normally operates in a comfortable and low-effort mode, and generally accepts system 1 suggestions.

The operations of system 1 help produce the implicit biases people have. For example, people of color and women often feel alone, she said. They feel that they are not good enough and that they are at fault. "The implicit biases of others—my own fear of failure in a field in which I was not recognized as belonging—has profound effects on all of us; it has profound effects on our students." This is not just a problem of white males, she said. It is a problem all people share. When Villa-Komaroff was visiting her mother-in-law in California, she was asked when her mother-in-law had hired her as a maid—"because as a Hispanic woman in California obviously I was a maid." Similarly, in science, even women and people of color judge CVs for men and women differently.

Finding workarounds for bias is hard, but it is happening. People can be educated about "how and why they make the instant judgments that they do," said Villa-Komaroff. Some of the characteristics of system 1 can be used to promote change. For example, one approach is to build familiarity and then consensus by raising an issue repeatedly. "Try to set up a situation where a person comes around over time." Both confrontation and persuasion are needed. "It's hard work. It takes a lot of time."

Students and other young people also can have an enormous effect, she observes. For example, postdoc associations can help raise these issues and maintain their visibility. Similarly, gathering of people with similar concerns, such as those created by the Understanding Interventions conferences, create "a nucleus of people who care about the issues and are willing to find other ways to engage." Participants in such groups can in turn speak to other groups and spread the message.

"We need to convince our colleagues that this must be paid attention to . . . We need to help convince our colleagues that this is rigorous, that this is a human problem. . . . When chemistry departments start hiring women and people of color because the chairman recognizes that we must deal with inherent bias, that is a good thing. We need to expand those efforts throughout the enterprise. We don't have to become experts in psychology, but we do need to become translators of those findings and we need to talk about them in a nonjudgmental way."

WEAKENING THE EFFECT OF CHRONIC STEREOTYPE THREAT ON MALADAPTIVE ACHIEVEMENT GOALS

African American and Hispanic/Latino students have to deal with negative racial stereotypes about their aptitude for science-related endeavors from an early age, noted Anna Woodcock, a research faculty member at California State University San Marcos (CSUSM). Woodcock is part of a team at the CSUSM Applied Social Psychology Lab examining the psychological processes underlying gender and racial/ethnic disparities in STEM. These stereotypes are a source of identity threat and can make it difficult for students to identify with the sciences. "Stereotype threat is being at risk of acting in the manner that is consistent about a negative stereotype about one's group," said Woodcock. "Members of any stereotype group must deal with the possibility of being judged and treated stereotypically on the one hand, but they also have to contend with doing something that unwittingly will confirm that stereotype." The recognition of this risk can become a psychological burden for students, especially when they have to deal with this threat for prolonged periods of time. Stereotype threat has been implicated in disparities such as those seen in the U.S. scientific workplace, although few studies have measured the effect of persistent and pervasive threat across time on students' academic motivation and their engagement in pursuit of a scientific career.

Woodcock and her colleagues analyzed these factors in the context of a well-established intervention and training program, the NIH's Research Initiative for Scientific Enhancement (RISE) program. RISE's objective is to increase the capacity of underrepresented minority students in the biomedical and behavioral sciences to complete a PhD in these fields. Since its inception in 1972, RISE programs on university campuses across the United States and Puerto Rico have been offering students on- and off-campus research experiences, helping them with graduate school applications, facilitating faculty mentorships, and providing stipends. While RISE was not specifically designed to reduce the experience of stereotypes on minority groups, Woodcock and her colleagues hypothesized that programs like RISE might create a context that alters students' experiences of stereotype threat. They wanted to measure both the direct impact of stereotype threat on science students' stated intentions to pursue a scientific research career and their actual engagement in the pursuit of that career across time, as well as the indirect impact of these outcomes as a consequence of students' academic motivation.

They tested their hypotheses with a sample drawn from a large-scale, quasi-experimental study of underrepresented science students—*TheScienceStudy*. More than 1,400 science students were recruited into *TheScienceStudy* research panel in 2005 from colleges and universities across the United States. The panel consists of RISE students and a matched-comparison group of non-RISE students. The comparison group was essential to study the impact of programs such as RISE on psychological processes such as stereotype threat on their students compared with similar students without an intervention program. The matched-comparison group was recruited from campuses with no RISE program, as RISE program directors tend to pick all of the best students on their campus for their program. To form the comparison group, *TheScienceStudy* team used a propensity score matching procedure to ensure equivalence across the two groups, which enabled them to draw causal claims about impact of RISE. Once the students were selected, *TheScienceStudy* team became responsible for following the participants across time. Participants are surveyed twice per year and compensated $25 for every survey, at the launch of each survey wave rather than at the completion of each survey. This system works on the principle of reciprocity and is a particularly important and effective strategy for longitudinal studies. This is an ongoing study, and participants are still active in their tenth year. In the most recent survey wave (wave 19), they achieved a 71 percent response-rate, which is consistent across waves, although not the same participants respond each time. The study team has valid data for 96 percent of panel participants.

A sample of 424 African American and Hispanic undergraduates was chosen for these analyses. This was a group of highly motivated students who wanted to pursue a career in the sciences, half of whom were in the RISE program and the other half of whom had never been in an undergraduate research program. Most of the participants were female, which was in line with RISE enrollment at the time, and most were drawn from Biological and Natural Sciences, with some from Behavioral Sciences, Math and Computer Sciences, and Engineering. Measures of perceived stereotype threat, academic achievement goals, and scientific career intentions and engagement were taken from each student across six years, during their junior and senior years, the following year, and then four years post baccalaureate. The length of the study allowed for the statistical control of prior instances of each measure.

This study tested the hypotheses that the RISE program would have a significant and positive impact on retaining URM science students on the path toward a scientific research career and that this effect would be due, in part, to the RISE programs' influence of students' responses to stereotype threat. Specifically, it explored whether stereotype threat would have negative downstream consequences on no-program students' academic achievement goals that would not be evident in RISE students. Three distinct achievement goal measures were used that assess how students contend with academic challenges. First are mastery goals, where students are motivated to develop personal competence and attain mastery of the academic material. The main outcome of this goal is learning for the sake of learning, and mastery goals produce good academic outcomes. Second are performance-approach goals, where students are motivated to demonstrate competence in the presence of others. These behaviors have the possibility to both help and hinder student performance. Third are performance-avoidance goals, where students seek to demonstrate that they are competent in the presence of others. These are the types of negative academic performance outcomes that educators want to avoid.

The adoption of mastery goals while eschewing performance-avoidance goals is optimal, said Woodcock. "We want students to be at college to learn for the sake of learning, and we know from our research that this is kind of the sweet spot for academic success in the long term and persistence in science for underrepresented science students."

The results were striking. Four years post baccalaureate, just over half of the former RISE students in the study were still actively engaged in science careers. Former RISE program students were 1.74 times more likely to be engaged in, or training for, a scientific career than students from the matched no-program control group. "We found, not surprisingly, that the RISE program had no effect whatsoever on students' experience of stereotype threat," said Woodcock. "Whether you're in RISE, or whether you're not in RISE, you're still experiencing stereotype threat at the same kinds of levels. However, the RISE program had a significant effect on how URM science students dealt with stereotype threat across time." For those students not in RISE, chronic stereotype threat ultimately reduced their ability to adopt mastery goals. It hindered them from learning the material for the sake of learning. Their actions became more heavily influenced by other students' perceptions of their abilities.

On the other hand, the study participants from RISE were buffered from the negative downstream effects on intention and engagement of chronic stereotype threat. While the study did not indicate the specific factors in RISE that contributed to students' success in overcoming chronic stereotype threat, it did reveal that the program provided some sort of context that allowed students to deal with the threat in more effective ways that did not hinder them from their pursuit of a scientific career. Woodcock concluded that, while programs like RISE do not eliminate chronic stereotype threat, they lessen the effects on maladaptive achievement goals, which contributes to the program's success and ultimately improves students' academic outcomes and their persistence in the sciences.

2

Community Colleges

A special focus of the 2015 conference was community colleges and the transition from two-year to four-year institutions. More than 40 percent of U.S. undergraduates are enrolled at community colleges, and groups underrepresented in STEM make up a significant portion of students on community-college campuses. Furthermore, about 50 percent of bachelor's degree recipients in science, engineering, and health fields attended community colleges at some point in their studies, as did about 45 percent of master's degree recipients (Mooney and Foley, 2011).

Many factors affect whether students succeed in community college or when transferring from a community college to a four-year institution, including age, GPA, being first generation, talking with faculty members outside class, meeting with advisors, engaging in study groups, participating in school clubs, participating in intramural sports, working fewer hours at a job, having dependent children, socioeconomic status, and academic preparation. A plenary session and several presentations in symposia sessions examined these factors and opportunities for increasing the success of underrepresented minority community college students.

SHIFTING STUDENTS' PERCEPTIONS OF SCIENTISTS IN A DIVERSE COMMUNITY COLLEGE CONTEXT

De Anza Community College, which is in the San Francisco Bay area, is one of the largest single-campus community colleges in the United States, with about 23,000 students. The student body is quite diverse, with no one ethnic or racial group forming a majority of students. During a plenary presentation at the conference, Jeff Schinske, professor of biology at De Anza Community College, and three current or former students—Amanda Snyder, Jahana Kaliangara, and Monica Cardenas—described an intervention designed to enhance students' sense of belonging in STEM classrooms with diverse student populations.

Students are constantly receiving both implicit and explicit messages about who scientists are from numerous sources, including the media, educational and governmental institutions, and scientists themselves, Schinske observed. "These messages we send about scientists are received, whether we mean them to be received or not, and they do matter." In particular, if students do not themselves identify with the images of scientists we convey, this could decrease their sense of belonging and ultimately impact interest and success in STEM.

In addressing this, however, faculty members may be reluctant to engage in frank discussions about race, gender, and identity with their students. But they would likely feel comfortable having discussions about issues that benefit their coverage of the content while also sending an explicit message about diversity and equity. To facilitate these types of discussions, Schinske has developed a set of weekly exercises called Scientist Spotlights for a non-majors biology course. For example, one such exercise started as follows:

Lawrence David is a Filipino-American biologist currently working as a professor at Duke University and Harvard. His work focuses on the trillions of bacteria that live on and in the human body, and he is particularly interested in how bacteria contribute to health and disease in the developing world, including in Bangladesh and other non-western areas. He also helped start a website to showcase illustrated, science-related poetry (http://www.sciku.org/).

Students were provided with links to an autobiographical podcast by David and a *Nature* article he co-authored. They then were asked to write a 350-word or more reflection on what they had learned about David. Suggested topics were:

1. What was most interesting or most confusing about the podcast and article?
2. What can you learn from the podcast/article about the relationships between our body and bacteria?
3. What does this podcast/article tell you about the types of people that do science?
4. What new questions do you have after hearing the story?

Ten Scientist Spotlights were used over the course of an 11-week quarter as a way to make the equity message explicit while also conveying some of the content of the course, Schinske said.

Testing Hypotheses

To assess the effects of this intervention, Schinske and several student research assistants (including Mary Wyer and Heather Perkins, in addition to the presenters at the conference) used essay prompts and survey questions to test five hypotheses:

1. Students would initially hold stereotypical images of scientists and would initially report a lack of personal connections with scientists.
2. After completing Scientist Spotlights, students would hold more non-stereotypical images of scientists.
3. After completing Scientist Spotlights, students would feel they could personally relate to at least one scientist.
4. Students would tend to cite gender/racial-matched scientists as those to whom they could most closely relate.
5. Self-reported ability to relate to a scientist would correlate with achievement in class.

The essay prompt was "Based on what you know now, describe the types of people that do science. If possible, refer to specific scientists and what they tell you about the types of people that do science." The survey question was "I know of one or more important scientists to whom I can personally relate," which was responded to through a four-point Likert scale, followed by a short essay explanation. The descriptions of scientists in essay responses were coded either as "stereotypes" (Mead and Metraux, 1957) or as "nonstereotypes," yielding an interrater reliability of 0.86 for the number of stereotypes recorded per paper and 0.89 for the number of nonstereotypes recorded per paper. By the time of the conference, Schinske and his student associates had analyzed 600 essays from 150 students and 192 essays from 48 students in a quasi-control class that did not do the Scientist Spotlights.

By the end of the quarter, the students completing Scientist Spotlights showed a decrease in the number of stereotypical descriptions of scientists and a very large increase in nonstereotypical descriptions (Figure 2-1). In the quasi-control class, stereotypical descriptions also decreased, though not as much, while the nonstereotypical descriptions remained at a very low level.

Exposure to the Scientist Spotlights changed the responses of students in ways that can be determined qualitatively. For example, in response to the essay prompt about the types of people who do science, one male Latino student wrote at the beginning of the quarter, "The types of people that do science are very patient and passionate people." At the end of the quarter, he wrote:

> The types of people that do science are all kinds of people. What I have learned throughout this course is that it is possible to be a scientist under any circumstances, from poverty to being from a different country to having a stereotypical assumption about a person, for example a cheerleader. Anyone can be a scientist if they want to. One thing all scientists we learned about had in common was that they weren't interested in science until something sparked their interest.

Another wrote at the end of the quarter:

> Before I learned about scientists in this class, I thought scientists were

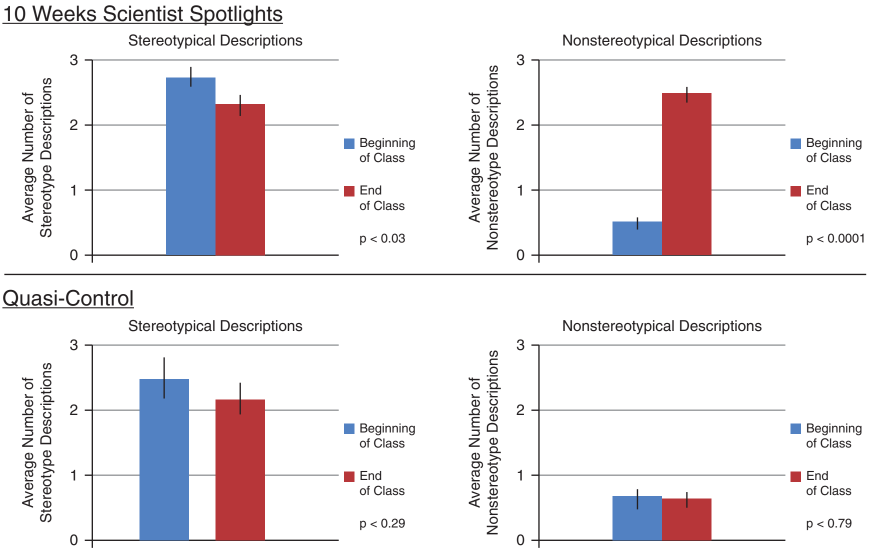

FIGURE 2-1 Scientist Spotlights shifted descriptions of scientists compared to a quasi-control group.

> like 'nerds' or what they show in movies. . . . However, through all the research I've done in this class, scientists are just normal people like myself. They love to learn new things, they have a life outside the laboratory, they are fun, and like to have fun. My opinion of people that do science has completely changed thanks to this class.

The Scientist Spotlights also enhanced the relatability of scientists compared to the quasi-control class (Figure 2-2). One student wrote of a transgender scientist the class studied:

> I can relate the most to Ben Barres because of the obvious discrimination he received as a woman. Being the older sister of a very bright brother, I am often compared to him and overlooked for my intelligence. Unless it comes from him, my opinion is just that of a woman.

Schinske and his research colleagues found that the ability to relate to a specific scientist correlated with higher course grades, with a particularly strong effect in men and in black, Latino, Native American, Filipino, and Pacific Islander students. An unexpected finding was that there was little gender or racial matching for the scientists to whom students related. Thus, hypotheses one through three and five in the above list were confirmed, while hypothesis four was not confirmed. "Some people could look at this and say, 'Well, gender and race don't matter; we can just have all white males as Scientist Spotlights,'" said Schinske. "Of course, I think that we all know intuitively that that's not true. We can see from that last quote . . . that that person related

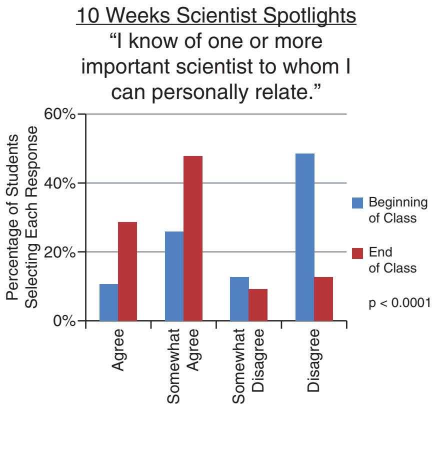

FIGURE 2-2 Scientists Spotlights enhanced the relatability of scientists compared to a quasi-control group.

to somebody who was actually a transgendered male. Even though [the student had] a different gender, they related because of the shared bias that they had both experienced, so having this diversity actually is important." Indeed, several responses from students indicated that gender or racial matching was very important to some students. For example, one African American student wrote of learning about an African American scientist, "That, as a fellow African American, brought me joy, as it shows that African Americans are no longer abiding to the negative stigma we have."

Since Scientist Spotlights complement course content, require almost no class time, and are simple to grade, they provide an enticing inroad to addressing equity directly in STEM classes, Schinske said. The initial research results also point to some intriguing future directions in research. Student responses could be compared to results of quantitative surveys of stereotypes and identity. Future research could look for connections between shifts in stereotypes or identity and intent to take additional science classes. Longitudinal data could be collected to evaluate retention and ongoing impacts, such as reductions in equity gaps. And faculty development experiences could be designed to disseminate and test Scientist Spotlights in other class contexts.

A JOINT-DUAL DEGREE PROGRAM IN NEW YORK CITY

In 2003, the Eugenio María de Hostos Community College and the Grove School of Engineering (GSoE) of the City College of New York (CCNY) of the City University of New York (CUNY) signed an agreement to create the Joint Dual Admission Engineering Degree Associate in Science/Bachelor in Engineering (A.S./B.E.) Program in *Electrical Engineering*, and the first students enrolled the following year. Hostos Community College, which was one of the ten finalists for the Aspen Prize for Community College Excellence in 2015 (http://www.aspeninstitute.org/policy-work/college-excellence), is located in the South Bronx and has about 7,000 students. Approximately two-thirds of the students are females, 60 percent are Hispanic, 22 percent are black, 3 percent are Asian, and 2 percent are white. The mission of the Joint Dual Engineering Degree Program is to provide this multicultural and underrepresented student population with a strong foundation of knowledge in science and mathematics and a high-quality general education background. In a second plenary session presentation, Yoel Rodríguez, Associate Professor of Physics and Chemistry at Hostos Community College, described the program and its outcomes.

As of today, Hostos Community College has expanded its Joint Dual Engineering Program and offers Associate in Science degrees in Civil, Chemical, Electrical, Mechanical, and Environmental Engineering. These programs, as mentioned above, are jointly registered, dual admission programs with the existing Bachelor of Engineering degrees at CCNY's GsoE of CUNY. These programs have been designed to meet the licensure guidelines of the Accreditation Board for Engineering and Technology (ABET) and provide Hostos students with the same curriculum as the first two years of the licensure qualifying program required at CCNY's GSoE. Upon successful completion of the lower division at Hostos, students have a seamless transition to the upper division of the baccalaureate program at CCNY's GSoE.

The engineering curriculum at Hostos has been designed to familiarize students with the environment they will encounter at CCNY's GSoE, Rodríguez said. Because Hostos is an open enrollment institution, many students also take developmental classes. To join the Engineering Program, students need to be ready to take at least pre-calculus and a specific group of reading and writing courses. Once in the program, D is not considered a passing grade for the program, and C's or better are required in all chemistry, physics, mathematics, and engineering courses. Students need to keep an overall grade point average of 2.7 or higher and 2.5 in their mathematics and science courses. They also need to take two writing-intensive courses before they transfer.

Early advisement is a key factor in the Engineering Program, observed Rodríguez. For students planning to take a class in the spring term, advisement opens in October. For students planning to take a class in the summer and/or fall terms, advice is provided in March. Students who are planning to take an ePermit class (where students take classes at alternate CUNY campuses) at CCNY's GSoE need to attend a mandatory orientation at the Grove School of Engineering before they begin.

Enrollment in the Joint Dual Engineering Degree Program has increased over time (Figure 2-3A and B). More than 125 students have graduated from the program, with females representing about 12 percent of these graduates. Ninety-two students have transferred to City College since the program began, of whom 35 have switched away from or dropped out of the program. However, the retention rate has increased over time, both at Hostos Community College and at the Grove School of Engineering. Students have gone to

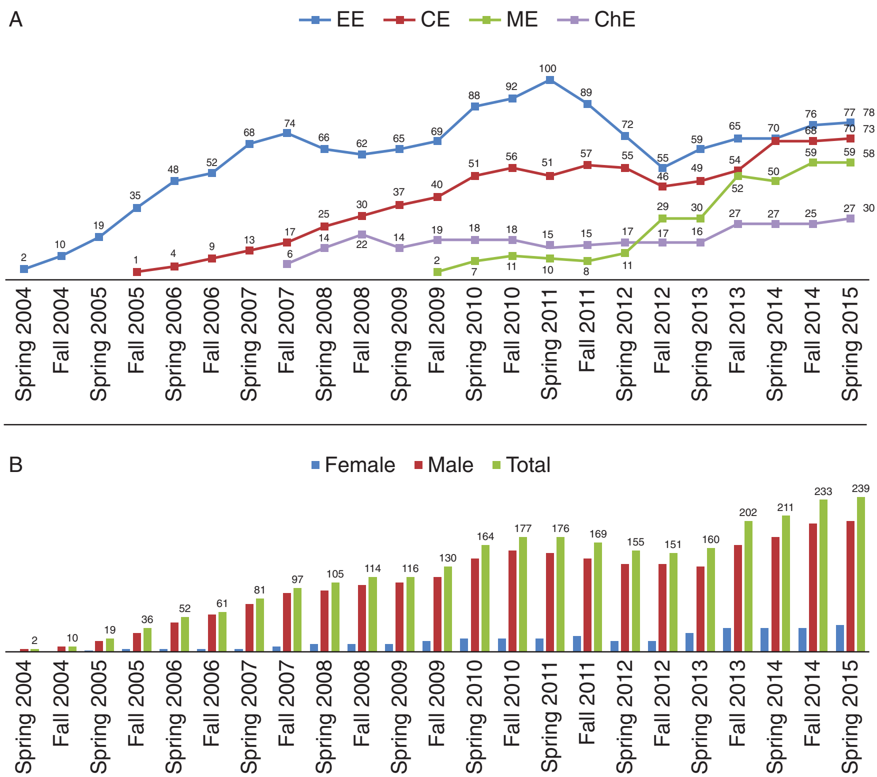

FIGURE 2-3 Joint dual engineering degree program enrollment (A) by major and (B) by gender.

GSoE as well as to schools such as the New York City College of Technology and Lehman College both of CUNY. Hostos Community College students also have been accepted at Stanford, Fairleigh Dickinson College, Carnegie Mellon University, Texas Tech University and Manhattan College to pursue their Bachelor in Engineering degrees. Three program alumni are currently pursuing their PhD and MS degrees at Princeton, Pennsylvania State, and Stanford Universities.

The program still faces challenges, Rodríguez acknowledged. Many students have little science background from their previous education and weak mathematics backgrounds. The culture of the community college also is not necessarily aligned with that of the senior college. Students need to know what the senior college demands and get ready, which requires communication between the two institutions, Rodríguez said. And even though they received support from advisors, students tend to miss deadlines. Advisors try to help students solve problems, but they need to let them know what a deadline means and be firm, said Rodríguez.

A variety of interventions have been established to confront these challenges, including a STEM Institute offered in the winter and summer intersessions, Engineering Orientation and Transfer Days Conversation with Advanced Science and Engineering Students, Panel Discussions with Practicing Engineers, and an Engineering Alumni Reunion. Rodríguez particularly emphasized the work of an Advisory Council formed by faculty instructors in the Engineering Program, most of whom also become mentors to students. The Office of Academic Affairs also has provided an advising coordinator who takes care of all the advising and strategy related to student advisement.

Another intervention has been STEM field trips, which expose students to national laboratories, research-intensive universities, and science museums as well as showing them the kinds of jobs they achieve through the program. Students are also encouraged to do research in New York City's research-intensive institutions and at such places as NASA's Marshall Space Flight Center in Alabama, Brookhaven National Laboratory, and PepsiCo.

EXPERIENCES OF AFRICAN AMERICAN STUDENTS AT HISTORICALLY BLACK COMMUNITY COLLEGES

The majority of the research on African American students in STEM has focused on four-year institutions, but African Americans also constitute 15 percent of the enrollees at two-year colleges. Too little is known about the role community colleges play in the production of STEM graduates, particularly African Americans, but these colleges "do a very good job of transferring students to four-year colleges or universities," said Leticia McCain, dean of instructional services at Bishop State Community College in Mobile, Alabama.

The study described by McCain looked at students' academic and social integration within historically black two-year campuses, their interactions with other students and faculty members, their persistence through their first year at community college, and whether they were on track to graduate with their associate's degree. The study used the model developed by Tinto (1975) as a theoretical framework to document the experiences, perspectives, and recommendations of African American students at two-year colleges. A phenomenological approach guided the study of 15 students matriculating at the five institutions.

The study examined five research questions:

1. What kind of college experiences did students acquire as a result of having participated in STEM courses?
2. How did academic integration influence persistence toward degree completion?
3. In what ways did social integration influence persistence toward degree completion?
4. What was the influence of faculty mentoring on adaptation to the academic environment of the college?
5. How did interacting with other students influence student persistence toward degree completion in STEM pathways?

Of the 14 historically black community colleges nationwide, 6 are in the state of Alabama and 5 participated in this study. Alabama has a state articulation agreement so that all courses taught at two-year community college automatically transfer to private and public universities in the state. The state also has an instructional association of all the deans and vice presidents of two-year colleges, with professional development activities three times a year and ongoing communications.

The 15 students who participated in the study had an average age in the young 20s, ten were African American males, and five were African American females. Two were pursuing associate's degrees in nursing, while the others planned to transfer into engineering, chemistry, biology, or another STEM major. All were on track to graduate from their two-year college and transfer after two years.

Interviews, campus observations, and other forms of data gathering were divided into categories based on Tinto's model, including academic integration, faculty involvement, and social integration. For example, the research demonstrated the importance of mentoring, in that students reported that if they did not have a faculty mentor guiding and motivating them, then they would have not have persisted. The research also uncovered the large number of informal interaction and campus activities with which students were involved. In particular, the study partners and friendships that they forged in class allowed them to form study groups, work on projects together, and collaborate on coursework.

McCain drew several observations from the study. First, the program generated a great deal of faculty development at all the institutions. Second, the tutoring laboratories, field trips, and research opportunities provided services that enabled students to persist. Third, students felt connected to their institutions because they were able to contact faculty members readily. Fourth, students appreciated the change to begin at a community college. In fact, some students started at a university and transferred to a community college, McCain pointed out, because that gave them a better foundation in their STEM courses.

Only two of the students received dual enrollment credit. Also, all of the students in the study participated in advanced placement courses in high school, but none passed an AP exam. This raises the issue of whether AP dual enrollment should be encouraged, said McCain.

She also drew several recommendations from the program's experiences. First, faculty on the campus need to reflect the student population that is being recruited. Second, students need support beyond financial aid, including mentoring, research opportunities, and preparation for four-year institutions.

The results of the study argue for continued support for historically black two-year colleges, McCain said, because of the success these institutions have had in placing students in four-year colleges or universities. "The majority of the students in this 15-member cohort have just completed their junior year at their four-year institutions," she said, "and they're still in their STEM fields."

A HYBRID ONLINE DEGREE PROGRAM FROM A RESEARCH-INTENSIVE UNIVERSITY

The Microbiology and Cell Science Department in the College of Agricultural and Life Sciences at the University of Florida has developed an innovative model of a two-plus-two degree program that has increased the participation of undergraduate minority students. It uses distance education to reach students in off-campus locations rather than trying to recruit them to a central campus. As Jennifer Drew, a faculty member at the University of Florida said in describing the program, "We're trying to bring our curriculum to the students, instead of asking them to relocate to us."

In 2011 the University of Florida launched a distance education microbiology major in which community college graduates transfer into the program to complete their bachelor's degrees. The experiences of students in the distance learning program are very similar to those of on-campus students. They take the same departmental courses taught by the same instructors, take required laboratory courses in a face-to-face format, take only proctored exams, and have the same availability to instructors.

Strategic planning with a key partner was an essential element of the program's success, said Drew. The university established a partnership with Miami Dade College–North Campus, which is the largest minority-serving institution in the United States. "Community college faculty know their students very well," said Drew. "They understand their needs. They helped us understand that there are many students at Miami Dade college who are very interested in transferring and earning their four-year degree in a STEM field, but for cultural reasons, financial reasons, many different factors, they can't physically relocate." The university also used a marketing firm with experience in distance education to promote the program and increase enrollments.

The online course is considered to have the same quality as the on-campus course, Drew noted. Students have the same expectations and graduation requirements. Students taking the course online do their laboratories in rented teaching space, in a ten-day immersion laboratory at the University of Florida, or in an equivalent setting. The distance education students receive peer tutoring, undergraduate research opportunities, scholarships, and career mentoring. Though some faculty members originally resisted adapting their courses to an online format, they have been won over through ample information technology support, workshops, and the provision of other resources, said Drew. The university is now starting to put other programs online, given the success of the Microbiology and Cell Science program.

The program started with 11 students in 2011 and had 68 in the fall of 2014. The distance education cohort has a higher retention rate than the students who transfer and physically relocate to the University of Florida. The distance education students also had grade point averages that were comparable to the on-campus transfer students. In fact, the online component has been so successful that many faculty members are incorporating online elements into their on-campus courses.

Most important for the Understanding Interventions conference, Drew said, more than half of the students in the program are underrepresented minorities, which is a higher percentage than among the on-campus students. The proportion of women in the program is also higher than among on-campus students. Furthermore, in a survey, 30 percent of respondents indicated that the distance education program was their only option to pursue a four-year degree, which suggests that the online students are not necessarily being drawn from a pool of students who would go to college on campus if possible.

The program is continuing to form partnerships with new community college partners. It also is seeking to further characterize the students in the program and analyze their long-term outcomes compared with other groups of students. The students in the program have intriguing histories, said Drew, including a single mother, a student taking care of family members, and a firefighter. "It's an interesting student body, and we're looking forward to seeing what else we can learn about these students."

3

Undergraduate Interventions

The largest number of interventions discussed at the conference involved undergraduates. As Phillip Bowman, professor of higher education at the University of Michigan, said in introducing one of the sessions at the conference, many interventions designed to broaden participation in research careers reflect the idea that the members of groups underrepresented in STEM fields have deficits that need to be addressed, even though this idea may be implicit or informal. Understanding the elements of strong programs and student barriers can transform deficit thinking into strengths-based programs, practice, and policy. Students face barriers as they pursue STEM education and careers, and they can use their strengths to overcome these barriers, said Bowman. For example, underrepresented students may come from poor homes or K–12 school systems that provided them with fewer opportunities to prepare for college than their classmates had. But they may have personal, community, or cultural strengths that, if nurtured and expressed, allow them to overcome this lack of opportunities. In addition, a focus on the strengths students have can be a paradigm for theory-driven research to understand the mechanisms of successful programs.

Many of the interventions discussed in this chapter adopt this strengths-based approach, which in turn influences efforts to understand the factors that contribute to students' academic success and their subsequent interest in pursuing research and research careers.

THE MEYERHOFF SCHOLARS PROGRAM

The Meyerhoff Scholars Program is built on the premise that, by assembling a strong concentration of high-achieving students in a tightly knit learning community, students continually inspire one another to excel in a strengths-based approach. Building on this underlying principle is the assumption that every affiliated student is capable of succeeding in STEM when given appropriate opportunities and resources. This concept and university commitment has ignited major institutional transformation and systemic change at UMBC.

Keith Harmon, director of the Meyerhoff Scholarship Program at UMBC, introduced the program and its role in transforming the university into what he called “an incubator for initiatives for student success.” The program was founded to build community support for minorities in STEM fields, Harmon explained, and it seeks applicants from a pool of high-achieving students who are interested in terminal degrees and also have an interest in issues around underrepresentation in STEM. The key factors in their success, he said, are advising and coaching, moral and social support, encouragement, and enrichment. In founding the program, the organizers tackled head-on some of the factors known to impede student success, including low expectations, academic and cultural isolation, unsupportive peer groups, and lack of practical research experience.

The Meyerhoff Scholars Program and Beyond

Updating the strengths-based program on which the Meyerhoff Scholars Program was based, Mariano R. Sto. Domingo, research scientist at UMBC, noted that:

- People have many strengths and the capacity to continue to learn, grow, and change.
- Intervention focuses on the strengths and aspirations of the members of the community.
- Communities and social environments are seen as being full of resources.
- Collaboration is a key to learning and achieving.
- Problems are seen as the result of interactions between individuals, organizations, or structures rather than deficits within individuals, organizations, or structures.

The Meyerhoff Scholars Program was founded in the late 1980s to develop a more positive climate for students of color in STEM who would become leaders and role models for the country. The current program composition of about 300 students is 53 percent African American, 22 percent white, 18 percent Asian and Pacific Islander, and 6 percent Hispanic. In the current first year class of 61 students, three-quarters are underrepresented minorities.

The program seeks to enhance the academic and professional success of underrepresented students in STEM, to encourage collaboration and close working relationships among students and faculty members, and to provide students with financial, academic, and social support. The program model has a variety of components, theory-based psychosocial influences, desired student outcomes, and contexts (Figure 3-1). To achieve the desired outcomes, it has 13 components:

1. Financial aid
2. Summer bridge program
3. Program values
4. Advising and counseling
5. On-campus and summer research internships
6. Faculty involvement and mentoring
7. Recruitment and selection weekend
8. Study groups
9. Program community
10. Tutoring
11. Administrative support and campus champions
12. Community service
13. Family involvement

Many of these components overlap. For example, the summer bridge program introduces students to the program and its values and also starts building community. The combination makes for an exceedingly rich experience for students, Sto. Domingo said.

The theory-based psychosocial influences in the program model include:

- High levels of expectations and challenges
- Academic and social integration
- Role models and a critical mass of like-minded students of color
- Mitigation of stereotype threats
- Comprehensive support and guidance
- Relationships and networks that facilitate career success

The intended outcomes are:

- Knowledge, skills, and STEM self-efficacy
- Motivation
- Identity as a scientist and as a Meyerhoff scholar
- Sense of community, professionalism, leadership, and persistence
- Commitment to PhD attainment
- Entry to STEM PhD program
- STEM PhD completion

These influences and outcomes are both shaped by the contexts in which the program operates. For students, these contexts include major and career options, their life influences, and their personal fit with STEM culture. For example, one of the strongest and most consistent predictors of entry into STEM PhD programs is the student's pre-college interest and excitement about scientific research. At the level of the campus, contextual factors include a stable

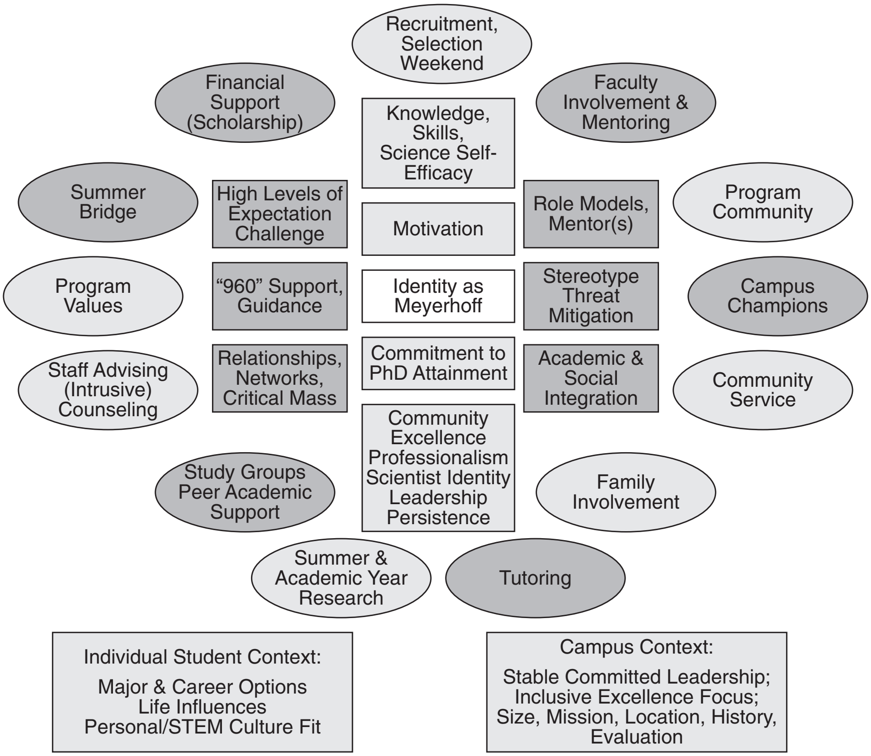

FIGURE 3-1 Components, psychosocial influences, student outcomes, and contexts for the Meyerhoff Scholars Program.

and committed leadership; a focus on inclusive excellence; the size, mission, location, and history of an institution; and program evaluation.

The academic outcomes for Meyerhoff Scholars in the years since the program was founded have been remarkable, said Sto. Domingo. African American Meyerhoff students in the years 1989 through 2008 were 5.2 times more likely to matriculate in graduate STEM programs than students who were offered the scholarship but declined the offer and went to a different institution (40 percent versus 8.4 percent). Meyerhoff students opted for medical school less often than students who declined the offer (15.4 percent versus 28.6 percent). And Meyerhoff students were more likely to enter STEM PhD programs than to enter either master's or allied health programs or no graduate STEM program.

The program also has had a profound impact on the institution as a whole. The number of African American undergraduates majoring in science and engineering has increased more that 11.5-fold since 1985. Overall and science enrollments among Latino students have grown 6.1- and 16.1-fold, respectively, since 1985. And the average grade point average of African

American students majoring in science and engineering increased from 2.7 in 1989 to 3.2 in 2014. In addition, a number of institution-wide improvements have resulted in part from new program additions for underrepresented minorities and improvements in pedagogy, including:

1. The Evaluation, Integration, and Institutionalization of Initiatives to Enhance STEM Student Success (iCubed@UMBC project)
2. The Building Infrastructure Leading to Diversity (BUILD) initiative
3. The Sherman STEM Teacher Education Scholars Program
4. The Center for Women and Information Technology (CWIT)
5. Maximizing Access to Research Careers Undergraduate Student Training in Academic Research (MARC U*STAR)
6. The University System of Maryland's Louis Stokes Alliance for Minority Participation (LSAMP)

As Sto. Domingo said, "Many, many students who are outside of the program are benefiting from the practices that originally were tested, applied, and experienced by the Meyerhoff Scholars."

Because of the success of the program, universities elsewhere have been getting in touch with program administrators in an effort to implement components of the program on their campuses. One outcome of this outside interest has been the Meyerhoff Adaptation Project, which is an alliance among the Howard Hughes Medical Institute; the University of North Carolina, Chapel Hill; Pennsylvania State University; and UMBC. An integrated research design for this project has nine evaluation components:

- Multilevel implementation assessment
- Yearly student academic outcomes
- Program component implementation
- Value-added student academic outcomes
- Institutional impact on science culture and the success of underrepresented minorities
- Formative assessment and feedback
- Modeling analyses
- Partnership assessment consultation
- Integrative report of findings

To date, said Sto. Domingo, 175 interviews have been conducted with 60 key personnel from all of the campuses involved, focusing on program implementation, development, accomplishment, and challenges. At the time of the conference, analysis of the results was underway, with an initial finding of a general convergence across responses and a high level of candor.

Sto. Domingo closed by pointing to several challenges to programs like the Meyerhoff Scholars Program. These include transitions in campus leadership, changes in program personnel, limited lead time afforded to program directors, overlap with existing programs, and campus structure and culture. As one example, Sto. Domingo noted that institutions like the University of

North Carolina emphasize student autonomy, while the Meyerhoff program has a focus on community. "It's not easy to adapt the Meyerhoff way, because its family-like cohesion and development has been forged through intense summer bridge bonding and modeling from all the cohorts. The other two universities do not have that history yet and those years of experience and relationships."

The Meyerhoff program is continuing to evolve. It is continuing its implementation of an integrated cross-campus research design that includes study of short-term and medium-term academic outcomes, the implementation fidelity of core program components, and the relation of theory-based mediating variables to program components and outcomes. It also is continuing its commitment to the Meyerhoff Adaptation Project, with an emphasis on refining and generalizing key program components, conducting implementation assessments, and assessing the strengths and weaknesses of the partnership. "We believe that, through incremental development, many of the programs initiating today using the strengths-based paradigm could reach the point that they will be similar to the Meyerhoff program today."

Change Resulting from the Meyerhoff Program

Mitsue Wiggs, assistant director of the Meyerhoff program, talked about what UMBC looked like prior to implementing the program and the change that has taken place since the program began operating. The university realized 25 years ago there was a problem in looking at its graduation statistics, she explained: "When you're graduating fewer than 18 African-American students in STEM, it's time for a change."

The Meyerhoff program changed those numbers, she said, but it also rubbed off on other students at UMBC. "We now have a number of students that we don't claim as our own financially, but we absolutely claim as our own in terms of support and resources." As a result, the culture of the campus has benefitted from the program.

The program's retention strategies, Wiggs explained, revolved around three components: administrative, social, and academic. Recruitment and administrative support were important to the integrity of the program and are handled as part of the program, not externally. The program also considers each student as a whole person and focuses not only on academic success but on social success and community building as well. "When you can make a program bigger than any individual, then there's strength to it," she said. However, the Meyerhoff program sets high expectations for students and strives to have them look at the whole picture: from freshman year to PhD and beyond. This type of vision cultivates ownership and accountability, Wiggs said.

Wiggs shared a few indicators of success from the Meyerhoff program. Retention for students who participate in their summer bridge program is at 95 percent, and cumulative GPA among the Meyerhoff scholars is 3.5. Today the program has 205 students that have completed their PhD, and 78 percent of those are from underrepresented student populations. An additional 186 students are in the process of PhD completion.

One of the lessons they've learned from the program, she said, is that strength of community cannot be overvalued. The program relies on and encourages student collaboration, friendly competition, and group work. Wiggs also emphasized the importance of having the program components be part of the larger workings of the institution. "You cannot work in a vacuum and expect to have great success," she said. Not only do the pieces of the Meyerhoff program align with the mission and purpose of UMBC, they are completely transparent to students so that every program participant knows the rationale behind the teaching methods.

One final lesson learned, Wiggs said, is the importance of working with families. Parents work closely with staff to ensure that students have support on campus and at home.

Applying the Lessons from the Meyerhoff Program

The lessons learned from the Meyerhoff program have been used to create honors experiences for a much broader range of students, explained Diane Lee, vice provost for undergraduate and professional education at UMBC. By looking at what made the Meyerhoff program successful and implementing those strategies within other programs, significant positive changes have occurred throughout the UMBC campus. For example, small group learning with real-world problems brought increased success in large chemistry classes. "Students work well in small groups; they get a sense of belonging." The university also created first year seminars, which have increased graduation rates among students. A request for more writing opportunities led to UMBC implementing an intensive writing requirement. Grants for innovation among students and faculty have been offered, which created new courses and new experiences. Some critical changes have come from listening to students and what they want.

Giving back is also one of the central points of the Meyerhoff system. This point also has been emphasized at the campus level, looking at where the skills students are learning could add value in the community.

UMBC now hosts an undergraduate research conference annually, where between 2,000 and 3,000 people view undergraduate reports on their independent research. Students can apply for Undergraduate Research Awards to conduct a year of independent research in collaboration with a faculty mentor. Work is published in a UMBC research journal run by undergraduate students. And UMBC has a collegiate success institute modeled after the summer bridge program that is such an integral part of Meyerhoff.

"One thing we always remind ourselves is that we have to adapt and adjust," Harmon concluded. "We know that we can be better and do better. We are not at the point of thinking we know it all."

UNDERGRADUATE RESEARCH PROGRAMS

Interventions at the K–12, undergraduate, graduate, and postdoctoral levels have been organized in an attempt to expand the participation of ethnic minorities, women, and low-income students in STEM careers, These efforts have led to a growing amount of research that has clear policy relevance. Most of the research on STEM education interventions has consisted of either descriptive analysis of exemplary STEM pipeline interventions, with emphasis on such factors as financial aid or instruction, or formal formative and summative evaluations, with an emphasis on implementation issues or program outcomes. However, a major gap in the existing higher education literature is an understanding of the underlying learning mechanisms that cause pipeline interventions to be effective, noted TaShara Bailey, a postdoctoral fellow at UMBC. In other words, said Bailey, "we cannot yet fully explain successful intervention outcomes, such as STEM plans and higher education and career success."

To explain successful outcomes, theory-driven studies need to clarify both organizational and individual factors within exemplary pipeline intervention settings, Bailey observed. Participants in successful interventions are more often satisfied with their overall experiences, and the interventions have benefits related both to short-term outcomes, such as educational and career plans, and longer-term outcomes, such as successful educational and career behaviors. For example, interventions among underrepresented undergraduates that increase short-term plans for STEM graduate study and research careers also have significance for STEM persistence.

Though many promising model interventions exist, Bailey continued, several descriptive and evaluation studies suggest that strong pipeline interventions contain multiple components and are formally organized to be comprehensive. Bailey described the study of a comprehensive approach designed to explore, first, the social organization of strong pipeline interventions and, second, the relationship between strong organizational support and successful STEM outcomes among underrepresented students. The focus is on participants who applied to a set of Summer Research Opportunity Program (SROP) interventions for undergraduates coordinated by the Committee on Institutional Cooperation (CIC), which is an academic consortium of the university systems in the Big Ten conference and the University of Chicago. CIC institutions confer over 15 percent of all PhD degrees awarded nationally and more than 20 percent in STEM fields.

Since 1986, SROP has provided nearly 12,000 research experiences for talented students, more than 3,000 of whom have pursued graduate studies. SROP is an 8- to 10-week residential program that includes faculty mentoring, intensive research experiences, and enrichment activities. The goals of the study were to develop reliable and valid measures of strong formal and informal organizational support that will be useful for research with underrepresented college students in summer research pipeline interventions, and to explore how these organizational support measures may help explain successful STEM outcomes among students in summer research.

The study built on an integrative conceptual framework to focus on five major propositions informed by the literature:

1. Strong pipeline interventions, including the provision of multiple resources, supportive norms, and interpersonal trust, promote STEM outcomes.
2. Strong formal organizational support, characterized by participant satisfaction with specific program components, enhances the positive intervention effects on STEM outcomes.
3. Strong informal organizational support from program mentors, staff, and co-participants enhances positive intervention effects on STEM outcomes.
4. The positive effects of strong formal and informal organizational support on intervention efficacy will be greatest for underrepresented students faced with high levels of role stress.
5. The adaptive strengths of underrepresented students can buffer the adverse effects of role stress on STEM outcomes.

The panel data for this study were a subset of longitudinal data collected by a broader mixed method study funded by the National Institute of General Medical Sciences at NIH and under the direction of Phillip Bowman at the University of Michigan. Consistent with the definition of strong organizational support, the study hypothesized that students who participated in SROP activities with a greater number of program components would be more satisfied with their program than students who participated in research experiences with a single component. Survey data found a very strong relationship between strong formal organizational support and program satisfaction. Significant but more modest relationships existed between program satisfaction and STEM research career plans. In addition, findings show a very strong relationship between STEM major and research career plans, in that students majoring in STEM fields were significantly more certain that they would pursue STEM research careers. While formal organizational support was a significant predictor of overall program satisfaction, even after accounting for STEM major and program intervention, it did not predict student STEM research career plans, Bailey noted.

In general, the study produced reliable and valid measures of both formal and informal organizational support that will be useful for research on underrepresented students and pipeline interventions, Bailey concluded. It showed that strong organizational support had clear relationships to overall program satisfaction but less clear relationships to STEM research career plans. Future research should go beyond short-term STEM research career plans and focus in addition on persistence in STEM majors and longer-term STEM outcomes.

FINANCIAL AND ACADEMIC BARRIERS TO STEM INTERVENTION SUCCESS

Using the same dataset as Bailey, Krystal Williams, a postdoctoral fellow at the Educational Testing Service, looked at pivotal academic and financial barriers to student success in an effort to understand how to help students to be successful.

Both the types of resources available to students and their academic preparation can have substantial effects on their success. When students face barriers in either of these areas, they can experience what is known as role strain. Role strain encompasses both the objective difficulties that individuals face in their role as students as well as the affiliated cognitive or subjective appraisals of those difficulties. For example, said Williams, if a student arrives at a college having done well in mathematics and expecting to become a mathematician, a placement examination may nevertheless show that the student is not performing at a college-ready level. "That would be an example of an objective barrier, because I'm entering college and I'm not prepared to really perform on a college level in mathematics," said Williams. In addition, "because I'm aware of this objective barrier, I may have some psychological response to it. I may be discouraged, I may decide that this subject area isn't for me, I may decide that college isn't for me. . . . That would be an example of my subjective response to the objective barrier."

With regard to academic preparation, student role strain is the objective and subjective challenges that students encounter due to a lack of exposure to college-level work. Similarly, with regard to student finances, role strain is the objective and subjective challenges that students encounter due to financial hardships, which can potentially serve as impediments to college success.

Williams' research asked how financial and academic student role strains relate to advanced study and career plans for underrepresented students. Using data from 376 underrepresented students in the CIC Summer Research Opportunities Program, she found that STEM research career plans were enhanced by strengths-based interventions, but impeded by financial and academic barriers. For example, about 40 percent of the students were from families that use some type of public assistance, and 62 percent qualified for federal grants or college work-study programs. Their average grade point average was about 3.7, and they had college examination scores well above the national average. On average, the students indicated a moderate level of financial stress.

The findings were not surprising, said Williams. On average, students with lower test scores and higher financial stress have reduced STEM career plans. Study findings also suggested that personal resiliency, which is a measure of adaptive cultural strength, can promote successful STEM outcomes, despite barriers.

The bottom line, said Williams, is that factors other than the opportunities provided in an intervention can reduce overall outcome levels. "Low test scores and financial stress reduce the intervention's efficacy," said Williams, "despite the supports offered within the context of the intervention. This is important to note." Holistic assessments of interventions have to take into account the strains that students bring into an environment to judge the efficacy of the intervention. Programs also need to address particular challenges in addition to providing opportunities to students, Williams noted.

UNDERGRADUATE RESEARCH

Building Cultural Capital, Social Capital, and Science Identity

Women of color face a number of barriers that contribute to their underrepresentation among PhD recipients and faculty members in STEM fields. Most immediately, they face a "double bind [for] being a female as well as a person of color," said Tonisha Lane, assistant professor at the University of South Florida. They may lack confidence or not feel a sense of belonging in STEM. Some women of color in these fields state that they feel alienated and isolated not only by their majority male peers, but also by some men of color. They can have difficulties developing relationships with faculty mentors. And some state that their norms and cultures may not be respected in the STEM disciplines.

Undergraduate research experiences have shown some success in keeping women of color interested in the STEM disciplines, said Lane. Undergraduate research can help build the cultural capital, social capital, and science identity that are contributing factors to student success. For example, when women are engaged in activities outside of the classroom, their experiences with faculty members are often better, and undergraduate research helps support these relationships.

In her research, Lane examined two questions: 1) what experiences contribute to cultural and social capital attainment in undergraduate research experiences, and 2) how do these experiences influence perceptions, attitudes and dispositions for graduate education? She engaged in a holistic explanatory case study of one STEM enrichment program at a large predominantly white public research university. Her study was part of a larger study encompassing about 50 participants in which Lane used interviews, focus groups, document analyses, and participant observations. In particular, she did semi-structured interviews with black females and Latinas, half of whom were lower-income or first generation college students.

Lane called attention to several findings in the course of doing undergraduate research. Building relations with faculty and peers were important to the students. Engaging in scientific practices strengthened their technical skills. Connecting what was happening in the laboratory to what they were learning in the classroom helped the women link theoretical and practical knowledge. Women also appreciated being recognized for their abilities and knowledge, which solidified their identities as future scientists and engineers.

Undergraduate research also demonstrated to women that, as Lane put it, "I have the capacity to succeed in these environments, and if I decide to pursue graduate education, that is very feasible for me." Because the participants were aware of the lack of women of color in academia, many wanted to disprove stereotypical beliefs about women in STEM, and some desired to achieve faculty positions.

Lane recounted some of what she learned from individual study participants. For example, one related how important it was to be invited to and attend lab meetings. These interactions made her realize how valued her contribution was to the research team. She also began working with international students, which provided opportunities to work with individuals across a variety of cultural differences. Another talked about the autonomy she had to build a research project, how different it was from her classroom experiences, and how the experience added to her development of a STEM identity.

Lane drew several broad conclusions from the study. First, undergraduate research can serve as a critical conduit to graduate education. It allows students to engage early on in important practices for graduate education, shows them the roles and responsibilities they will assume, and demonstrates that they could succeed in those roles.

Given the importance of cultural and social capital in STEM success, a framework that includes metrics and assessments of such changes is needed, Lane said. Even giving women a chance to reflect upon and document changes in their STEM identity was important to these women.

Finally, women aspiring to faculty positions need continual development so that they can demonstrate the forms of knowledge that they are attaining.

INTEGRATED PROGRAMS

Integrated Undergraduate Development Programs at Emory University

The synergy of integrated programs can help students succeed, graduate, and ultimately achieve their dreams. "We can go from a model of an old pipeline that was kicking and spewing people out with only a few sneaking through to the end to succeed in their PhD to one where we have fertilizer and rain and sprinklers and people can find many ways through the system," said Patricia Marsteller, biology professor at Emory University.

To illustrate the benefits of integrated programs, Marsteller described one of her recent graduates, an African immigrant who came to America believing that it was the Promised Land where he could succeed in anything he wanted to do. While working as a janitor, he overheard a woman telling her son that he had to study hard to succeed. The next day he enrolled in a community college near Georgia Perimeter College, where he entered a pipeline program that encouraged students to take a summer research program run by Emory University. He was able to study cardiology and anthropology over the summer and went on to graduate from Emory with a 3.9 GPA. During his senior year, he started a program for women in Africa to pursue the sciences, and raised enough money for five women to participate in summer undergraduate research. He then entered medical school intending to earn a PhD.

Many similar success stories have come from the integrated undergraduate development programs at Emory University, which are organized and run by the Emory College Center for Science Education (ECCSE). The programs work by involving many disciplines, not just STEM fields. Intersecting programs include the Hughes Undergraduates Excelling in Science (HUES) program, started in 1995, which offers a week-long summer institute for incoming freshman followed by activities and support throughout the students' time at the university, a pre-freshman bridge program called Getting a Leg Up at Emory (GLUE), work-study opportunities in research, and collaborations with Oxford University.

With so many programs and opportunities, Marsteller emphasized that the initial, integral step in undergraduate success is for students to figure out their passions. Students "see images of medical doctors doing things for the community, making a difference, but they don't see that image of science," she said. Exercises early in a student's career can help them think about their strengths, their passions, and the pathways available in different fields. "We know from much of the literature that, especially among underrepresented students, they want to make a difference, they want to give back, they want that to be part of their career pattern," Marsteller said.

Early on at Emory, students are able to create plans and think about alternative pathways through the summer bridge programs. Two different programs are offered—the residential bridge program that lasts for three weeks over the summer, and the less expensive online bridge program. In each, students receive instruction in case-based learning modules and explore tools and access to campus resources, including faculty mentors. The online and residential components work together to form a community of supportive and engaged students. Students in groups that include on-line and residential students conduct a global environmental research project and present their work via the web. Students who participate in the bridge courses have a higher rate of success and perseverance in STEM majors. Emory also offers faculty mini classes two or three days before the semester begins.

At the end of a yearlong experience, students get the chance to meet alumni who graduated from the Emory business program and learn more about career opportunities and pathways in STEM fields. Since HUES began, more than 1,400 people have gone through the program, and many of these alumni return to share their experiences in STEM careers.

After engaging in research experiences over the summer, underrepresented minority students can have financial challenges during the academic year. Many of these students have work-study obligations and spend much of their time studying in the library or working through their on-campus jobs. Marsteller helped develop a series of courses and introductory programming that groups undergraduates with graduate students to learn about the research experience and find a mentor. After their training, students can fulfill their work-study requirements doing research in a laboratory. So far, 120 students a year are supported by this project.

A long-term, solo research program builds from these introductory experiences. This year, 200 Emory students applied, along with 600 applicants from schools outside of Emory. Through the program, 70 percent of the graduates continue on to graduate school, and many go on to earn MDs or PhDs. A research ethics program acts as a companion to these student research experiences. Since 1992, Emory has required 30 hours of ethics training as part of the program.

Through integrated programs, students are able to learn about work–family balance, social justice, and communication. They gain diverse and in-depth experiences, build strong communities, and have access to mentors from the very beginning.

Integrated programs help students succeed, but they also bring challenges. For integrated programs to work, "you need to have dedicated staff, support from the institution, dedicated faculty and faculty mentors, and someone who writes grants all the time," said Marsteller. The institution has to believe in the mission, and many relationships must be built across the campus. Faculty members need to understand how to be better mentors, and students need to understand how to get the mentoring they need. Ultimately, integrated programs are about supplying the resources and experiences that students are asking for and, in this way, helping them succeed.

VALUE AFFIRMATION INTERVENTIONS

Closing Social Class Achievement Gaps with Value Affirmation Interventions

Two interventions at the University of Wisconsin improved underrepresented minority students' academic performance and retention rates. Both interventions took place in the same undergraduate biology course, a large gateway course for students who had completed chemistry and other prerequisites. It is a critical course for students in STEM fields, but it is a difficult course, with 800 to 900 students per semester, multiple lectures, multiple teaching assistants, and various discussion recitation lectures. Students can get lost in such a large class, and there is a particular performance discrepancy between first generation students and continuing generation students. First generation students make up 15 percent to 25 percent of the class and often come from working class backgrounds. They tend to lack a sense of belonging, and they attain lower grades and have higher dropout rates than the rest of the students.

Yoi Tibbetts, a fourth year graduate student from University of Wisconsin being trained as an experimental social psychologist and working with his mentor, Judy Harackiewicz, described the two types of interventions that occurred in this course. The first was a utility value intervention, which is course specific and aims to help students appreciate the relevance of the course material. The second was a value affirmation intervention, which is course independent, and aims to help students reflect on the personal values that they bring to the course.

Value affirmation interventions can be especially useful for underrepresented minority students where different motivational and psychological factors are at play. Tibbetts cited the cultural mismatch theory developed by Nicole Stephens and her colleagues at Northwestern. This theory posits that, while tradition university norms are often independent in nature, motivations and orientations of first generation students are much more interdependent in nature. This clash between independent norms and interdependent values can create a cultural mismatch that causes decreased performance, a reduced sense of academic belonging, and other detrimental effects for first generation students.

When Stephens polled university administrators about what they wanted their students to learn, half referred to independent skills and the other half referred to more interdependent skills, and university administrators noted a preference for independent skills. In contrast, when incoming students were polled about their motivations for attending college, first generation students reported more interdependent reasons such as providing a better life for their children and giving back to their community. In a regression model testing future grades, Stephens learned that independent motives positively predicted grades. The more independent motives a student endorsed, the better they performed in the following two years at college. On the other hand, "the more interdependent motives you had, the worse you performed in school over the next two years," said Tibbetts. These motivational factors were present in the introductory biology class used for both interventions. First generation students reported having fewer independent motives, more interdependent motives, less academic belonging, and more belonging uncertainty and concerns about their academic and social standing, he said.

Geoffrey Cohen and colleagues at Stanford University pioneered an intervention called Value Affirmation, which focused on personal values as a motivational tool. The intervention aimed to reaffirm integrity and act as a buffer against social identity threats, stereotype threats, and cultural mismatch. In the intervention, students wrote essays about why particular values were important for them. The intervention was tested on middle school students and on women in a physics college class, and in both instances it improved the performance of underrepresented minority students.

In the biology class at University of Wisconsin, this intervention was implemented as a double blind randomized experiment with 800 students, 154 of whom were first generation students. The intervention had 12 to 16 values and was completed twice over the course of the semester, once in the second week of the course and once in the eighth week. Students filled out a treatment or value affirmation prompt where they circled two or three of the most important values to them and wrote why they were particularly important. In the control condition, they circled two or three of the values least important to them and wrote why they might be important to someone else.

The achievement gap was halved in the value affirmations condition. First generation students performed significantly better when they reflected on their personal values and wrote about why they mattered. The intervention improved many first generation students' grades from C's to B's, a significant difference. Additionally, there was a continuation effect such that first generation students in the value affirmation condition were more likely to take a second sequence of biology. Of first generation students in the intervention, 85 percent went on to take a second course versus 65 percent in the control condition.

Previous research with value affirmations shows that years later, students continue to earn better grades than they would without the intervention. In a three-year follow up with the value affirmations participants at the University of Wisconsin, 64 percent of the students had graduated, 30 percent were still enrolled, and only 7 percent transferred or left the university. The social class achievement gap was closed by about 60 percent. It might be that when first generation students read about their interdependent values, "it may reaffirm the self, it may reaffirm those values that they've already established to make them feel comfortable in the course, thus allowing them to perform better," said Tibbetts. On the other hand, "it could be that when first generation students affirm their independence, which is context congruent, they might incur the benefits of this particular intervention because they may feel more aligned with the university context." Research shows that when a task feels more congruent with students' identities, they are more persistent and willing and they perform better.

In the biology course, the two sets of essays—1,600 altogether—were recorded based on student-reported themes of independence or interdependence in binary code. The results revealed that it was particularly beneficial for first generation students to reflect on independence. Many students did not realize the value of independence. The first generation students who benefited the most from value affirmations were those who affirmed their independence. This affirmation improved their subsequent GPAs, perhaps because it helped them feel like they belonged in a context that is independent in nature. While the value affirmation intervention is essentially a correlational analysis, it would be an interesting test to see what would happen if students were explicitly asked to write an independent or interdependent value affirmation essay, Tibbetts said.

Although value affirmation interventions will not work all the time for every student, many first generation students benefited. One student from the study wrote, "I realized that I needed to dedicate more time to studying by myself and getting some alone time. After dedicating more of my schedule to independence time, I began to understand material better and got to know myself and my goals better." The intervention seemed to help students realize their place in the university context, as well as their academic and personal goals.

To implement the intervention at other institutions, it may help to have a semester of assessment and to survey students further down the line. Ultimately, it is best to adapt a value affirmation intervention to its specific context, Tibbetts said.

Closing First Generation Achievement Gaps with Utility Value Interventions

Value affirmation interventions are about how students feel about themselves and the way they think about what they were studying, said Judy Harackiewicz, professor of psychology at University of Wisconsin, who discussed the second intervention conducted in the university's biology class in the fall of 2011. The intervention first had to be examined in the context of the student populace at the University of Wisconsin. "We need to think about the characteristics of our students, and it's a hard goal at the University of Wisconsin, where we don't have a lot of these students, to try to disentangle motivational profiles associated with underrepresented minority and first generation students," said Harackiewicz. The institution has a small number of underrepresented minority students, with about 20 percent first generation students. Over three years, data were collected from surveys of students in biology classes to try to separate the effects of race and social class in understanding discrepancies and performance.

The study's primary aim was to look at motivational values, Harackiewicz said. In four semesters of introductory biology, there were eight sections, each with 300 to 400 students enrolled. Every first generation and underrepresented minority student was included in the study, with a corresponding number of continuing generation majority (Caucasian or Asian) students. In total, the study included 423 majority continuing generation students, 427 first generation continuing majority students, 126 continuing generation minority students, and 64 first generation minority students.

The first generation and underrepresented minority students came in with lower grades, with the first generation, underrepresented minority students having the lowest grades of all. In their self-reported biology background, minority students reported having less background in the field, and first generation students, majority or minority, wondered if they belonged in the class.

Despite these challenges, minority students were particularly likely to value competence and were motivated to do well and contribute to society through the study of biology. First generation students and continuing generation minority students were more likely to cite interdependent motives—helping their families after college, giving back to the community, providing a better life for their children—than continuing generation majority students. In particular, first generation underrepresented minority students endorsed these values, with more than 80 percent of the population circling all three of these motives. "So the question is, can we intervene to help these students, can we take what we know, to think about which kind of intervention might be particularly effective for students with these motivational patterns?" Harackiewicz asked.

The utility value intervention was based on the Expectancy-Value Theory of Achievement Motivation, which argues that when students perceive value in academic tasks, they may become more highly motivated, more interested, and more engaged, thereby promoting performance (Wigfield and Ecclers, 2000). "If we can help students find the value of what they are studying, if we can help them connect what they are studying to the things they care about, we may be able to promote their performance," Harackiewicz hypothesized. In the utility value intervention at the University of Wisconsin, students selected a concept or issue that had been covered in a lecture in each of the three units of the course. They then each wrote a 500-word essay that formulated a question, addressed it, and discussed the relevance of that concept or issue to their own life. In some instances, students had the opportunities to write a letter to a family or friend addressing the question and then discussing how it was relevant to the other person.

Like the value affirmation intervention, the utility value intervention was a double blind randomized experiment. In the control group, students wrote essays of the same length that integrated and summarized ideas presented in class. In either case, the writing was valuable. Each of the three essay assignments over the 13-week semester was administered to students via e-mail, and the instructors were blind to which assignments the students received. The students turned the essays into an online dropbox, and the essays were worth a small percentage of the students' overall grade. Graders took approximately 15 minutes per essay, and feedback was an important part of the intervention.

Once the course was completed, it turned out that the students who participated in the utility value intervention obtained higher grades in the class. The intervention helped them think about the material at a higher level. The experiment helped close the gap between underrepresented minority students and majority students. The utility value intervention worked to a small degree for continuing generation students, and had neither a positive nor negative effect for majority first generation students and continuing generation underrepresented minority students. However, it had a particularly powerful effect on first generation underrepresented minority students in promoting their interest and engagement in the field of biology. It helped these students connect course topics to their important personal goals and revealed the opportunities in the field. For example, one student said of the intervention, "Before being enlightened this semester, I never knew that plants affect virtually every aspect of my life. I've always seen that they are everywhere, but I never realized that they directly affect everything from my health to my environment. It's safe to say that I've been converted to a tree-hugging plant enthusiast."

Another participant, when asked about specific career goals, responded, "I want to help people feel like they belong and reduce the achievement gap." The utility value intervention aims to accomplish these same goals, Harackiewicz concluded. "This is working for students because they are connecting the material to their desires and their strong motivation to help others and give back," she said. It can work for any topic, among different grade levels, but only when targeting a particular problem. Between the two interventions tested at University of Wisconsin, the utility value intervention is easier to implement and produces concrete benefits for the most disadvantaged student groups.

INSTITUTIONAL CASE STUDIES

The Inclusive Chemistry Success Project at the University of Colorado

The Department of Chemistry at the University of Colorado at Boulder partnered with the Student Academic Success Center (SASC) to create the Inclusive Chemistry Success Project, which aims to help underrepresented minority students pursue careers in STEM fields. The project involves pre-assessment, advising, core instruction for introductory chemistry, and post-assessment for 25 students.

Rebecca Ciancanelli was hired by the women-run SASC as STEM coordinator for the project. Prior to that, she taught chemistry co-seminars at the University of Colorado for ten years. As STEM coordinator, Ciancanelli runs the co-seminar program while also working on improving the quality of chemistry instruction for her students.

The SASC considers candidates for their program who have lower SAT scores and lower high school GPAs than typical students at the university. The SASC receives around 400 applications from the admissions department in December, and the students chosen for the program are then provisionally accepted into the university. The SASC also has an open door policy, meaning that any student from the University of Colorado who wants to be in the program can apply, and students who are admitted can apply for the scholarships and classes offered by the SASC.

"Our mission is to provide equal work opportunity for academic personal and career success," Ciancanelli said. The program provides the heaviest support during most years, and is working on increasing retention graduation rates. Currently, the SASC graduation rate is equivalent to the campus graduation rate, but over the next four years, the university's goal is to raise the graduation rate from 60 percent to 80 percent.

The SASC offers core courses in mathematics and writing. In science, students participate in typical large lectures and then take one-credit classes through SASC that are intended to support these courses. These co-seminars are offered in physics, biology, chemistry, economics, and psychology. Many of the students in the program are pre-med, so they have to make it through the general chemistry curriculum to finish their major. Along with the supporting co-seminars, tutoring is offered through all departments.

Three chemistry courses are offered to freshmen students at the university. Introductory chemistry is designed for students with a weak chemistry background, while general chemistry is for students who work at a quicker pace. In the fall, 500 students were enrolled in the introductory course and 1,000 students in the general course. Introductory chemistry covers eight chapters in a semester, while general chemistry covers fifteen chapters. The introductory course features a heavy mathematics sequence at the beginning of the semester, while the general course assumes students already possess these mathematical skills.

As students progress from one chemistry course to the next at the University of Colorado, they tend to drop one letter grade. In a cohort of three years between 2010 and 2013, 67 percent of students stopped after introductory chemistry, 14 percent of students continued and completed the two-course sequence, and 19 percent finished the whole three-course sequence. Of the students who started with general chemistry, 73 percent stopped after that single course, and 23 percent finished the two-course sequence. The University of Colorado discovered a low success rate when students went straight into general chemistry, but the faculty was unsure how to determine proper student placement.

When Ciancanelli joined SASC, she applied for, and was awarded, several on-campus grants, including the chancellor's award first time education grant run through the Center for STEM Learning at Colorado. Her goal was to use the grant to identify all the things she could help students do better in STEM fields. The first thing she tackled was student placement. She introduced the Assessment and Learning in Knowledge Spaces (ALEKS) to the university, a system that determines a student's prerequisites. "We can use this placement exam not as a punishment tool, but as a way to evaluate if they're ready to get into introductory chemistry or general chemistry," she said. The test presents a student with a problem that requires an application and synthesis of skills. The test continually adapts as a student is unable to answer certain questions, providing easier problems to determine their set of abilities. Ciancanelli has students take the ALEKS exam both upon entrance to the STEM program and as a post-assessment to measure their level of growth throughout the course.

Ciancanelli also introduced a modified Process Oriented Guided Inquiry Learning (POGIL) method into her courses. She made an instructional shift from 100 students per lecture to 25 students per lecture. She upped the number of classes from three days a week to five, with lectures on Mondays, Wednesdays, and Fridays and small group collaborative learning sessions run by undergraduates on Tuesdays and Thursdays. This system takes students out of a passive learning environment and propels them through a much higher workload. They have to work and practice, and the best way to accomplish this is scheduled peer instruction with inquiry-based learning. Ciancanelli believes that it is important for students to understand that learning is their own responsibility.

Ciancanelli also introduced new measures to keep students engaged in their courses. She found that learning is most effective when students have a chance to digest a new topic before receiving the information in a lecture. She created designated roles within small student groups that help students develop lifelong skills. The manager of the group keeps students on task, and the spokesperson presents the groups' views to the larger student body. Different roles remove students from their comfort zones. Critical thinking skills are necessary, and they feel more accountable for their actions. "One thing we want to be teaching them is the kind of skills they are going to need to interview for jobs, to join a team, to be a good team member, to go out in the world and be a successful, lifelong learner," Ciancanelli said.

In the spring of 2014, before Ciancanelli initiated the POGIL program, students in SASC were scoring 7 percent to 8 percent below the lecture average. There was a 42 percent failure rate among SASC students, with only 25 receiving A's or B's. But by the third exam after the start of the project, SASC students were outperforming their peers. By the end of the most recent semester, 63 percent of the students earned A's and B's and only 5 percent received D's and F's. Because of the small class size, Ciancanelli was able to touch base with all 25 students in her class three to four days a week.

In the semester before the project in Chemistry 1, a more challenging course, 13 percent of SASC students were receiving A's and B's and there was a 22 percent failure rate. After the projects, the success rate rose to 38 percent and the failure rate dropped to 9.5 percent.

The program also produced positive qualitative results. In one survey, for example, students reported increased interest and understanding of chemistry and how it relates to everyday life.

The next steps in the program include improving the general Chemistry 1 course, shifting the homework system so students practice more outside the classroom, and continuing to place high expectations on the students.

Factors that Predict Interest in Pursuing Research Careers among Students at North Carolina State University

While the enrollment in science, engineering, and health programs has increased by 30 percent between the years 2000 and 2010, there is a discouraging lack of diversity in the student populace, reported Amy Leonard, part of a team of researchers at North Carolina State University (NCSU). Of the 630,000 students enrolled in these programs nationwide, 28,609 were Hispanic or Latino, 2,500 were American Indian or Alaskan Native, 32,185 were Asian, 31,094 were black or African American, and only 1,088 were Native Hawaiian or Pacific Islander.

Programs providing a quality undergraduate and graduate training environment have the capacity to tackle these issues, said Erin Banks, another member of the NCSU team. The studies at NCSU aim to identify the role that structure and program type have on students' academic outcomes and career choices. The research looks into the factors that predict interest in pursuing research careers among underrepresented groups so that institutions can more effectively design their programs to serve a diverse cadre of students.

Leonard described a number of purposes underlying their studies. Their first purpose was to expand the existing research field relating to academic outcomes of underrepresented students in biomedical and behavioral sciences. The second goal was to examine how mentoring and research experiences influence students' decisions to pursue a research career—specifically, to identify the ways in which faculty influence student success. The third goal was to evaluate the role of individual factors such as resilience. Finally, the team hoped to examine these variables across multiple undergraduate research training programs.

The team's first studies were within the Initiative for Maximizing Student Diversity (IMSD) program at NCSU. Since the data set at NCSU was small, the team expanded their sample to include members of the Mid Atlantic Prep/IMSD Research Symposium (MAPRS), an alliance that represents the IMSD program, the Prep program, and students from the Louis Stokes Alliances for Minority Participation (LSAMP) program within the Mid-Atlantic region.

The study looks at a number of individual level variables and characteristics that are often overlooked, including the role of mentorship and resilience when it comes to proximal and distal outcomes for underrepresented students. Proximal outcomes include students' current research engagement, while distal outcomes include their career expectations. Among the research questions addressed were the impact of program characteristics and variables on resilience, interest, and research. At the MAPRS conference, 111 students participated in an online survey—17 percent undergraduates, 48 percent graduate students, and 29 percent alumni. Of this sample, 73 percent was female, and 50 percent was African American.

In the study, three different variables identify a student's interest in research. First, students were questioned on whether they expected to engage in research as a career. Nearly three-quarters (73 percent) of the respondents said yes, and 20 percent did not know. Second, participants were asked how much research they expected would be part of their career. Finally, respondents were given a scale with 15 items that addressed quantitative and qualitative dimensions of engagement, ability, and interest in research. Among this group, 56 percent believed that research would be a significant part of their future career. There was a strong correlation between students currently doing research and their proximal and distal interest in research.

To understand the development of student interest in research, the study measured resilience through a modified version of the Davidson resilience scale, which looks at a student's ability to succeed in an academic setting despite the existence of adverse conditions. Based on the study, it turns out that "resilience matters, but only in the short term. It does not predict interest in research over the long term," Banks said.

The researchers also examined the research mentoring experience through two separate domains—the psychological domain and the career domain. The first analyzes the emotional support provided by a mentoring relationship, while the second analyzes the efforts mentors make to help students acquire the specific tools needed to successfully complete a research project.

Mentoring can come from many sources besides the faculty. "We found that in our sample, [students] are getting it from their peers, they are getting it from their family, they are getting it from program staff, and they are getting it from postdocs, not necessarily from faculty in the lab," said Banks. "I think the faculty are having difficulty dealing with students on an emotional level because they automatically think that it's counseling," she added. "There is good and bad mentoring," said Craig Brookins, another member of the team. However, "we don't see resilience as connected with the mentoring, and one of the things is that students across all of these programs come in resilient," he said.

The variables of this study contribute to the research outcome expectancy measure, or the outcomes one might expect to happen as a result of engagement in research activities. These outcomes might affect a person across multiple areas including their career, life, relationships, and self-image.

As a next step, Banks emphasized that it is not enough merely to identify the key characteristics that instill student value in research. Research training programs need to go beyond individual measures and focus on larger steps for training directors to increase interest in research. This will develop student's present interest in their research as well as their interest in pursuing scientific careers.

Successful STEM Graduate School Preparation at Morgan State University

Morgan State University in Baltimore, Maryland, has had excellent outcomes in producing PhD STEM candidates through specific strategies in its School of Engineering (SoE) and School of Computer, Mathematics, and Natural Sciences (SCMNS). MSU has a total student body of nearly 8,000 students, with 650 undergraduates in SCMNS and 900 undergraduates in SoE. Of its students, 82 percent are African American, 85 percent are minority, and 55 percent are Pell grant recipients. Most of the students come from inner city or proximal suburban public schools, and there are many first generation students, particularly in STEM fields. Currently, MSU is ninth in the nation among baccalaureate-granting institutions for African American PhDs in the life sciences and second in the nation among baccalaureate-granting institutions for African American PhDs in engineering. In the past decade, 137 MSU BA and BS graduates have received doctoral degrees.

Christine Hohmann, RISE program director and part of an interdisciplinary team of three biologists, two engineers, and a sociologist at MSU, focused her presentation on the common denominators that helped produce successful preparation for STEM graduate school. The key, she suggested, has been addressing the specific needs of the SoE and SCMNS student body.

The SCMNS included two long-term, wide-reaching programs funded by the NIH—MARC U-STAR and MBRS-RISE—which encompass 20 to 30 students per year. While the programs are somewhat different, both include mentoring and the idea of a community of practice and a community of science. According to surveys, more than 85 percent of students in the RISE program agree or highly agree that year-round mentored research experience increased their self-confidence, leadership abilities, and networking skills.

Training can last between one and four years, with a two-year average. RISE admits students of nearly all academic levels, at any time in their college career, and allows them to develop on an individual basis. In contrast, MARC is more regimented and works with rising juniors and follows them through their junior and senior years. Both include a number of support and learning systems such as year-round mentored research, interdisciplinary seminars, an annual research symposium, problem-based workshops, and career workshops dealing with teaching soft skills like responsible conduct. These opportunities are available not only to students in MARC and RISE programs, but also to the entire university community.

In the SoE, the Pre-freshman Accelerated Curriculum in Engineering (PACE) plays an influential role from the beginning of a student's education. "Engineering is a degree of practice and students identify as engineers. Also, when students first come into the school of engineering, they really come into the same general curriculum because the initial courses everybody in engineering takes are pretty much the same quantitative skill training courses," Hohmann said. The PACE program builds a community of practice. Students are motivated by their peer interactions to develop design and practice identities, and these interests spill over into the campus at large. This is different from the SCMNS, where "students come in as majors and [have] a variety of disciplines with very different curricula. So their first engagement in a community of like-minded individuals comes when they enter research training," she explained.

Critical thinking, group support, and mentored research are emphasized in the PACE training model. Students also have opportunities to learn about career and graduate opportunities through retreats, workshops, and extramural research experiences.

The overall message from comparing the research training in the School of Engineering to that at SCMNS was the importance of building a community of practice and research among the students. This was accomplished in a somewhat different programmatic manner in either school due to the differences in the academic training environment.

In summary, Hohmann emphasized the importance of tailoring training to the specific discipline. Since engineering is a degree of practice, all students identify as engineers from the onset. They specialize only later, so they have the opportunity to shape effective organizational communities early on in the learning process. In contrast, SCMNS is highly interdisciplinary, and students identify as diverse academic majors. The first common denominator is shared engagement in research, and identities are built around these programs to help students foster a sense of a scientific community. "You need to look at the best practices and their effectiveness in the context of the academic and disciplinary environment in which you're trying to apply them," Hohmann concluded.

Integrating Sustainability Concerns into Retention Strategies at New Mexico State University

Employers are finding that even when students earn a degree in a STEM field, they are often not equipped with the skills and abilities needed to work in a new environment. Although students may have strong technical skills, they often lack the soft skills required to interact with people and deal with problems on the job. "Universities need to collaborate with the industry in order to provide these new learning environments where students gain and integrate the technical knowledge they acquired in the classroom with real goal scenarios or real world kinds of environments," said Imelda Olague-Caballero from the Department of Industrial Engineering at New Mexico State University.

Olague-Caballero helped develop a program that creates partnerships between the institution and different companies to facilitate these goals. The program at New Mexico State started in the fall of 2012 with the sophomore and senior curricula of methods engineering and of facilities planning. Both of these classes are taught in the same department, and the content can be applied in work environments. The model consists of five components: identification and selection of industry partners and potential projects; attendance at in-class mini-lectures and assignment of pertinent readings supporting selected projects; student training before being incorporated into a project; mentoring by peer and industry mentors and class instructors; and continuous evaluation and assessment of the learning experience through weekly reports and a final project presented to the company's CEO.

At the beginning of each semester, students are given industry projects, where they are matched with a company and given certain objectives. These projects require that students spend a certain amount of time inside a company where they act as consultant, identifying a particular problem, understanding that problem, and providing a solution. During on-campus classes, students listen to lectures where they learn the basic knowledge, tools, and methodologies that they will need to apply during the semester to solve or run the industry-based project. Basic training and logistics seminars provide the foundation for student success. During this time, students also learn the required etiquette that they need to follow to be part of the company.

Once students begin their projects at the companies, faculty and company liaison do constant monitoring of student performance, providing weekly reports to the class instructor. On site, students learn and practice fundamental concepts of industrial engineering such as lean manufacturing, time studies, line balancing, quality control, and safety engineering. At the end of the semester, students provide documents from their work as part of their final report. Student evaluation is based on in-class assignments, progress reports, quizzes, a midterm, final project presentations, and submission of their final report.

The program allows students to understand the importance of global and cultural competencies and the value in developing a strong base of soft and technical skills to enhance their employability. Students master skills through repetition, develop confidence in their ability to accomplish a task, and learn and imitate behavior of role models or professional mentors.

The partnership program increased the number of students attending classes and increased interest in engineering among students. A group of 20 students participated in the first semester of the course, and 60 students enrolled in the most recent semester. Student employability increases substantially, said Olague-Caballero, which "creates opportunities for employers to interact with potential employees and promotes industry involvement in the education of future engineers."

Despite the success of the program, its sustainability is a concern. Because the students have to travel to the companies, the university has to exercise controls on student behavior and get special insurance coverage. Additionally, industries need to assume responsibility as active participants in the process of educating new engineers. One of the program's continuing objectives is to get more companies to commit to the program, but it can be challenging since there are no substantial benefits for the company. Furthermore, it is challenging to develop the curricula needed for additional engineering classes.

The design, structure, and application of the program depend on the implementation of quality assurance techniques, permanent monitoring of students, and constant communication with industry partners. Some proposed strategies to increase sustainability include identifying and emphasizing the benefits for the industry partners and assessing institutional support of the program through structured surveys. To assess the program, a quantitative research approach was used; data were collected by means of a structured questionnaire using the SEM (Structural Equation Models) by means of the PLS (Partial Least Squares) technique. This assessment tool aims to understand the implications of cultural competencies and other latent variables in the education of students. In the future, new types of collaborations with industries need to be developed. "We need to prepare the new generation of global engineers and to get the involvement of all the stakeholders," Olague-Caballero concluded.

Scholarships for First, Second, Third, and Fourth Year Students at the University of Texas at El Paso

For the past 30 years, through funding from the NIH-MARC program, the University of Texas at El Paso (UTEP) has mentored and guided undergraduate students through the last two years of their degree programs into PhD programs and subsequent careers. The program has produced many success stories, primarily due to the intensive undergraduate research program leading to an orally presented, and defended, undergraduate thesis. However, students in the early years of university were unable to benefit from the program, even though the first two undergraduate years are crucial for retention and graduation in STEM fields. In the past five years, through funding by the NSF Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) program, the university has started a scholarship program that addresses this weakness.

The University of Texas at El Paso is a large institution with 25,000 students, 15 percent graduate students, 50 percent female, and 81 percent Hispanic. There is a high underrepresented minority population, and most of these students come from the local region. Almost 50 percent of the student body is first generation, and 70 percent are on Pell grants. The average time to graduation is seven years, although many students never complete their degrees. The university is in a blue-collar community (the median family income in El Paso is about $35,000 a year) on the border with Mexico, with 5 percent of the students from Mexico, benefiting from the state policy that Mexican Nationals on the border with Texas pay in-state tuition.

When the NIH-MARC program began, the university offered only a single PhD program, Geology; today there are 20 such programs, and 11 of them are within the STEM disciplines. A significant contribution to the university's changing attitude to, and capacity to perform, research can be ascribed to the NIH-funded programs such as MARC and RISE and the NSF-funded Materials Research Center of Excellence. Both recognitions occurred well before the non-geology PhD programs. Thus, the national recognition by NIH and NSF was a transformative intervention that permitted the institution to escape the "only one PhD" statewide category, yielding a vigorous research program across campus with an annual university-wide research budget of $85 million.

The current MARC program has grown to sixteen students from an initial cohort of eight. To date, more than 110 scholars from the program have either gained or are in the process of receiving their PhD degrees. At present, ten such scholars hold faculty positions in American universities and colleges.

The students in the MARC program are required to maintain a good GPA and are placed in a rigorous research environment where they spend at least 20 hours a week for two years. At the end of this time, students write and defend a thesis in front of students and faculty.

A particularly local aspect of the El Paso program is the regular contact the MARC students have with liberal arts faculty. Non-STEM faculty from the departments of English, History, Art, Music, Political Science, and other disciplines come to the MARC Introduction to Research class to present various intellectual endeavors that highlight the importance of research and exploration in all fields of study. It is a crucial illustration that research is not confined to the STEM arena and helps bridge the gap between scholarship in STEM and liberal arts fields. Another local intervention is the mandatory attendance at two MARC-only classes, one covering ethics from the standpoint of the Philosophy Department, and the other consisting of an entrepreneurship class taught by an instructor who has started several companies in El Paso that evolved from research of STEM students at the university.

From the above, it is clear that interventions at the junior and senior level have been creative, and successful. However, such programs do not address the significant pipeline considerations of high dropout during the first two years of STEM degree programs. To address this issue, a NSF-STEM scholars program offers a two-year scholarship to incoming freshmen. Based on the concept that minimal, but crucial, interventions were needed, only three basic requirements exist above and beyond appropriate academic standing at the University Scholarship level; all scholars must live on-campus, each is provided or chooses an individual faculty tutor, and all meet weekly as a group with the program director (Pannell). Thus, despite each of their families living between 10 and 40 minutes away from campus, the mandatory student on-campus living is crucial. The scholarship allows students to live in dormitories where they "don't have to worry about taking the dogs for a walk or looking after the little baby brother," said Keith Pannell of UTEP. "They don't have to worry about anything other than their studies and general intellectual advancement." Furthermore, and crucially, parents get the best of both worlds, since their children are "away at college" but are able to come home on the weekends.

Each of the NSF-STEM scholars was allocated, or chose, an individual faculty tutor. These tutors are not homework assistants but interact with students more socially, for coffee, to talk, to answer questions, and to give advice. "Faculty are somewhat on a pedestal for our students, and once a student has close contact with one, it makes it so much easier to have closer contact with others," Pannell said. Although interventions often emphasize that mentors come from the same background as the students, Pannell said this was unnecessary for a productive relationship.

Overall, the NSF-STEM program's major key to success is its flexibility and capacity to change proposed activities to suit the needs of students and the local environment. For example, initially travel expenses were available for attendance at meetings; however, as it became clear that given the range of career expectations encompassed a wide variety or professions, such as pharmacy, instrument sales, and medicine, it was realized that such visits did not accomplish the desired aim for junior academicians, so that aspect was dropped and funds were used for provision of more scholarships. The minimalism of the program allows students to focus on their studies, such as joining more clubs to savor the breadth of the university experience, attending foreign movies and exhibitions, and so on. At the end, it became clear that students in the program performed better than their peers, taking more credit hours per semester and graduating sooner, They had a higher GPA compared to their peers and, to date, a 100 percent graduation record. It can also be noted that a significant percentage of the NSF scholars changed their career goals to a more research-oriented direction, probably due to their interactions with the MARC scholars.

An annual capstone intervention in both programs is a retreat in New Mexico. Over three days, all STEM students, including new students, are brought together, with selected faculty. MARC students give presentations of their research in biology, chemistry, and physics, and all students present their ethics reports. The NSF-STEM students participate by outlining the impact their program has provided and the personal stories of how these interventions are molding their future plans.

For programs to be successful, directors need to give good advice to their students and not simply satisfy a quota for participation, Pannell observed. By focusing on students' needs and goals, the limited interventions at the University of Texas at El Paso have improved student success in STEM fields.

A Disciplinary First Year Seminar Tackles the Achievement Gap at the University of Wisconsin–Madison

As part of an HHMI Undergraduate Science Education Award, a team at the University of Wisconsin–Madison (UW) developed a series of interventions to address the achievement gap and subsequent loss of underrepresented minority and first generation college students from biology. UW does not have a department of biology, explained Caroline Jakuba Wienhold, a postdoctoral fellow at the university. The program is decentralized, with 32 majors that fall under the biosciences on campus. Often, students do not take biology until their second year, after they complete chemistry and mathematics prerequisites. "It's possible that a student could not consciously meet a single biology person their first year on campus," Wienhold said.

Without a community in the first year of college, students can feel isolated from the group and decide to leave the field rather than stick it out. This can be particularly true for underrepresented minority students, who often enter university with a feeling of isolation from their peers. At UW, 85 percent of students graduate within six years, but only 70 percent of minority students graduate within this timeframe. Of students who take introductory biology, 70 percent graduate with a major in biology after six years, but only 63 percent of minority students do so even when earning passing grades in introductory biology. In addition, they leave the biosciences at a higher rate.

Several programs were developed that aim to create a sense of community and integrate students into biology at UW by creating discipline-based learning communities for biology students. The programs were influenced by Vincent Tinto's theory of student retention, which argues that students achieve integration through their own motivation and through support from the university, which falls into five categories: academic involvement and support, early contact and community building, transition assistance, counseling and advising, and monitoring and early warning. The interventions at UW include a three-day freshman orientation called MadBiology Boot Camp, where students are introduced to the biology landscape in an intensive three-day residential course. A learning center called Biocommons was created as a physical space that focuses only on the students and their needs in biology. At the Biocommons, students can meet each other, learn about the 32 different majors offered on campus, and attend social functions. A peer mentoring leadership program is being constructed where upper class biology majors take on leadership roles in undergraduate biology classrooms. Students interested in biology also have the opportunity to live in a residential learning community called Biohouse during their first and second years. Finally, students can take Exploring Biology, a first year seminar to expose them to biology at an earlier stage. This seminar is a large lecture course that also meets weekly as small classes of 20–25 students to focus on narrow topics of interest. All of the seminars engage in academic planning activities and discuss engagement opportunities and orientation strategies.

Combining Tinto's theory with the disciplinary themes of the first year seminars, Wienhold and her team hypothesized that providing transitional support in a discipline-based format would lead to improved retention and success of underrepresented minority and first generation students in biology. "The first year of a student's life in a college, and even their first interaction on college, is paramount to determining their level of commitment to their academic goals at that institution and getting to graduation," Wienhold said.

In the first year seminar, the five core concept outlined in *Vision and Change* (American Association for the Advancement of Science, 2011), are used to teach students a different framework and a new way of thinking about biology. This gives students an organizational foundation to build on in later courses and allows them to make connections between different biology topics. The course also aims to foster student connections. Students are taken to curricular fairs where they have the opportunity to talk to mentors and begin building résumés that will give them opportunities to get internships and jobs later down the line. Faculty speakers are brought in during the first year to begin creating a community, and the seminar instructors are graduate students and postdoctoral fellows. The variety of student and faculty interactions allows students to create a support network where they can seek advice and help. In their first year seminars, students plan the coursework needed to obtain a biology degree in four years. They develop biology learning skills—study skills, cognitive framework skills, and ways to approach biology. The seminar does not aim to pre-teach material but rather to teach the skills needed for students to succeed.

Data collected between the fall of 2011 and the fall of 2014 showed the effectiveness of the first year seminars. The sample started with 7,000 students, but by the end a group of 2,500 core students were studied, broken down into an Exploring Biology group and a comparison group. The participants were all first year students who were studying biology, physical science, or undecided. The study wanted to focus on students who had the ability to succeed in biology, so only students who earned a C or better in the first year chemistry course were included in the sample.

The two cohorts had very similar demographics—about 8 percent minority and 19 percent first generation, an accurate reflection of the institution-wide student composition. First, the groups were compared based on their level of preparedness in entering college. The Exploring Biology students had a lower median score on their ACTs than the comparison group, leading to the conclusion that they were less academically prepared. However, these expectations were inverted in the first cumulative GPA results, where Exploring Biology students surpassed the comparison group. When broken down by minority status, all of the Exploring Biology underrepresented minority students had the lowest ACT scores and were the least academically prepared out of the 2,500 students. However, by the end of the first year, these students' cumulative GPAs equalized or surpassed the median GPAs on the comparison group.

ACT scores are not necessarily accurate predictors of success in biology, so Wienhold and her team also studied how well students performed in introductory biology. In an overall comparison, the control group and the Exploring Biology group failed introductory biology at about the same rate. Majority students in both groups had very similar rates of passing and failing, but minority students who did not take Exploring Biology failed introductory biology at higher rates than their majority counterparts—about 15 percent compared to 5 percent. Moreover, all minority students who took Exploring Biology passed introductory biology.

Wienhold's team identified eight categories for improvement in the program, including peer mentoring, social transitions, and increased engagement. While the student median engagement level was higher in Exploring Biology than among other students, almost 45 percent of students said they had only one or no mentors, and first generation students were consistently at the low end of having mentors. When looking at engagement, first generation students were participating in zero to four activities, whereas majority students were recorded in up to six different engagement activities.

A survey of 15 percent of biology majors tried to determine whether Exploring Biology did anything to keep students in their major. Students were asked to write five words or phrases characterizing their experiences in the course. The word cloud included words like interesting, boring, informative, and busy work. These terms were coded for positive, negative, and neutral evaluations, and the results were that 57 percent of students were positively aligned and 26 percent of students were negative or misaligned. However, these negative responses may have come from students who were not targeted to be in the course. The program aims to include minority students and first generation students who do not have the benefit of insider knowledge. The skills taught—how to get a biology mentor, how to enter a research lab, how to write a CV—might not be interesting to students who had grown up in an affluent, educated household.

The results from this study show the need for better recruitment strategies, said Wienhold. The program is working on partnering with the other divisions in the university to help engage more students in biology. Ultimately, Wienhold hopes that students are exposed to many types of careers through the program, so that they can see the variety of opportunities available to biology majors post graduation.

Exploring Biology has proved immensely successful with minority students, Wienhold concluded, and the program aims to continue to reach underrepresented populations and establish partnerships that promote success.

THE EDUCATION OF FUTURE TEACHERS

Blended Learning Strategies in Teaching Mixed Method Research to Student Teachers

Student teachers in colleges and universities, including those taking master's degree courses, usually do not feel competent in conducting research, despite receiving training in research methodology, noted Echo Wu and Samir Patel, professors at Murray State University. The teachers may think that they are not capable of doing research, they may not be confident in their abilities, they may think it is too time consuming, or they may think that research is not practical or useful for their teaching. This is especially the case for future or practicing preschool and kindergarten teachers, who often are busy in teaching and taking care of young students, who may also have less training, and who may lack the skills and knowledge regarding research methods.

Wu and Patel described a case study using blended learning with in-service preschool teachers in Hong Kong to teach them how to conduct mixed methods research. Blended learning is the combination of different training media, including traditional lectures, technologies, activities, and events, to create an optimum training program for a specific audience. Such programs use many different forms of e-learning, sometimes complemented with instructor-led training and/or student-centered learning formats. Recent research has reported high student satisfaction with blended learning, along with greater instructor satisfaction than with traditional learning. Blended learning can make education "more fun, more interesting, and more engaging," said Wu and Patel.

Teachers in Hong Kong typically have larger classes than teachers in the United States. Even in preschool, teachers typically have more than 30 students. In Hong Kong, to take in-service classes, teachers come after the work day and attend class for twelve weeks from 6:30 to 9:30 in the evening, with most of the students being female and often mothers.

The student teachers learn the essential steps of conducting research, including:

- Asking proper research questions
- Explaining the rationale for doing research
- Conducting literature reviews

- Designing data collection methods
- Collecting and analyzing data
- Presenting results and discussing implications
- Writing final reports

The student-teachers are given the opportunities to discuss, share, and explore, step by step, what topics or research questions can be relevant and interesting to them and how they could design the most suitable research projects to suit their own teaching circumstances. They learn how to collect and analyze data, and also how to report and present the results. Meanwhile, they also engage in and learn blended learning teaching strategies for their own classrooms, including traditional whole-class lectures, individual presentations, peer work, role playing, debate, group discussions, and other forms of interaction. In the process, the teachers learn how to interact with young children more effectively, how to observe the children properly, how to raise research problems, and how to explore and answer each question through research.

Wu and Patel presented several outcomes and implications of their research. Better teaching outcomes depend on the effectiveness of employing various blended learning strategies with groups of students, they said. Also, student-teachers need to be motivated and encouraged to engage in classroom learning, most likely with more practical and more effective strategies.

The Institute on Neuroscience Summer Research Program for Outstanding High School Students and Teachers

The Institute on Neuroscience conducts an eight-week summer research program for talented high school students and, more recently, middle and high school teachers. Program participants engage in authentic neuroscience research in working laboratories or clinics in the metro Atlanta area, including facilities at Georgia State University, Emory University, the Georgia Institute of Technology, Morehouse College, and Spelman College. "We both work at Georgia State University which is in the heart of downtown Atlanta," said Chris Goode, senior lecturer and director of undergraduate students at Georgia State University, of himself and his colleague, Kyle Frantz, professor of biology and neuroscience at Georgia State University. "It's a majority-minority city, and a majority-minority university, so it represents a unique opportunity to recruit from this population and create a group where those underrepresented groups are overrepresented in our senior pool—and indeed that's what we get."

Since 2003, a diverse group of 110 scholars have participated in the program. Seventy-six percent of the participants were women, and 33 percent were from racial or ethnic groups currently underrepresented in the sciences. Students undergo a one-week neuroscience orientation course and then do research for the next seven weeks. One day a week students engage in enrichment workshops on such subjects as scientific communication, writing research reports, and, for the teachers, developing lesson plans that align what they have learned by doing research with the standards they have to teach their students.

Goode, Frantz, and their colleagues have used a variety of mixed-method quantitative and qualitative approaches to examine program outcomes over the years. For example, they have tested the hypothesis that a summer research experience positively affects intent to persist in a science or research career via improvements in scientific research self-efficacy, science teaching self-efficacy, neuroscience content knowledge, science identity, and science and research anxiety. "We're particularly interested in how internal dispositions are changing as a result of the research experience, including things like their own self confidence," said Goode.

According to pre-, mid- and post-program surveys of two cohorts of 12 participants each, participants reported improved confidence with neuroscience concepts, scientific research self-efficacy, science identity, and intent to persist in a science career, as well as decreased research anxiety. Students and teachers particularly valued the written projects they were required to complete over the course of the program, including a research report and PowerPoint presentation summarizing their research accomplishments.

Regression models revealed that confidence with neuroscience concepts, greater science identity, and stable research anxiety predicted intent to persist in a research career. About two-thirds of students indicate that they are likely to pursue another research experience in the future. Some students, however, were averse to the bureaucracy they encountered in science and the anxiety about writing proposals and securing grants.

Study of the teachers in the program found increased science teaching self-efficacy. Teachers have developed lesson plans and evaluation rubrics and have posted them online for other teachers to use. They also have delivered science teaching workshops and have attended national conferences. However, the research experience did not change commitment to a teaching career, which appears to be partly related to frustration with their jobs, Goode reported.

In summary, said Goode, the initial short-term benefits of a summer research immersion predict long-term benefits, such as retention in pathways toward research careers for students and improvement of science teaching. The program does face challenges, he added, including evaluating the effectiveness of the lesson plans teachers produce and changing the low commitment to teaching found among the teachers involved. Nevertheless, the program contributes to the preparation and diversity of the biomedical research workforce.

THE NSF INCLUDES PROGRAM

The 2016 budget request for the National Science Foundation includes a new initiative related to broadening participation in STEM fields called Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science (INCLUDES). A workshop conducted at the conference by Claudia Rankins, of the National Science Foundation, used small-group discussions to identify a set of visions for broadening participation in STEM as part of an effort to engage stakeholders in informing NSF's investment in the program.

INCLUDES is envisioned as a comprehensive national initiative that uses a collective impact approach to increase the preparation, participation, advancement, and contributions of all scientists and engineering students, including those who traditionally have been underserved and underrepresented in STEM. This includes underrepresented ethnic and racial groups, women and girls, and persons with disabilities.

The INCLUDES initiative is currently planning to have two pilot programs: Networks for STEM Excellence, and Empowering All Youth for STEM. The workshop focused on the latter of these two pilots, which will be led by the Directorate for Education and Human Resources in collaboration with the other NSF directorates and the Office of Integrative Activities.

Feedback from workshop participants generated a number of priorities. One attendee said that NSF could have a major impact in high schools, particularly by partnering with other groups in the community such as museums and nonprofits. Such an intervention could help students come to college with a better foundation in STEM fields. Another participant added that even in middle school students are not receiving enough science education and suggested working with teachers to improve middle school STEM courses.

Teacher recruitment and preparation was another suggestion. If NSF can reward and encourage undergraduates in STEM to go into teaching at the elementary, middle, and high school levels, their students could be better prepared for college. The issue of teacher pay was raised, with one participant noting that low pay discourages many highly qualified individuals from those jobs.

A workshop member from California noted that programs to bring high school students into universities for research experience have greatly improved their skills. Another attendee suggested that computer science gets too little attention in K–12 curriculum and could receive new emphasis.

When participants at the workshop were asked how they would spend $5 million to improve STEM education, one suggested providing mentoring and job shadowing opportunities for middle and high school students to expose them to different STEM careers. Erin Banks from North Carolina State University discussed her university's partnerships with STEM-focused elementary schools in the area. She agreed that the entire pipeline is important, not just one part of it.

One participant asked NSF to think nationally and proposed sending STEM college students to speak at high school and middle schools about their experiences. Another participant suggested tying together programs that already exist to increase efficiency and reach.

Ashalla Freeman from the University of North Carolina at Chapel Hill added that many students admire the career track she has taken, from a PhD in microbiology to positions as a postdoctoral fellow, science administrator, and program director. NSF could create a career track to give students the opportunity to direct programs themselves, she suggested. She also proposed creating a position for a PhD to talk to teachers in middle and high school and give them better STEM training.

Other suggestions for NSF included the following:

- Hiring full-time tenure-track professors with a focus on social justice and equity
- Incentivizing faculty to address bias, in part by putting money into building competencies and teaching about bias in departments
- Copying successful programs and trying to replicate successful outcomes
- Integrating insights from different sectors to chart a productive path foward
- Increasing the diversity of teachers, particularly at the middle school and high school levels
- Encouraging tenured faculty to talk about their research in grade schools and middle schools

4

Graduate and Career Interventions

While many of the interventions effective at the undergraduate level also are valuable at the postbaccalaureate, postdoctoral, and early career levels, graduate school poses unique challenges. Underrepresented minority students and women often continue to have negative experiences and encounter negative attitudes, yet they may have fewer supports on which they can draw. Furthermore, the kinds of support they need can differ from their undergraduate years as they become deeply involved in research, consider career options, and prepare to transition into the workforce.

THE ALLIANCES FOR GRADUATE EDUCATION AND THE PROFESSORIATE PROGRAMS

The Tuskegee Alliance to Forge Pathways to Academia Careers in STEM

The Alliances for Graduate Education and the Professoriate (AGEP), funded by NSF, is an effort to facilitate graduate degree production among groups that are traditionally underrepresented in STEM degree achievement. AGEP alliances are free to focus on any of the phases of the graduate school and career trajectory, whether master's students, PhD students, postdoctoral fellows, the professoriate, or any combination of these. AGEP also encourages colleges, universities, and other stakeholders to come together, form alliances, and propose innovative models to address existing problems.

The Tuskegee Alliance to Forge Pathways to Academic Careers in STEM (T-PAC) has three partner institutions: Tuskegee University, Auburn University, and Alabama State University. The focus of T-PAC is to recruit first year underrepresented minority doctoral students at the three institutions and assist them in their preparation by eliminating barriers and providing strategic interventions, said Melody Russell, associate professor of science education at Auburn University. In particular, the novelty of the T-PAC model lies in the joint mentorship that is provided by engaging scholars in *virtual* interventions.

Study of the intervention among underrepresented minorities is guided by three strategically formulated research questions:

1. What factors affect decisions to pursue careers as STEM faculty at historically black colleges and universities and traditionally white institutions?
2. What factors determine STEM identity development?
3. Does STEM identity affect career choice and academic outcomes?

The study is looking at nine activities: online mentoring, online tutorials, online comprehensive examination preparation, online graduate courses, a literature search and technical writing activity, research experience in STEM at host alliance institutions, an online graduate course on proposal development, an online STEM teaching experience, and workshops to prepare future faculty. STEM identity is determined by perceived self-efficacy, positive self academic concept, and levels of motivation and persistence. The study included both qualitative and quantitative components, including online surveys, semi-structured interviews, and focus group interviews.

At the time of the conference, the study was in the early stages of data collection and analysis. Preliminary analyses looked at seven factors—study habits, organizational self-perception, peer evaluation of academic ability, self-concept in academics, satisfaction with school, self-doubt regarding ability, and self-evaluation with external factors. Two particularly stood out—self-confidence in academics, and self-evaluation with external factors. As students began conducting independent research, their self-confidence in academics increased. But underrepresented minorities were lower than other students on this measure. Also, underrepresented minorities tended to have less positive self-evaluations based on external factors in the early stages of research, though this self-evaluation increased in later stages.

Interviews have revealed that students generally would like more research experience, more experience in writing, and better preparation for comprehensive examinations. Though these results are still preliminary, they are very much in line with the interventions being offered, Russell noted. For example, writing experience preparation for comprehensive examinations is a focus of the program.

The researchers are continuing to work on enhancing survey participation. They also are particularly interested in persistence to careers as STEM faculty members and in the differences between historically black colleges and universities and traditionally white institutions.

The Texas A&M University System Alliance

The Texas A&M University System (TAMUS) has an AGEP initiative entitled Collaborative Research: Advancing Interdisciplinary STEM Graduate Education in Energy and Sustainability Disciplines. The goal of the program is to open multiple paths to the doctorate and professoriate for underrepresented minorities by developing and sustaining large-scale, distributed, and interconnected STEM communities among a range of institutions, said Rhonda Fowler, program coordinator for the TAMUS AGEP program. The initiative is led by five PhD-granting institutions, including a historically black university, two Hispanic-serving institutions, and a rural institution. Six additional collaborating undergraduate and master's degree institutions add to the diversity of the alliance.

The initiative has four objectives:

1. Increasing the number of underrepresented minority students entering STEM doctoral degree programs and at the PhD-granting institutions
2. Reducing the average time to degree to five years
3. Providing students with the preparation necessary to compete for faculty positions, and increasing the number of underrepresented minorities students transitioning from STEM PhD programs to faculty or competitive postdoctoral positions
4. Fostering alliance-wide faculty research collaborations with undergraduate, master's, and PhD student researchers to increase the number of doctoral research dissertations co-advised by faculty from at least two partner institutions.

The initiative has pursued a number of interconnected interventions to achieve these goals. It offers bonus awards based on a student's participation in activities across the alliance. Travel awards enable students to talk about their research at the alliance institutions and at national conferences. An AGEP participation guide used across the alliance provides assistance at different stages in the graduate process. AGEP conferences and summer institutes focus on professional and community development to help build collaboration across the alliances. Students receive support to prepare personal statements and grant applications. An alliance peer writing group across the alliance has resulted in the designation of accountability partners to serve as peers across the graduate school process. Seed grants allow students to develop new innovative research projects, with co-mentoring from two faculty members from alliance institutions. Committees on each campus include faculty, staff, and administrators who have teamed up to provide mentors.

Research being done on the initiative focuses on empirical questions related to feelings of inclusion of underrepresented minority STEM graduate students at each of the alliance institutions. In particular, the research questions concern the effects of isolation or ostracism on the productivity and progress of underrepresented STEM graduate students and their intentions to continue to the professoriate. What factors promote or mediate against underrepresented students expressing feelings of isolation or ostracism?

At the time of the conference, only preliminary data had been gathered. But survey and interview data on perceptions of campus environment reveal that students value the help they have received. "This seems to be working for most of the students, but there's still work we need to do," said Fowler. Among the obstacles students perceive are time management skills, family demands, personal barriers, research and course work, and intimidation by faculty and peers.

So far the sample sizes have been small—only about 20 interviews have been conducted—and researchers are trying to increase participation in the surveys. Also, many of the students are still in their first or second years, so they have not had much experience with some of the interventions. Some of the master's students have indicated that they do not want to pursue a doctoral degree, which is the goal of this program, for various reasons, including the pay offered in industry. "As we get more data, we can actually look at this more closely," Fowler said.

Holistic Professional Development for Graduate Students and Postdoctoral Fellows

The departure from a familiar community and culture can cause underrepresented students to struggle in STEM fields at undergraduate and graduate levels. These students can feel inadequate, disconnected, and unaccepted in the face of intersecting oppressions linked to race, class, and gender. PROMISE, the AGEP program for the 14 institutions in the University System of Maryland (USM), which is led by the University of Maryland, Baltimore County (UMBC), draws on this perspective to inform the structure of interventions that influence the retention of underrepresented minority STEM graduate students and postdoctoral fellow in STEM graduate programs and the pursuit of STEM careers. "We are interested in STEM identity and in how people in our programs are looking at themselves and considering themselves members of the STEM field," said Renetta Garrison Tull, associate vice provost for graduate student development and postdoctoral affairs at UMBC and founding director/co-PI for PROMISE at the system level.

In the fall of 2014, UMBC had approximately 14,000 students. Of these, 2,600 were graduate students, including 426 underrepresented minority students and 210 underrepresented minority STEM students. Often underrepresented minority students coming into such a large student body have not had the access to the tools and knowledge needed for particular career paths post-graduation. This information is not dispensed in the classroom, but it is vital for professional and personal success.

The PROMISE AGEP aims to improve this situation by offering students regular and repeated professional development leading to higher levels of STEM competence and performance. This is the case for the PROMISE programs at UMBC and on the leading partner campuses, the University of Maryland College Park and the University of Maryland Baltimore. At UMBC, PROMISE particularly focuses on three areas of holistic professional development: psychological well-being, financial literacy, and career–life balance, said

Tull. The integration of holistic and academic forms of professional development helps build connections among underrepresented minority students. These programs also are shared at system-wide events that include all of the institutions.

The program drew from many studies to find the best practice methods. McMillan and Chavis' theory of a Psychological Sense of Community emphasizes membership, influence, reinforcement, and shared emotional connection as the keys to success (McMillan and Chavis, 1986). The PROMISE AGEP program focuses on students' sense of belonging, a term more suited to education than a "psychological sense of community," Tull said. The PROMISE AGEP strives to fulfill these principles by fostering a feeling of belonging, a sense of sharing, reinforcement, integration, fulfillment of needs, and a shared emotional connection.

The PROMISE AGEP examines the intersection between race, recognition and competencies to determine retention. These factors play into a student's STEM identity, defined as the strong connection to the discipline of study. The PROMISE AGEP aims to understand whether, when people go to conferences and meetings, they are "recognized as a scientist or engineer," said Tull.

In their theory of science identity, Carlone and Johnson (2007) point to three dimensions that impact perseverance: competence, performance, and recognition. Carlone and Johnson found that women with research science identities were passionate about science, recognized themselves as scientists, and were recognized by faculty as scientists. Women with altruistic scientist identities regarded science as a vehicle for altruism, whereas women with disrupted scientist identities sought but did not receive recognition by meaningful scientific others. These women faced the most difficult trajectories, since they never felt secure in their STEM identities. The PROMISE AGEP in Maryland decided that, in order to foster strong STEM identities and connections to the field, all three elements of Carlone and Johnson's theory had to be implemented.

The workshops run at UMBC are open to all graduate students and postdoctoral fellows. They are not necessarily run within the walls of the institution, giving students a chance to explore new physical and mental spaces. The holistic workshops, which are less academic in nature, offer instruction on leading healthy, productive, and sustainable lives. "Our conceptual framework had the seminars as the interventions, and the psychological sense of community was used as sort of the lens for our process," Tull explained. The psychological well-being workshops address student anxieties and identify cognitive distortions such as catastrophizing. The financially-based seminars include investing and planning for retirement. Students learn about developing a budget, personal finance, credit scores, consumer debt, long-term financial planning, saving for retirement, consumer debt, and managing debt. The career–life balance sessions help students learn ways to give back to their communities. In addition to these holistic competency workshops, UMBC offers more traditional workshops such as "Writing for Publication" and "Public Speaking."

All of these workshops have been studied using a manual mixed methods research approach that combines quantitative and qualitative data analysis.

Methods included qualitative open-ended questions, content analysis, and formative evaluation to determine the retention, satisfaction, and overall success of the seminars.

Before taking the financial literacy seminars, underrepresented minority students received the maximum failure rate on a 31-question test on financial literacy. In a high school sample, 86.4 percent of African Americans and 75.6 percent of Hispanics failed the test, as opposed to 57.8 percent of Caucasian students. In a college sample, 51.7 percent of African Americans and 43.3 percent Hispanics failed, compared with 31.7 percent of Caucasian students. After participating in various financially based seminars, a series of questions revealed that while underrepresented minority students came into the course with larger deficits in knowledge and lower levels of current knowledge, they cultivated more knowledge over the course of the seminar than the rest of the students.

In the career–life balance and psychological well-being workshops, survey responses showed that more than 80 percent of underrepresented minority students found that the workshops served the dual role of providing information and a sense of community. In the public speaking seminars, among both underrepresented and majority students, participants gained new knowledge, confidence, preparedness, and effectiveness in public speaking. In the writing for publication seminar, students had similar experiences, with increases in knowledge, confidence, and motivational information to increase journal submissions during graduate careers.

In addition to the PROMISE AGEP's workshops and seminars, UMBC's Office of Postdoctoral Affairs' morning coffees offer postdoctoral fellows the chance to develop their STEM identities among faculty and peers. Postdocs are asked to do exercises where they view themselves as scientists and acknowledge their strengths. They write mock letters of recommendation from their mentors where they recognize their technical competencies over their personal attributes. They discuss and consider the traits of leaders in the scientific community.

The PROMISE AGEP program, in partnership with UMBC's Career Services Center, also provides Career Paths for Graduate Students, where 10 to 15 people from a variety of different groups come together over a two-hour period and meet successful employees from different companies and organizations. The events have a speed dating structure, where students spend several minutes with each participant and then, at the end of the session, are able to have more in-depth conversations with anyone of particular interest.

Overall, both underrepresented minority students and majority students found the multitude of seminars and workshops to be useful. They thought that the academic seminars helped prepare them for their graduate theses and dissertation defenses, while the holistic seminars offered them a chance to improve skills and build connections. The combination of holistic workshops with community and identity building constituted an intervention for retention.

Tull ended with some recommendations for creating an effective intervention like the PROMISE AGEP. The program must offer an extended suite of seminars and workshops for graduate students and postdoctoral fellows that cater to all aspects of a person's life, she said. Additionally, it should include consistent internal STEM seminar facilitators and speakers. Mentors need to validate a participant's place in the research environment to foster a supportive environment. Finally, seminars must be intentionally developed to build competencies, allow performance, and include recognition.

CASE STUDIES

The Steps Toward Academic Research Fellowship Program at the University of North Texas Health Science Center

Nine years ago the University of North Texas Health Science Center's Texas Center for Health Disparities developed the Steps Toward Academic Research Fellowship Program (STAR). The overriding goal of STAR, said Harlan Jones, co-director of the STAR program and assistant professor at the University of North Texas Health Science Center, was to address the unmet need for more diversity in biomedical research. The STAR program began as a way to give faculty from minority-serving institutions interested in health disparity research greater access to professional development activities.

When the STAR program was being developed, an intensive format was considered where participating faculty would take two to three months' leave from their home institutions to develop their research methods. But previous experience revealed the difficulties in moving faculty members from their homes and families. Instead, the STAR developed a one-year program with both on-site and distance learning to accommodate the needs of the participants. The length of the program provides a number of advantages, said Jones. The fellows come from diverse backgrounds and are in different stages of research preparation. "Maybe some of the experienced researchers are adept at doing research in reference databases, but for our cohort at a very early stage, they may need a little reminder or even an introduction to the different ways of searching the literature to begin their research project." The program's length also allows fellows to receive the background training they need before moving forward, and it gives fellows the ability to meet both their family and professional obligations.

Through an initiative funded by NIH, the National Research Mentoring Network (NRMN) was established to provide opportunities for mentees across career stages to find culturally competent mentors and engage in productive, supportive mentoring relationships and professional development opportunities. NRMN is a consortium to enhance the training and career development of individuals from diverse backgrounds who are pursuing biomedical, behavioral, clinical, and social science research careers (collectively termed biomedical research careers) through enhanced networking and mentorship experiences. The program has three functional cores: mentorship and networking, mentor training, and professional development. These three cores serve as the base for a truly national research-mentoring network. The mentoring and networking core is based at the University of North Texas, the mentor-training core is based at the University of Wisconsin, and the professional development core is based at the University of Minnesota. The National Research Mentoring Network STAR (NRMN STAR) was modeled after the original STAR program and is one of four programs of the professional development core within NRMN. Each professional development core consists of a select team of faculty trainees named fellows who have diverse backgrounds and are from colleges and universities across the United States.

Over the course of the year, fellows are required to attend an on-campus session every other month where they participate in full-day training workshops on Fridays and Saturdays. In alternating months, fellows participate in online training experiences for two-hour time periods. In the first three to four months of the program, fellows work together to develop a research question that addresses their interests. Once they decide on a topic, they develop specific aims and a full proposal that is then peer reviewed by a group of faculty mentors. Through this exercise, participants learn how to formulate research questions and goals, how to write a grant proposal, and how to defend their work in front of a peer review group. The curriculum includes courses on such subjects as protecting human subjects in research, working with an IRB, and finding alternative mechanisms for funding. Since not every fellow can be expected to receive an R01, the program aims to provide alternative opportunities for funding throughout the curriculum.

After the introductory period, each fellow is paired with a mentor. Fellows then begin to work on individual research projects over the course of the year. Through this mentor, fellows "learn how to begin to develop their independent research based on what they really want to do," Jones said. Mentors are carefully chosen to reflect a participant's specific interests and to help them develop the skill sets contained in the curriculum. At the same time, fellows begin to understand how to build mentor relationships.

Past fellows who have been successful in the STAR program return to share their experiences with current participants, demonstrating their success to the trainees. Lectures from a variety of speakers and role models teach trainees about the grant-writing and research processes.

Fellows discuss how to write and tailor grants. "We go through the process of grant preparation in terms of understanding the ins-and-outs and nuts-and-bolts," said Jones. Fellows also learn about basic translational community research. At the end of the year, each fellow is expected to have a fully written grant application that can be submitted to an external agency for funding.

The STAR program is about sustainability, Jones observed. Trainees are not simply sent off after a year's instruction. Rather, they participate in a five-year program overall that features progressive steps of development. Participants create short-term and long-term goals based on their stage in the process. In the first year, they serve as interim faculty fellows while participating in a mentoring process. In the fellowship year, they develop a contract where they set goals that align with the STAR program and their expectations for themselves. By the third year, after the completion of the fellowship, participants are able to develop successful applications and grants, with the STAR program continuing to monitor their progress. By year four, participants may be ready to submit an R01 grant.

The NRNM program has expanded to a national level, including Alaska, Hawaii, and Puerto Rico, and it is working to establish sites in the Southeast and Northeast. The eventual goal, said Jones, is to have professional development sites all around the country.

Transforming Recruitment and Graduate Training Through an IMSD Grant

The University of Texas Health Science Center at San Antonio (UTHSC-SA) is located in a city where the Hispanic population comprises 60 percent of its residents, yet six years ago only 12 percent of the student population in the Graduate School of Biomedical Sciences were from underrepresented groups in STEM. In addition, the program faced attrition of 40 percent of underrepresented students who left the program in the first year, primarily for academic reasons. Of those who persisted, time to degree was delayed about a year compared with their well-represented peers. "This is not a problem that's going to be solved in two days or two years," said Nicquet Blake, assistant dean for admissions and recruitment at UTHSC-SA. "This is clearly a comprehensive problem."

Blake and her colleagues were aware of a general impression among faculty members that underrepresented students were not as talented and took too much work to develop. But the institution's mission statement said that it trained a diverse student body, so expanding diversity was clearly within the mission. Doing so required developing a shared vision, because no one person could take on the task alone. It also required funding, because otherwise the task would not get done.

Admitting a more diverse student body encountered some resistance, Blake noted. Some people might focus on low test scores, even when a statement demonstrated an applicant's potential. Gradually, though, admissions policies moved to a more holistic approach.

The institution also implemented a variety of interventions, with support from an IMSD grant, to support underrepresented students. Upon acceptance, students were placed in a transition peer mentor program that aligned incoming students with current students. Incoming students also attended a set of pre-matriculation courses that addressed deficiencies in their preparation and taught them what was expected of students in a graduate program. Students receive "holistic mentoring" involving faculty mentors, the IMSD program director, and peer mentors. Outreach activities help build student–community interactions and cohort building among students. They work together to meet challenges, such as all of the second-year students passing qualifying exams on time. "I challenge them to be wildly unrealistic," said Blake. "What could we do as graduate students that everybody would say that's just not possible?"

In the first year of the new recruitment plan, 8 of the 42 matriculating students (19 percent) were underrepresented minorities, up from 12 percent in the previous year. By 2015, 34 percent of incoming students came from underrepresented groups. The undergraduate grade point average of matriculating underrepresented students has improved steadily over the direction of the IMSD grant, from 3.05 to 3.52. Of the 22 scholars who have been appointed to the IMSD grant, 50 percent completed the mandatory, eight-credit-hour first year core course with a grade of A, and none required remediation of the first year core course. The first IMSD student defended his dissertation in April, 2015, with a time-to-degree of under four years.

The interventions that guided the dramatic improvements in the recruitment, retention and persistence of IMSD scholars have now been adopted institution-wide by the graduate school at UTHSC-SA. The boot camp activity that was piloted in the IMSD program is slated to be incorporated as a requirement across the graduate school. A recent reorganization of the graduate school curriculum institutionalized many of the practices incubated in the UTHSC-SA IMSD program.

The Loma Linda University Health Disparities Research Pipeline Program

The Loma Linda University Health Disparities Research Pipeline Program (LLU-HDRPP) has demonstrated significant success in recruiting and preparing more than 400 predominantly underrepresented minority students for matriculation into STEM and behavioral science graduate programs nationwide. Founded in 1999, it is a comprehensive program that relies heavily on research experiences, mentorship, institutional support, and community collaborations.

An early high school intervention increases persistence of underrepresented minorities in STEM disciplines, explained Marino De Leon, professor and director of the Center for Health Disparities and Molecular Medicine at the Loma Linda University School of Medicine. The program immerses high school students, as well as undergraduate, medical, and PhD graduate students, in an 8- to 10-week summer research and career development internship. All of the students work on a research project under the supervision of a PI and meet for several hours to participate in selected enrichment activities and health disparities seminars. "We partner with the school teachers, the principal, and the superintendent to help us to find their talented students," said De Leon. "The only sad thing is that we have to reject so many good students."

Quantitative data have consistently shown that the program increases research self-efficacy and targeted research skills. The largest gains reported by the participants were for "conducting research," "scientific writing," and research self-efficacy. For the high school participants, survey results indicate that the research internship mainly targeted the research capability and the STEM confidence of these participants. Further analysis shows the importance of the hands-on research experiences and mentoring experiences.

Outcomes data show that 94 percent of the high school students obtain a college degree, and 63 percent of those are in a STEM or behavioral science discipline. The data also show that 98 percent of the undergraduate students graduate from college, 94 percent of them with a STEM or behavioral science degree, and more than 98 percent of PhD graduate students are completing their degrees and pursuing postdoctoral career development. The medical students are incorporating research into their residency programs and establishing practices in medically underserved communities. Interestingly, 52 percent of the high school and 81 percent of the undergraduate students matriculate into graduate programs. Of those who have participated in the program, 176 have enrolled in a graduate program, and 121 of those have enrolled in Loma Linda University for their graduate education.

THE DEVELOPMENT OF CAREER GOALS

Taking the Next step: Examining Obstacles and Opportunities in STEM Career Pathways

Though African Americans make up 12.6 percent of the U.S. population (Humes et al., 2011), they account for just 3.4 percent of careers in engineering and 4.9 percent in computer and information science (National Science Foundation, 2011), and they represent only 2 percent of faculty members in engineering at research universities (Slaughter, 2009). Yet same-race role models are important for minority students considering academia, and industry has been touting the importance of diversity in driving innovation, noted Christopher Newman, assistant professor at the University of San Diego School of Leadership and Education Scientists.

To better understand the underrepresentation of African Americans in these fields, Newman undertook a project to answer the following question: How do institutional agents, programmatic interventions, co-curricular involvement, engagement opportunities, and personal finances influence the intention of pursuing a career in industry or graduate school immediately following baccalaureate degree attainment?

Factors predicting graduate or professional school enrollment include academic achievement, institutional quality, a student's socioeconomic status, and accumulated undergraduate debt. For example, Newman did a previous study in which he found that having any debt greater than zero makes students less likely to enroll in graduate school (Eagan and Newman, 2010). From a theoretical perspective, expenditures on education and other activities can augment a student's productive capacities. However, socioeconomic status, a lack of knowledge regarding the returns on an investment in human capital, and sparse or nonexistent networks of people who can act as role models all can act as barriers to student investments in education. In addition, institutions of higher education are under increased pressure as states decrease their contributions to publicly funded institutions, which has spurred a movement toward privatization and other "marketlike" behaviors, such as greater reliance on external grants, university–industry partnerships, and higher tuition. "The notion that universities serve the public good as compared to the private good is shifting," said Newman.

Newman studied two predominantly white public research institutions—one in the Midwest, and one in the Southeast—both of which are among the top 50 producers of baccalaureate degrees in engineering among African Americans (Figure 4-1) (Borden, 2010). Both focus on success at the student level and the institutional level—for example, by providing assistance for students who enter college with gaps in their preparation in mathematics or the sciences. He conducted semi-structured interviews 30 to 75 minutes long with 37 undergraduates, 8 recent alumni, 9 faculty members, and 16 administrators. Students were primarily recruited through the respective campuses' minority engineering programs, identified as African American or black (including multiracial), had declared an undergraduate engineering or computer science major, and had gradepoints of 3.0 or higher or had persisted to upper division coursework.

Newman focused on students' experiences with internships in industry and their consideration of careers in engineering or graduate school. Students reported that their internships taught them how to be a professional and affirmed their interest in their fields of study and future careers in those fields.

North Carolina A&T	Tennessee State	Pittsburgh
Georgia Tech	Howard	Texas A&M
Morgan State	George Mason	South Carolina
Prairie View A&M	Central Florida	Drexel
North Carolina State	New Jersey Tech	Ohio State
Southern	MIT	Virginia Commonwealth
Michigan	Polytechnic Institute of New York	Florida State
Florida	Purdue	Texas–Arlington
Tuskegee	Pennsylvania State	Florida International
Alabama A&M	Washington Univ. of St. Louis	Jackson State
Florida A&M	Vanderbilt	Illinois–Chicago
Missouri Sci & Tech	Mississippi State	Alabama
Virginia Tech	Auburn	Buffalo
CUNY–City College	Tennessee	Maryland–Baltimore County
Michigan State	Virginia	Cornell
Florida Atlantic	Clemson	Rensselaer Polytechnic
Louisiana State A&M		Wayne State

FIGURE 4-1 The top 50 producers of baccalaureate degrees in engineering among African Americans. Source: Borden, 2010

They saw how what they were learning in college had real world applications. For example, one student studying industrial engineering said:

> Actually, I think it was the most influential factor in really knowing what I'm getting myself into. Because when I took this internship I hadn't really been doing that many [industrial engineering] classes yet because I'm just coming off my sophomore year. . . . It kind of was like "this is what it's like in real life." Then when I was done and I really got into my core classes, all this stuff that I did I saw the industrial engineers do. I see it again in my schoolwork, so I'm like, "Oh, they really use this stuff."

Some students discovered from their internships that they were not interested in a particular line of work. For example, a student who spends the entire summer working to make a fuel cap leak proof or windshield wipers less streaky might realize they want to do other things, Newman observed. They might also discover some of the complications of being in a profession that offers the possibility of lucrative careers. For example, family members may want them to make high salaries rather than going to graduate school. "They felt that they were being selfish to think only about their career when someone else is depending on them." Or students may be interested in corporate jobs but balk at making multiyear commitments to a company. In addition, a lack of state government money for race-based scholarships and initiatives has caused institutions to turn to private sponsorship, which again tends to draw students toward industry rather than graduate school because students are pushed toward corporate internships.

Newman also pointed to a lack of awareness among many students of the options they have, which he attributed partly to faculty members' failing to give students information about future careers. He quoted one professor as saying:

> Collectively in academia we do a terrible job of even explaining to students why getting an advanced degree is important. Even for industry it's important because who are they going to retain when times get tough? We just don't explain that, so it comes across as faculty complaining. Faculty do not often pay attention to the vibes they're giving out, their appearance, just sort of how people view them, and so many students of color probably look at most faculty and say: "Why would I want to be like them? I want to be like the person who is out in industry." . . . The only way they see a different world is if we actively pluck them and bring them into the lab. Thankfully, most of the faculty who do that are good role models and are not the stereotypical walking around with the holes in the soles of their shoes and dowdy clothes. So they get a good exposure: these people are normal, they have families, they are regular human beings like the rest of us and turns out they love what they do.

Newman drew several broad conclusions from his interviews. Students want to see returns on the investments they have made in their own education, which has the effect of pushing them toward the private sector rather than graduate school and the professoriate. They also may not know people in academia who can act as role models, whereas they can see the immediate impact a job in industry would make for them and their families. Finally, if students are to have comparable encouragement to go to graduate school, they need awareness of their opportunities and options.

The Effects of Graduate School on Career Goals

Efforts to increase diversity at the undergraduate and graduate levels have been more successful than our efforts to increase diversity in the professoriate, noted Kimberley Griffin, associate professor in the Higher Education Student Affairs and International Higher Education program at the University of Maryland. Though about 10 percent of PhD students in the biomedical sciences are underrepresented minorities, only about 2 percent of tenure-track faculty members in medical schools are from underrepresented groups. Among underrepresented minority PhD recipients, why are more not deciding to become faculty members?

Griffin placed the question in the context of social cognitive career theory, in which interest in a field leads to goals, which in turn leads to actions. In that case, a major research question concerns the interests people have and how those interests change over time. At the same time, interests are critically influenced by self-efficacy and expectations of where particular career choices will lead, which in turn are shaped by learning experiences and acquired information. "Self-efficacy and outcome expectations influence the whole pathway that we're interested in," said Griffin.

Based on focus group research with 38 individuals who explored their experiences in graduate school and postdoctoral fellowships, Griffin and her colleagues developed a survey that that was widely sent to recent PhD recipients (all participants had graduated within the past five years). Among the 1,900 respondents, 62 percent (n=980) were in or had been in postdoctoral positions. Analyses for this study focused on individuals that had been postdoctoral scholars. The survey asked about career interests, self-efficacy, relationships with faculty members and advisors, and sources of information and support for career development. In particular, respondents reported their levels of interest in four different career paths: being a faculty member at a research-intensive institution, being a faculty member at a teaching-intensive institution, having a non-academic research career, and having a non-academic non-research career. They also were asked to reflect on their level of interest at three different time periods: before they started graduate school, at the end of graduate school, and at the time of the survey.

Griffin and her colleagues Kenneth Gibbs and John McReady analyzed the results according to well-represented men, well-represented women, underrepresented minority men, and underrepresented minority women.

Over time, fewer people stated that they had clear career goals. Surprisingly, Griffin said, they had the clearest career goals at the beginning of graduate school, when they also acknowledged that they had the least information about career options. "Having information about various careers doesn't necessarily mean that you have a lot of personal clarity about what you ultimately would like to do."

Respondents generally agree that their advisors were invested in their career development and advancement. But only about a quarter reported that their graduate department or postdoctoral institution offered them structured opportunities for career development. About half said that their graduate or postdoctoral advisors were equally supportive of academic and non-academic careers.

Over time, respondents showed progressively less interest in being faculty members at research-intensive institutions. In addition, women had statistically significant rates of lower interest than men at each time point. However, for underrepresented minority men, underrepresented minority women, and well-represented women, the majority of this change happened during graduate school, whereas for well-represented men, the majority of this change occurred during their postdocs.

The respondents generally reported increased interest over time in being a researcher in a non-academic context or pursuing a non-research career. Women, whether well represented or underrepresented, were less likely to report that they currently had high levels of interests in being a faculty member at a research-intensive institution than the other groups. And underrepresented minority women were more likely to report that they currently had high interest in a non-research career. However, these differences in current interests largely disappeared after controlling for other factors related to career development, such as personal dispositions, time in graduate school, and aspects of postdoctoral training.

Importantly, the strongest predictor of career pathways was high interest in a particular pathway at PhD completion. Controlling for high interest in being a faculty member at a research-intensive institution at the end of graduate school greatly minimized or eliminated differences across social identity groups in reported current level of interest in that career path. In other words, an underrepresented minority woman interested in being a faculty member at the end of graduate school is just as likely as a well-represented man with the same level of interest to maintain that interest and report current high levels of interest in that career path. However, as noted above, women and underrepresented men often report lower levels of interest at the end of graduate school. Further, individuals who reported higher levels of confidence were more likely to indicate they wanted to be faculty members at research-intensive institutions, whereas individuals who were in postdoctoral positions for longer were more likely to indicate interest in having a non-research career.

These results raise compelling questions about what is happening during graduate programs, said Griffin, particularly as they relate to self-efficacy. For example, underrepresented women were less likely to report high confidence in their skills, whereas well-represented and underrepresented men reported the highest levels of confidence in their skills. Griffin and her colleagues are now following up on these results in qualitative research.

The results also raise the issue of providing people with information during graduate school. Even when graduates students know a lot about the potential options that are open to them, they are often uncertain about which options are right for them, Griffin observed. "We need to think creatively about how to expose students to different career paths," she said. They also need this information sooner than during their postdoctoral years, since many students begin making decisions about future careers in these years or before, and more needs to be learned about how information and experience affect the thinking of members of different social groups.

Evolution of Career Intentions of Biomedical PhD Students

Research shows that as students progress toward earning their PhDs in the biomedical sciences, their interest in academic research careers declines. In particular, "women and underrepresented minority students, including African American students, Hispanic students, and Native American students, are more likely to lose interest in academic research careers than non-URM men," contributing to a low rate of progress toward achieving faculty diversity, said Christine Wood, a research associate at the Northwestern University Feinberg School of Medicine and a member of a team of social scientists and education researchers that is studying how biomedical PhD students make decisions about what careers to pursue as they progress through the first two years of graduate school. Wood explained that, typically, studies conducted around this issue tend to be cross-sectional surveys, which reveal little about the processes of change over time and why changes occur. However, Wood and her team created a longitudinal study that assesses student's intentions year by year. "We hear a lot about students' declining interest in academic research careers, but we haven't really heard much about what makes students persist toward academic research careers, and that's the focus of this presentation today," said Wood. The research group is part of the National Longitudinal Study of Young Life Scientists (NYSYLS), which began in 2008, and works with the Scientific Careers Research and Development Group housed at the Northwestern University Feinberg School of Medicine.

The study conducted annual in-depth interviews with 202 PhD students in the biomedical sciences for three to five years. The researchers drew from a diverse population that was two-thirds female, 29 percent underrepresented racially and ethnically, 15 percent black or African American, 11 percent Hispanic, and 2 percent Native American. Students' career intentions were assessed at each of three points: at the beginning of the PhD, at the start of the second year of the PhD, and at the start of the third year of graduate school, said Wood. Responses were coded using a rubric that assessed the strength of a student's career intention for three different types of academic careers as well as careers in industry, in government, and outside research. Findings were framed around four patterns of student interest: students with consistently high academic career intentions; increases in academic career intentions; decreases in academic career intentions; and fluctuating academic career intentions.

In the interviews, every time a student named a career and described an interest in that career, the interviewer assigned a value to that interest. If students were very positive about a career and demonstrated clear intentions to pursue that career, they received a plus two for that option. If students felt that a career was a possibility for them, they received a plus one. If students were ambiguous, they were given a score of zero for that career. If they felt slightly negative or were unsure about a career, they received a negative score. If students had no interest in a career and were strongly negative, they received a negative two.

Twenty-seven students named an academic research career as their first choice career during their first three years of graduate school. This group of 27 included nine underrepresented minorities and 18 non-underrepresented minorities. However, though women were overrepresented in the sample, slightly more males than females expressed strong interest in academic careers during the first three years.

The interviews helped the team determine the broad determinants of persistence toward academic careers: students in the group of 27 demonstrated independence, a desire to lead a research team, the ability to manage common challenges, and tolerance of risks. While research jobs have inherent risks—both in terms of funding and research outcome—students are not totally risk averse. "These students are aware of those risks and challenges, and manage them and anticipate them, but have such a strong desire to pursue the PI role that while they keep it in mind, it's not something that deters them," said Wood. Students who want to enter academic careers are attracted to the idea of leading a team of researchers and having the freedom to ask their own questions and choose their own topics of study. The team also found that leadership is often a quality developed later in students' education when they begin to desire to bring together those who share their enthusiasm for the field.

Some students also want to give back to their communities through their careers, and more specifically to help promote diversity in the biomedical sciences. Five underrepresented minority students in the study intended to return to their undergraduate institutions as faculty members. They wanted to improve the education at their own institutions and help others from similar racial and ethnic backgrounds. While these are admirable goals, some may question whether these intentions will interfere with success and persistence toward research careers in academia.

The five underrepresented minority students in the study who wanted to give back to their communities attributed their success to intervention programs. These were primarily first generation students with low to modest family resources. While these students had affinities toward undergraduate communities based on race and ethnicity, not all underrepresented minorities in the study shared the same feelings. Janelle, one of the underrepresented minority participants who helped with the undergraduate MARC program at her PhD institution, initially wanted to reach out to others within her racial and ethnic group. However, by her third year, she had broadened her objective to helping foster the next generation of scientists. She grew up in a mixed-race family with high economic resources, which may have allowed her a different perspective than some of the other participants in the study.

The three underrepresented minority students who did not discuss giving back to their communities also participated in intervention programs during their undergraduate educations, but these programs were not the reasons why they intended to pursue research careers. All three of these students had clear intentions before entering these programs.

In the study, women were generally aware of their low representation in institutions at a faculty level. Despite this awareness, they tended not to mention gender-related diversity service work in their career trajectories. For the most part, women had various strategies to manage their perceptions of underrepresentation. One was to conduct translational research on women, thereby claiming an identity and legitimizing research on women. Another was to express pride around female identities by not playing down one's gender. Some expressed optimism that gender representation would improve and that gender disparities are a generational problem.

During her second year, one of the female participants in the study said that the decline in women from the postdoctoral to faculty levels was a product of women's individual choices. She did not see any relation between disparity and gender bias or work–life balance. However, after experiencing mistreatment by two male committee members during her third year, she amended her perceptions. She described dealing with extreme levels of condescension and became much more vocal about gender bias being a consistent aspect of biomedical research.

This longitudinal study has several implications, according to Wood. First, "we need to continue to help foster students' sense of independence and leadership; that's ultimately what's propelling people toward academic careers." Some students want to do diversity work, while some have no interest. Faculty members need to be responsive to these desires while finding ways to encourage students to integrate their diversity goals with their identities and skills as researchers. Gender disparity in biomedical research needs to be acknowledged, Wood added, and open dialogue about ongoing gender, racial, and ethnic issues is crucial. Gendered language, faculty disparities, and work–life balance issues are all major issues in STEM fields, but these problems can be mitigated through acknowledgment and intentional action.

A Career-Specific Developmental Model for African Americans in STEM

According to the US Department of Labor, approximately 1.6 million supplementary workers with degrees in computing sciences are required to satisfy workforce demands within the last decade. Yet particularly large disparities affect African Americans in computer science careers. "The computing sciences is a field in general that's isolating in nature," said LaVar J. Charleston, assistant director and a senior research associate at the Equity and Inclusion Laboratory at the University of Wisconsin–Madison. "You add race on top of that, it can become more isolating; you add gender on top of that, it can become even more isolating," African Americans have never accounted for more than 2 percent of PhD graduates in computer science in a single year.

Charleston is part of an NSF-funded research team that aims to ascertain the key factors that contribute to African Americans' STEM pursuits. The team has completed approximately 14 research studies on African Americans in computing through its nine years of collaboration and evaluation. In their latest study, rather than focusing on students who do not persist in STEM fields or who are in the early years of their education, the team examined career trajectories of current STEM professionals, particularly in the computing sciences. "What we want to do is move away from the deficit model and ask questions of those who have been successful to illuminate their stories and their trajectories, figure out what worked for them from their own voices, as to how they were able to achieve success," Charleston said.

The researchers' sample drew from a large computing company in the Northeast, with 37 African American participants, 22 percent undergraduate students, 48 percent graduate students, 40 percent computing sciences PhD faculty and researchers, and 55 percent women. All participants were computer engineering, computer sciences, or other computing-related majors. The participants were individually interviewed in recorded 45- to 60-minute sessions over the three to four days of a conference, answering a series of open- and close-ended questions posed by African American male social scientists.

The interviews revealed certain themes leading to degree attainment. "The factors that contribute to African Americans' pursuit of computer science degrees are early advanced engagement with computers and computing—what we call technological incubation—rigorous grounding in science and mathematics, computing-related cohort building, a knowledge of the interdisciplinary nature of computing, and multifaceted mentorships," Charleston said.

Career pathways can be set from an early age. Children identify with what they are exposed to. The career matchmaking process can depend on resources and perceived barriers based on race and gender. The choice relates to skills, abilities, and temperament, and a lack of knowledge prohibits this process and can prevent African American students from pursuing computing science careers. Early and advanced engagement with the computing sciences can introduce creative possibilities, connect mathematical applications to tangible outputs, link concepts with real life experiences, increase mathematics performance, foster higher order thinking skills toward problem solving, and promote sustained engagement. Achieving these goals calls for a rigorous and robust curriculum in science and mathematics as well as supplementary education in the computing sciences.

In addition, technological incubation needs to be supported through three channels, said Charleston: schools, homes, and extracurricular activities. Individuals use technology in vastly different ways depending on context. By making the versatility of computing more transparent, people can realize its connection to community. "When you think about computers and computer use, it cuts across diverse aspects of modern culture," said Charleston. "You can't go anywhere without some active use of computers and computing." Myths surrounding the field distract from realizing the potential to help others, solve human problems, and address social inequities.

The study revealed that African Americans' decisions to pursue computing science degrees often depend on socially constructed factors. Frequently, positive social influences acted as a catalyst for introducing the participants to computing science and then served as the underlying rationale for their persistence. Many of the successful participants were in science clubs and similar activities at a grade school level. In many cases, participants asked a parent about the computing sciences, and when a parent was unable to answer their questions, they asked a teacher or a friend. Talking about computing sciences with peers and participating in extracurricular activities helped students build a sense of community and boosted their self-efficacy. Nevertheless, most participants did not decide to pursue computing sciences until they were past their first year of college; of all the participants, only one was interested in the computer sciences before attending college.

The study revealed a six-year period on average between students' first introduction to computer sciences and the time they were actively engaged. Earlier engagement introduces creative possibilities and connects students with tangible outcomes. However, sustained engagement is difficult to foster, Charleston noted, particularly because of society's immediate gratification structure.

Research experiences contributed to many participants' decisions to continue on to graduate school. Multifaceted mentorships also were beneficial, providing academic preparation, social contacts, career advice, and help in the job search. Cohort building is essential to success, where students learn the technical and social aspects of the field, formulate groups, compare skill levels, work together, facilitate teamwork, and complete collaborative assignments. Peers can serve as academic and social resources in strong support networks. However, students tended to lack career advice, career development, and career counselors.

Based on the results of the study, Charleston and his team formulated a template to encourage students to pursue careers in the computing sciences. The key components include early advanced engagement with computers and computing, technological incubation, and rigorous grounding in science and mathematics. The lack of a consistent computing science K–12 curriculum is one of the biggest problems in the educational system, Charleston said. "Computing science in one school is word processing, where other people are writing code and creating apps and things of that nature. We need to normalize that. This is the direction that our country is going in, that the world is going in. Just like there is a math curriculum, we probably need a consistent computing science curriculum for everybody to adopt." In addition, the trajectories of whites, Asians, and Indians need to be investigated and compared with the trajectories of African Americans in the computing sciences, he said. At each stage of the educational pipeline, efficacy, efficacy outcomes, and self-efficacy should be reestablished. Industry, higher education, and K–12 education can work together, along with corporate partnerships and additional funding, to provide the support that students need. To establish a growing and diverse workforce, computer science needs to be demystified, Charleston concluded.

DISCIPLINARY SOCIETY PROGRAMS

National Networks with a Disciplinary Focus

Professional societies can help reduce the falloff in participation by underrepresented minority students who fail to make the transition between undergraduate and graduate studies. In the discipline of physics, the American Physical Society (APS) has acted as a national recruiter of underrepresented minority physics students, connecting these students with graduate programs. "This solution works for many other disciplines," said Theodore Hodapp, director of education and diversity at the APS, but it requires two things. The first is that a central entity is needed to act as a clearinghouse. That is possible in physics but difficult in biology, where many different professional societies serve the overall discipline. The second is a revenue stream, which in the case of physics is provided by several major journals that serve the discipline.

Because of the relatively small size of the discipline, an increase of relatively few minority PhDs in physics could address the underrepresentation of minorities—just 30 would bring the fraction of PhDs up the fraction of underrepresented minorities who receive bachelor's degrees in the field, said Hodapp. Once those numbers are increased, other problems will start to solve themselves, because the population of physics PhDs will start to look more like the broader population.

One advantage a professional society has is that it can recruit for all universities. If a student does not get into one program, a professional society may be able to find another place for that student. Professional societies also can help students prepare so that they are accepted by more programs. The American Physical Society has established six bridge sites that offer courses students may not have received in their undergraduate institutions. To be accepted into a graduate school, most physics students need four core courses: quantum mechanics, electromagnetism, statistical mechanics, and theoretical mechanics. "If you didn't get quantum mechanics as an undergraduate," said Hodapp, "most graduate schools will not accept you. . . . You go under water so fast that there's nothing you can do." Bridge programs can help students get the preparation that they need to be accepted into graduate schools and succeed. "This is a replicable thing that could happen in any discipline, including the life sciences."

The society also monitors the progress of students. "We go and visit every single one of these students and talk to them personally," said Hodapp. "We talk to their instructors, we talk to the chair or the director of graduate studies, so we keep track of what's going on."

In only two years, the APS has placed enough students into graduate programs nationwide to effectively eliminate this achievement gap. The program has low costs, is well received among graduate programs, and has encouraged universities to adopt best practices that can improve their graduate admissions and retention.

Early Findings from a Broad Intervention Partnership

The Endocrine Society, which is one of the oldest scientific societies in the United States, has developed a mentoring and intervention program, known as MAP, that partners minority-serving institutions with research-oriented institutions and a professional society. MAP provides extensive mentoring and research training to prepare students for progression to postbaccalaureate and graduate study. As Mark Lawson, associate professor of reproductive medicine at the University of California, San Diego, pointed out, professional societies provide a way of letting graduate students know that they are "part of the society, not visitors to the society."

MAP leverages the existing community to improve training, mentorship, and career development. It is based on a two-year model, where Endocrine Society members recruit students from minority-serving institutions to participate in two summer research experiences. Participants attend the society annual meeting, where they are introduced to peers and mentors, attend career development sessions, and are guided through the general meeting. Afterwards, they join a summer program at a partner research institution. In the second year, participants again attend the meeting to present their previous summer's work. They also act as peer mentors to new participants. In addition, trainees are encouraged to attend recruiting conferences, such as those held by the Society for Advancement of Chicanos and Native Americans in Science and the Annual Biomedical Research Conference for Minority Students, and they are mentored through the graduate program application process.

The effectiveness of the program has been measured using a novel dual quantitative and qualitative approach. The evaluation is designed both to assess the program's outcomes and to uncover underlying mechanisms contributing to student success. The qualitative approach provides rich feedback from the students for program improvement via structured interviews and ethnographic data. The quantitative approach complements the qualitative evaluation with data on such indicators as graduation rates and graduate school acceptances.

Central to the evaluation, MAP students have been matched with a group of non-MAP underrepresented minority students who are equally talented and interested in a scientific research career. Across three years, Lawson and his colleagues found significant differences in the scientific career interest trajectories of MAP and matched non-MAP students. The non-MAP students show a significant decline in intention to pursue a scientific research career across their undergraduate years. However, MAP students are buffered from this decline and retain high intentions of persisting on the scientific research career path.

The researchers also have been trying to understand the psychological mediators that affect outcomes. Drawing from social psychological literature, they hypothesized that programs designed to develop lab skills and scientific self-efficacy also have positive effects on students' scientific identity, opportunities to fulfill communal (helping) goals, and resilience to stereotype threat. They found that these psychological outcomes are more powerful predictors of persistence in science than scientific skill and self-efficacy, which is a critical finding for the design and implementation of programs.

The researchers are interested in investigating whether communal goals are important to all groups of students or just some. They are also interested in what aspects of the program engender the greatest effects and how to boost these aspects in the program design.

FIRST GENERATION GRADUATE STUDENTS AND POSTDOCTORAL FELLOWS

Can Interventions Change the Decline in First Generation STEM Doctorate Recipients in STEM?

This talk presented data on the increasingly elite background of doctoral recipients based on the *Survey of Earned Doctorates 2013*, which showed that 25.4 percent of recipients have parents with at least a bachelor's degree and 42.9 percent have parents with an advanced degree. These data also show that whites and Asians earn a disproportionately large percentage of degrees in relation to their representation in the general population. Blacks and Latinos have hardly increased their proportion of earned doctorates in the last decade, noted Anne MacLachlan, senior researcher at the Center for Studies in Higher Education of the University of California, Berkeley, and the relationship of degree holders to their national populations remains disproportionately small. At the same time, a new study by the Council of Graduate Schools indicates that, at 62 percent and 37 percent, respectively, African American PhD recipients are from an even more uniformly educated background than the PhD recipient population at large.

The central argument of the talk was that this is a trend that needs much more attention among the many other features of graduate education. Unless more doctoral recipients and faculty are from underrepresented groups, first generation and/or minority, the dynamics of growing exclusion will continue.

Credentials for graduate school admission have been rising as this trend has developed. Admission increasingly requires a high level of academic achievement, including research experience. This level of attainment is usually only possible for underrepresented undergraduates who have participated in interventions possibly as early as middle school. Because doctoral education is a highly complex process with many serious problems, the implication of the trend in recipients from highly educated backgrounds is that such prior training is critical for survival and success.

Moreover, doctoral training is comprehensive, raising the question whether interventions in the form of special programs or extra training here and there are a suitable approach to dealing with the current trend, MacLachlan observed. More appropriate would be considering a fundamental reform of STEM doctoral training in which there is extensive orientation and socialization to both the process and the specific discipline, she said.

Overcoming Pressure Points for First Generation Graduate Students and Postdoctoral Fellows

Students who are in the first generation of their family to attend college face unique challenges in the undergraduate academic environment, including questioning of their belonging and academic identity, financial stressors, and family tensions resulting from their departure for college, noted Carrie Cameron, assistant professor at the University of Texas MD Anderson Cancer Center. However, very little attention has been paid to these students when they reach the graduate and postdoctoral levels. Indeed, the lack of supportive policies and interventions for these students suggests that they have "made it" and no longer encounter these stressors.

Through focus groups, interviews, and surveys at a major academic health center in Texas, Cameron and her colleague Melinda Yates sought to find out more about the graduate and postdoctoral experience of first generation trainees, including what stressors they identify, their perceptions of their relationships with mentors, and their perceptions of their communication skills (frequently considered a manifestation of socioeconomic, racial, and ethnic identity). They also sought to tease apart the influences of family economic status during the trainee's childhood, race, ethnicity, and native language from first generation status. The researchers were particularly interested in whether first generation status plays a role in shaping the research career intentions of biomedical sciences trainees.

A graduate student or postdoctoral fellow may be a skilled researcher, noted Cameron, but if scientific writing, presenting, and speaking are a hurdle, any researcher can be discouraged. Because our communication skills and style play a powerful role in defining our identity and group membership, especially with conversational (i.e., non-rehearsed) speaking, first generation students may not like to take risks and so remain in the background. She described Yates' group of first generation graduate students at the University of Texas Graduate School of Biomedical Sciences (GSBS) that meets monthly to discuss such topics as impostor syndrome, practical stress management, time management, financial planning, informational interviewing, and networking. With 28 students enrolled, and 45 percent of those underrepresented students, the group has been "very successful," according to Cameron and Yates.

First generation graduate students tend to have two pressure points, cultural and structural. Culturally, academia can be profoundly different from a working family's life. Many first generation graduate students say that their family does not understand what they do in graduate school. They ask why the student is still in school and when they are going to get a job. "Academic culture is idealistic, individualistic, and universalist," said Cameron. "First generation students may be more practically oriented, or more relationship oriented, and they can be torn between the two cultures" of life in the university and life at home. She recalled her own personal experience: "I still remember when I was almost through graduate school and my grandmother, who I adored, admitted to me that she thought that I should have never gone to graduate school and should have gotten a job. I was heartbroken."

The group's study results suggest that first generation students appear to have different perceptions of the mentoring relationship, reporting benefiting from fewer mentoring behaviors than legacy trainees do. In addition, they view their mentors as less responsive to them than is the case for others.

Finally, first generation students often cope with difficulties with finances, family obligations, and time constraints, as Yates' work with the GSBS group has highlighted. Cameron noted that one thing that would help is informational and personal development seminars, such as money management workshops, as well as raising awareness among administrators and mentors of the issues faced by this group. Online and in-person special interest groups also can provide support and advice.

5

Mentoring and Coaching

A particular area of focus during the 2015 Understanding Interventions conference was mentoring and coaching, which have proven to be critical elements of multifaceted interventions aimed at underrepresented minority students in STEM fields. Research has been revealing the aspects of mentoring and coaching that are most influential in helping students overcome the barriers they face, with important lessons for any institution.

TRANSFORMING PREP OUTCOMES THROUGH CHANGES IN MENTORING APPROACH

The University of Missouri–Columbia postbaccalaureate research education program (MU PREP) emphasizes the development of students who would not otherwise be in the upper levels of a biomedical career track. Successful applicants to the program are required to demonstrate high motivation to pursue doctoral study but may lack some of the requisite skill sets to be considered for admission into a competitive doctoral program in the biomedical sciences. Once admitted to the program, MU PREP Scholars usually enroll in first year graduate courses while participating in a meaningful research experience. They also participate in a weekly course designed to enhance professional communication skills and prepare them for the graduate school application process. While the program is designed to be successfully completed in one year, it is not uncommon for MU PREP Scholars to engage in a second year of study.

An initial funding period started in 2003 and ran through 2007, explained Michael Garcia, associate professor of biology at the University of Missouri–Columbia. After a year in which the program was not funded, the program resumed from 2009 until the present. In 2009, the program leaders decided to implement a more intense mentoring approach. Their rationale was twofold. First, while cultural sensitivity and solid support structures are critical components of the program, the leaders of the program were sensitive to the unintended consequence of dependence on such supports by trainees. Second, professional success at the doctoral level is often predicted by "degree quality," as measured by such factors as levels of productivity, the quality of networking circles, and a student's training pedigree.

As such, the program was modified to have an intense mentoring structure that prioritized rigor in training and an emphasis on developing cultural capital and identity as a successful scientist. During their first year, MU PREP Scholars receive very critical real-time feedback on their performance in venues such as journal clubs and snap research presentations within PREP group meetings. This critical feedback extends to regular individual meetings with a research mentoring committee and program leaders where all aspects of their performance in the program are discussed. Program expectations are mapped to the performance of scholars with an emphasis on maturity in scientific thought, behavior, and performance.

At the end of their first semester, the scholars are required to choose a laboratory in which to perform research. They also form a research advisory committee consisting of the research mentor, the principal investigator at the laboratory in which they are working, and a PREP advisory committee member, creating an advisory group similar to a master's dissertation committee. In addition, they go to professional meetings with an eye to forming connections that facilitate their applying to graduate school.

Many MU PREP Scholars have reported being overwhelmed in the first year, said Garcia, but scholars were in agreement with research mentors and program leaders that by the second year they had gained experience and confidence. In evaluation interviews and focus groups, the scholars talked about being pushed almost to their limits in the journal club and about often being recipients of "tough love" in one-on-one and committee meetings. But during their second year, they generally see how much those experiences challenged them and encouraged personal and professional growth. They came across as seasoned and much more senior when observed alongside second-year graduate students in joint focus group interviews. "They are much more confident, they identify as scientists, you can see them take on that role," said Garcia.

The change in the program coincided with a major increase in the number of completed applications, rising to 75 completed applications in 2015, Garcia reported. The average gradepoint of 3.2 did not change much between the two periods, and GRE scores were below average. Also, the colleges from which the students came did not differ much between the two periods.

However, the outcomes from program participation differed greatly between the two periods. Prior to the change in mentoring model, MU PREP Scholars were successful in making the transition to doctoral programs (93 percent), but were often placed in programs at mid-tier institutions. After the shift in mentoring approach, MU PREP Scholars are more typically placed in higher tier institutions, to the extent that the University of Missouri has much more difficulty retaining the PREP Scholars in its own graduate programs. About 80 percent of the scholars have been accepted into graduate programs, and 95 percent of them have completed or are on target to complete. (By comparison, the seven-year completion rate for underrepresented minorities in graduate school is less than 50 percent.) For MU PREP Scholars who completed the PhD, time to degree averaged 5.9 years—compared with a national average of 6.9 years—and they contributed to an average of 3.4 publications.

BENEFITS OF A COACHING INTERVENTION ON PERCEPTIONS OF ACADEMIC CAREER SUCCESS

Many factors influence an individual's intention to persist in an academic career, explained Bhoomi Thakore, a research associate with the Scientific Careers Research and Development Group at the Northwestern University Feinberg School of Medicine. First, an individual's personal motivation to pursue an academic career can vary during one's academic training, which Bhoomi referred to as "wanting." Second, acquiring an academic position—or "getting"—can entail difficulties in the current economic climate. Third, an individual's ability to succeed in an academic position upon acquiring one—"succeeding"—is related to the degree to which one's confidence increases or remains high over time.

The Academy for Future Science Faculty at Northwestern has been studying an intervention focused on the third of these factors. The Academy is a longitudinal intervention created to address the issues associated with achieving diversity among faculty in the biomedical sciences. The first wave of the Academy began with 99 beginning PhD students, representing a range of biomedical sciences departments and disciplines, and 80 controls. Those who applied were randomly assigned to the Academy or the control group, and the Academy group was equally stratified by race and gender.

The objectives of the Academy intervention are twofold. The first is to deliver information to promote graduate student success through annual in-person meetings. The second is to develop communities through the random placement of ten students into each, headed by an academic career coach. Coaches are senior scientists in the biomedical sciences who are committed to faculty diversity efforts.

In the fifth year of serving and interviewing students, 78 experimental and 64 control group students remain. Diversity in terms of race and gender has been maintained in the experimental group, but the control group is now majority white and does not have any underrepresented men.

The research Thakore described tested the effectiveness of the Academy intervention on students' perceptions of succeeding in an academic career. Students were asked, on a scale of 1 to 10, about their perceptions of confidence in succeeding. Data were collected at the end of the second and third year of the PhD, which corresponded with two and three years of the intervention.

The analysis found no significant differences between the experimental group and the control group in movements up or down in confidence. There also are no significant differences between underrepresented minorities and well-represented students in the Academy group. However, when the results were broken down by race and gender, a more nuanced story emerged. In general, men in the experimental and control groups showed a decline in confidence over time, with men in the Academy having a similar decline in confidence to those in the control group. But women in the Academy held constant while women in the control group declined. "There appears to be some sort of buffering effect" of the Academy, said Thakore. Among men, no underrepresented minority increased in confidence over time, whereas some women in both the underrepresented and well-represented groups increased in confidence, with a slightly larger percentage of those who increased three or more points in the experimental group compared to the control group.

Of the eight experimental students whose confidence stayed the same or increased over time—four underrepresented women, three well-represented woman, and one well-represented man, reflecting six of the ten coaching groups—interviews were done at three points in time under a coding scheme that broadly captured the effects of the Academy intervention. After the first year, students particularly mentioned the Academy workshops on laboratory rotations, choosing a PhD mentor, and developing their individual development plans. After the second year, students mentioned the Academy workshops on writing grant applications, ways of addressing discrimination, webinars on qualifying exams, and stress management. After the third year of the meetings, students again mentioned the usefulness of the workshops, such as a workshop on microaggression.

All of the students in the sample report reaching out to their coach and finding that guidance useful, with about half of the students engaging with their Academy coach on a regular basis. For example, one said, "I was expressing my frustrations about not making any progress in my project, and my coach recommended that I talk to my PI about work on a secondary project as well. That was actually really good advice and really helped a lot." Another who wanted to get more experience with teaching said, "My coach mentioned that there are avenues outside of your graduate program to have teaching experience. So that was actually reassuring."

Students in the sample talked about the usefulness of connecting with their coaching group early on in graduate school to learn from each other and gain perspective on others' experiences. However, over time, the students found the coaching groups less useful. One student said, "Many of the group members weren't continually checking back in. I don't know if that's because we're just busy and kind of forgot or what, but I think we need a little bit more organization and connection in that sense."

The researchers plan to look more specifically at longitudinal data between the experimental and the control groups to understand the long-term impacts of the Academy at the point of making decisions about one's career. The Academy also has been working with a number of professional societies to develop new Academy programming and experiment designs.

PERCEIVED ACADEMIC CAREER COACH EFFECTIVENESS BY COACHING STYLE

Career coaches are supplements rather than substitutes for a mentor or principal investigator relationship between a biomedical graduate student and a faculty member, explained Veronica Womack, a social psychologist with the Scientific Careers Research and Development Group at Northwestern University. As such, they do not need to be affiliated with a student's home institution, research, or evaluation, which makes it easier for them to provide "independent and unbiased advice," said Womack. In addition, students under the same coach can receive support from other students within that coaching group.

This coaching model has been in existence at Northwestern University for four years and it has yielded enough data to identify, assess, and compare coaching strategies in association with students' perceptions of coaching effectiveness. Womack described a study that had the objectives of categorizing the coaches by coaching style and using data from student interviews to identify perceptions of coach effectiveness by coaching style.

Approximately 100 U.S. biomedical graduate students were randomly assigned to one of ten coaching groups a month before beginning graduate school. Each coaching group had an equal number of men, women, underrepresented minorities, and well-represented students. Coaches in the program, who were not affiliated with the students' institutions, received training prior to meeting with students, and they were encouraged to remotely bring the students together throughout the year. The coaching groups met in person annually for three years. Students were encouraged to maintain virtual communication with both their coaching group and their coach throughout the year. The coaches were interviewed six months after the in-person meetings. Students were interviewed the summer before their first and second years of graduate school. The interviews before the second year were the focus of the study

A researcher read the coach interviews and extracted details related to "strategies to engage," "perceptions of individual students," "perceptions of student engagement," and "self-assessment." These data were used to construct a profile for each coach, and the coaching style was based on the profile content. In addition, previously coded student interviews were analyzed with particular attention to those within "relationship with coach." A summary of the students' evaluation of their coach was created, from which nine measures of coach effectiveness emerged. Womack's study focused on coach effectiveness as measured by "usefulness."

One key theme that emerged in the coaching profiles was the degree of proactivity in engaging individual students. One difference, for example, involved student-driven discussions versus coach-driven discussions. Another difference involved the proactivity of a coach toward individuals and toward the coaching group.

Womack identified four coaching styles: high proactivity toward individuals, low proactivity toward individuals, high proactivity toward coaching groups, and low proactivity towards coaching groups. For example, coaches were considered to be high proactivity if they reached out to students and low proactivity if they waited for students to reach out to them.

In the analysis, four coaches were highly proactive toward individuals, three had low proactivity toward individuals, and two were moderate in proactivity, with one coach being unable to participate in the six-month interview. At the group level, six were highly proactive and the other three were low in proactivity.

Across coach styles and student responses, coaches were perceived as useful, especially when they provided encouragement and detailed feedback on research proposals. The latter was seen most frequently with female underrepresented minority students. Students with a high proactivity coach (for individuals or the group) talked more to their coach about stressful situations than those with low proactivity coaches. Students with low proactivity coaches stated that they wanted to have more interaction with their coach and coaching group.

Womack read several quotations from students that provided a qualitative sense of coaching effectiveness. For example, one underrepresented male student said, "My coach found out I didn't pass my qualifying exams the first time. [My coach] helped me devise a plan of attack so I could go ahead and do well the next time around. She made me realize some flaws that I needed to work on and suggested that I not spend so much time in the lab and focus on the examination, which I have. She actually took time to sit me down and lecture me a little bit, which was good. She needed to provide constructive criticism essentially."

Another student, a well-represented female student said, "I probably would have broken down [without the assistance of her coach]. I know my first year I was getting to the point where I wanted to quit. Like I honestly was going to drop out, but just having Coach X there to talk to made it better for me. And then the second year, none of my problems were serious enough for me to think like 'Okay, I'm just going to quit this. I'm not going to do it anymore.' I honestly don't know where I would be if she wasn't there because I don't know who I would have talked to, because I honestly don't have anybody else to talk to in that regard. Maybe I could have just reached out to my peers if I just had to, but she was there and I never had to do that."

Finally, an underrepresented female said, "With the whole mentor situation, I talked to my coach. He definitely helped me out a lot. I had to retake some of my classes from my first year over again. And he again helped me tremendously with that and just telling me that it's going to be okay and making me feel that I do deserve to be here, and that I am meant to be here."

In summary, said Womack, coaches were perceived as most useful when they were proactive, available, provided resources, gave feedback on proposals, and offered emotional support. Coaches who actively reach out both to individuals and their coaching groups, as opposed to waiting for the students to contact them, can provide critical support for students. These results could help with the training of coaches during the next iteration of the coaching groups.

STUDENT MENTORING IN A COMMUNITY COLLEGE SETTING

Eugenia Paulus, professor of chemistry at North Hennepin Community College, discussed mentoring strategies that she has found successful over many years of working with students. Successful mentoring leads to increased retention, improved student learning, and enhanced student achievement, she said, and it starts the day that the course commences. "Preparing students for successful careers should be part of every educator's job," she said. Mentors are not only teachers; they are advocates for the students they mentor.

The mentor–mentee relationship is established when the student sits down with the mentor and discusses personal goals. The first task is to create a Plan A and a Plan B, with a timeline, mapping out where the student wants to go and how to get there. Paulus explained that once a road map is established, she does periodic reviews with students to see how well they are doing.

Networking is also essential, and mentors can help their students tremendously by coaching them on networking strategies and helping make connections and useful contacts. For example, Paulus takes her students to scientific meetings and science fairs to introduce them to her colleagues.

Presentation and interview skills are another piece of the puzzle. To combat the complaint from students that they do not have time to practice, Paulus records their laboratory report presentations in her class and lets them review their own performance. The quick videos she takes on her iPhone are enough to give students momentum toward improving their presentations, and the reports help them get comfortable talking in front of an audience.

Experienced alumni mentors are another way of helping students achieve their goals in STEM fields. Paulus asks every student who requests a letter of recommendation from her to come back once a year and speak to her current students. Some alumni can even provide opportunities for job shadowing or internships with their employers.

Paulus's students have peer mentors, who provide advice on classes to take or pathways to follow and offer information on available resources or methods of study. This is one way in which mentoring creates a strong and vibrant community of scholars.

Paulus acknowledged that mentoring can be time-consuming, her mentoring expands her personal network, she said, and the success she sees in her students is fulfilling personally and professionally.

6

Gender-Based Interventions

Another area of focus during the 2015 conference was gender-based interventions. As with other underrepresented groups, women have strengths on which interventions can build to increase their success in STEM education and careers.

THE LATINA STEM PATHWAYS TO THE PROFESSORIATE: FINDINGS FROM PRESIDENT'S POSTDOCTORAL FELLOWSHIP PROGRAM INTERVIEW STUDY.

The goal of the institutional transformation grant at the University of California, Davis, is to establish an institution-wide inclusive STEM climate that values diversity and promotes STEM career advancement for women and other underrepresented students. A major component of the grant is to understand the barriers to careers in academia and the reasons why students might choose to leave the academy after graduate school and go into a different career. Yvette Flores, professor of Chicana/o Studies, and graduate student Lisceth Brazil-Cruz at the University of California, Davis, described one arm of the research program and its results.

An interdisciplinary team of researchers has set out to investigate the career paths of former Latina University of California President Postdoctoral Fellows (PPFP) in various STEM disciplines between 1998 and 2014. Of the entire pool of 537 women, 58 are Latinas, of whom 23 did their postdoctoral fellowships in core STEM fields. As of the conference, the researchers had interviewed ten of these women, in addition to nine other women in the social and biological sciences. Semi-structured, in-depth interviews ranged in time from one to two hours. Questions covered the women's background, early education, experience of their postdoctoral fellowship program, their career paths after completing the fellowship, work environment, work–life balance, and future goals. Using the grounded theory approach to qualitative analysis, the researchers generated narrative representations of themes and patterns.

One of the themes that emerged is resilience, said Flores. Despite the micro- and macro-aggressions they faced, the women received enough structural and programmatic supports to persist. "These women are extremely resilient," said Flores, "and we want to understand that better."

Among the programs identified as valuable in helping women stay in career programs in STEM fields are the Maximizing Access to Research Careers (MARC) program, the Minority Biomedical Resource Support (MBRS) program, and various bridge programs among institutions. For example, said Brazil-Cruz, several of the women had been in community colleges between three and ten years before they transferred to a university. In those cases, the University of California Transfer Agreement Program and Transfer Agreement Guarantee were essential for their successful transfers.

Another theme that emerged was the creation of a community of scholars through the President's Postdoctoral Fellowship. This program helped level the playing field for vulnerable scholars by demonstrating that they can be members of a scholarly community and speak the same academic language. These supports are especially crucial for those who are the most disadvantaged, such as first generation women of color. Many of the women in the program also were mothers, and the mentoring and other supports they received helped them balance their obligations to their families and their careers. "Developing that identity for them has been very crucial, to see themselves as a scientist and to be called the scientist by somebody else," said Brazil-Cruz. "This is essential."

Mentors with similar cultural backgrounds were important to many of the scholars. Such mentors can understand the cultural context with their families and the broader society and help them create an identity within that context. Many of the women scholars did not have family members who could help them navigate institutions of higher education. "It was astonishing to interview these women and to hear that they had been in a community college for ten years, and they still persisted and are now STEM faculty at a major university." Especially critical were peer mentors who had gone through similar experiences and could offer advice, including the suggestion of applying for the fellowship.

The President Postdoctoral Fellows are provided with five years of funding at a University of California campus, which makes them very attractive to any university in the system. Nevertheless, some of the women decided not to go into academia for various reasons, Brazil-Cruz pointed out. One reason was the much higher salaries they could command in industry. Some started their own consulting businesses. In some cases, partners and children made their lives more complicated. More information at earlier junctures in their education, said Brazil-Cruz, could help them realize that "It's okay to become a mother, you can still go into science" or "it's okay for you to be pregnant or to have a child when you're in the job market, because there're now policies to get around that."

"There is no right path," Brazil-Cruz concluded. "All the women have very different life trajectories." But all of them had had life experiences that built their resilience and helped them succeed. The researchers are continuing to explore these experiences and the light they shed on career success.

LATINA RESILIENCY: DEALING WITH CONTEXTUAL MITIGATING FACTORS IN PURSUIT OF STEM CAREERS

Three years ago, Alejandro Gallard, Goizueta Distinguished Chair of Education, Department of Teaching, Learning, and a team of researchers from Georgia Southern University started a study to investigate what produces success in STEM fields for Latina students. "While there has been an increase in success among Latinas, their level of accomplishment in a male-dominated world should not be romanticized; rather, given the odds of overcoming the many obstacles faced along the academic and professional paths, Latinas' successes must be highlighted," Gallard said. Latinas struggle to maintain a sense of balance between professional aspirations in STEM fields and the multiple socio-political contexts in which they live. Considering Latinas as a homogeneous group often overlooks these rich and distinct contexts. Through a series of case studies where individual stories were collected and analyzed for general patterns, Gallard and his team aimed to understand the factors that contribute to individual Latina success.

Gallard and his team were careful in defining the terms of their study. They did not use the word persistence, which has connotations that if a student works hard enough, he or she will succeed. Rather, they examined positionality and resiliency. Positionality is when a person acts in a certain way because they are responding to cultural, political, and social contextual factors that define a person. Gallard gave an example from his experiences working on a project in Miami, where he noticed that males and females typically had different rationales for doing different things. When men were late for work, they often blamed traffic, whereas women often cited family issues. Women were relegated to the traditional role of wife and homemaker, while men had the privilege of more independence.

Gallard and his team also formulated a new definition of resilience. "We think it's a form of emancipatory consciousness," he said. "You can't be resilient unless you really understand that there are contextual factors that are against you. It is a form of liberation where an individual self-determines how they navigate . . . and how to sustain their positionality within various contexts."

In Gallard's definition, resilience is a personal, individual attribute. "Everyone is resilient in their own particular ways, because they arrive at understanding in their own ways," he emphasized. Resilience's very existence indicates the existence of societal inequities that target people because of who they are. At the beginning of the study, Gallard and his team wanted to learn whether resiliency was a property or a right of an individual, whether some people had to be more resilient than others, and whether notions of meritocracy and competition are applicable only to those who have valued cultural capital. While their team is not anti-meritocracy or anti-competition, they recognize that these are not the solutions for everything. "We need to recognize that the results of meritocracy and competition are determined by cultural capital," Gallard said.

Sixty Latina females who were doing well in STEM fields at a high school level, university level, and professional level were asked to participate in the study. Three interviews were conducted per participant, and interviewers took note of participants' tone of voice and the looks on their faces as they spoke.

The study was particularly interested in examining the connection between positonality and resiliency, and whether Latina success could be determined by these factors. Specifically, the researchers looked at developmental contextual mitigating factors, which are not variables, but rather factors that continually influence and position people. People are positioned in society because of the deeper realities associated with cultural, economic, historical, and social factors, Gallard said. One large-scale example of a cultural mitigating factor is how, by elementary school, most females are already dissuaded from a path that will lead to a STEM career. Even for those who follow a STEM pathway, the paradigm has shifted so that educators aim to develop scientists rather than scientifically literate people. The education system has become so complex that often educators are forced to cater to the least common denominator rather than addressing students' personal experiences.

To understand how to create successful education programs, it is necessary to delve beneath the surface, Gallard said. Students who attend a two-year community college have a 68 percent less chance of getting into a medical school than students from a four-year college. And when you look at who is attending community college, it is often first generation students who can struggle in STEM courses due to contextual mitigating factors.

Ultimately, a systemic change is necessary, he said, involving a deep awareness and appreciation that those who are underrepresented can succeed, but not because society is necessarily improving. Contextual mitigating factors cannot be used as reductive variables but rather as agents that position people in disempowered stations. "I work with students instead of on them in ways that both affirm and open new and productive ways to participate in their attainment of emancipatory consciousness," said Gallard. By gaining awareness of their own contextual mitigating factors, students can connect their personal experience to wider purposes and begin to question institutional practices as well as reflect on individual experiences and redirect behaviors toward personal goals.

Educators need to have the patience to allow students to learn through their personal contexts. A combination of problem-based learning as opposed to traditional lecturing should be used to meet the spectrum of needs within a classroom, and educators need to help students develop the tools that will help them attain personal resiliency. Above all, teachers need to shift their mindset from working on their students to working with what they bring to the classroom.

SUCCESS STRATEGIES FROM WOMEN IN STEM: A PORTABLE MENTOR

An important question often asked by aspiring professionals in STEM fields is: "What are the important skills that I need to climb the ladder while successfully managing my career, both academically and professionally?" According to Christine Grant, coeditor of the book *Success Strategies for Women in STEM: A Portable Mentor*, mental toughness, personal style, networking, mentoring, transitions, time stress, leadership, balance, and negotiation are all core skills required to succeed in STEM fields (Pritchard and Grant, 2015).

Grant emphasized the importance of cross-cultural mentoring and asked participants about their own experiences being both a mentor and a mentee. She said that everyone should have a portfolio of mentors, not just one mentor, because what they need will change over time. Sometimes those mentors will have obvious programmatic connections, but Grant pointed out that often the best mentors come through unofficial channels. She encouraged everyone in attendance to seek out alternative mentoring if they felt their department was not providing the support they needed.

Mentors can learn from mentees as well, she said. After a time the mentoring relationship often becomes a peer relationship as the mentee's career advances.

Grant presented some feedback from mentees on the good and bad parts of mentoring that she collected at various meetings. Respondents believed that a good mentor will champion and foster a mentee's goals, give honest feedback, help problem-solve, share good opportunities, and celebrate a mentee's success. A good mentor should make time to meet, should recognize when they do not have the necessary knowledge to mentor on a specific topic, should always be respectful, and should never discourage a mentee or limit their ambition.

Grant touched briefly on the mechanisms for mentoring: assigned mentors, cluster mentors (mentoring a group together), naturally occurring mentors, and peer mentors. Grant also discussed the points made by the coeditor of her book, Peggy Pritchard, of North Carolina State University, in a chapter on mental toughness. Students need strength of will, mental agility, awareness and mindfulness to help them be successful. Women can develop these skills through career and personal and professional development, but institutional infrastructure is also important and may need to change. "One could argue that institutional change is fostered by leadership, informed by beneficiaries and implemented through allies, and that's critical for change to occur," Grant said.

She invited participants to work in groups on an intervention that they would want to see implemented at their institution, using a model with those three groups: beneficiaries (women and underrepresented minorities), allies (faculty, mentors, program leaders), and leadership. "How can the beneficiaries engage the allies and educate the leaders without putting themselves at risk?" she asked. For allies, how can they connect with the beneficiaries and represent interventions to organizational leadership? And how does the leadership develop an authentic partnership with the allies and participate in an intervention that will benefit the entire institution?

Grant argued that interventions are often very siloed, and encouraged the workshop participants to think about obstacles and opportunities with their proposed intervention. "There is a tug of war between the obstacles and opportunities," she pointed out, asking the workshop groups to think about which would come out on top. Having a great intervention is not enough, she said. It is important also to consider how to get it noticed, how to get more people involved, and how to get through potential roadblocks.

When thinking about opportunities, Grant said, the question is what the different groups need in order to actually effect change. She presented an example of non-tenured faculty at North Carolina State University, who are primarily women. That group was feeling disempowered and isolated, because only tenured faculty had voting power.

As the associate dean of faculty advancement, Grant was able to manage conversations between these groups and also influence new policy at the university to help non-tenured faculty. She found that non-tenured faculty did not believe they could get promoted, but once they saw the potential of the promotion process, they felt more empowered and more positive.

Grant also asked the workshop groups to consider what the different groups (allies, leadership, and beneficiaries) could learn from each other and how to pull obstacles into the realm of opportunity. "I'm hoping that the process we went through has enabled you to start thinking about interventions differently," she said.

Finally, Grant addressed the issue of time pressure, which is one of the biggest barriers to successful interventions. She said that the biggest benefit is finding a way to make a program a win-win for everyone involved.

7

Tools for Interventions

A final topic of emphasis at the 2015 conference was the wealth of tools available to those who are both implementing and studying interventions to broaden participation in science careers. A particular highlight was the unveiling of the UI Index, with other sessions devoted to the exploration of measures used to gauge effectiveness.

THE UI INDEX

The Understanding Interventions Index (UI Index) is a set of resources that has been integrated into the UI website. Intended as a resource for the members of the UI community, it provides background information about broadening participation and diversity efforts, citations to the scholarly literature related to education and career interventions, published evaluation instruments, and access to policy-relevant reports. Information can be searched and categorized according to one's interests. According to Tony DePass, associate dean for research and associate professor of biology at Long Island University–Brooklyn. "The UI Index is a major resource for those who are coming from practice and want to learn more about the scholarship, and for those who are coming from scholarship and need to understand context."

The creators of the UI Index demonstrated the first resource that is available for users. This resource, currently labeled "UI Annotated Bibliography" is a searchable database of articles related to understanding interventions. Users of the UI Annotated Bibliography can conduct searches by the title of the publication, the author(s), the title of journal in which an article appears, publication year, or keywords. For example, explained Angela Ebreo, associate director of the Diversity Research and Policy Program (DRPP) and an associate research scientist at the University of Michigan's National Center for

Institutional Diversity, users can search for all the articles related to gender, to underrepresented minorities, to a particular researcher's name, or other terms of interest. The developers of the Index are also categorizing entries in the Index into such categories as empirical and non-empirical, types of publication, and whether articles describe evaluations, measures, or some other topics. Copyright issues are still being resolved that will allow users to see abstracts and full-text versions.

A second searchable database covers the 300 or so journals encountered in putting the Index together, so that users of the UI Index can identify journals that contain material related to topics of interest or find journals that may serve as outlets for publishing the user's work. The UI Index may eventually provide an annotated list of other bibliographies that complement the work being done by the UI community, along with a list of organizations and professional societies involved in these areas. The resources contained in the UI Index will continue to be expanded and refined in part through inputs and feedback from the user community, Ebreo said, and members of the community can submit publications to the Index that should be included.

Constructing the UI Index turned out to be more complex than expected, said DePass. The journals containing articles of interest were spread across a wide range of scientific disciplines. Many of the people within communities of practice are in the life and physical sciences and are less familiar with the procedures and language of interventions research. Some work is focused on the biomedical and biobehavioral sciences, while other work extends to STEM education or education in general. Also, the work is often more academic and less translational, whereas communities of practice need work that can be applied to the issues they face.

At the conference, attendees at a workshop on the UI Index were invited to offer suggestions for adding to and elaborating on the Index. Among their ideas were the following:

- Including white papers published by professional associations and other organizations
- Including summaries and reports from relevant meetings
- Listing programs at different educational levels, including K–12 educational programs
- Increasing the number of search terms to include, for example, specific research instruments and methodologies
- Adding dissertations related to understanding interventions
- Including earlier literature, including the seminal works on which much interventions research is based today
- Adding hyperlinks to authors' other works
- Including links to other websites that provide similar resources
- Appending commentaries to entries describing possible uses of that resource
- Including funding resources and opportunities for interventions research

INTERPRETING MEASURES OF EFFECTIVENESS

The ultimate goal of many of the programs discussed during the Understanding Interventions conferences is to increase the diversity of those in the PhD ranks, which typically has been translated as the number of underrepresented students entering doctoral programs by the end of a program's funding period. Grant reviewers and programs have relied mainly on this metric to determine a program's effectiveness.

Yet this number remains relatively low. One of the plenary sessions at the conference explored issues involving these interpretations of efficiency. Are the right questions being asked? Is the character of programs being misinterpreted based on the data used? Are different metrics needed that better reflect institutional differences and the needs of students?

As explained by DePass, the sciences are actually better than many other fields at producing doctoral degrees among women, given the number of men and women who receive undergraduate degrees in these fields. For example, engineering-related fields produce 11.5 doctoral degrees per 100 undergraduate males who receive engineering-related bachelor's degrees, while 19.1 women receive doctoral degrees for every 100 undergraduate women who receive degrees in these fields (Flaherty, 2014). Even though the overall numbers of women receiving these degrees are relatively low, the "efficiency" of degree production is higher for women than for men.

DePass also pointed to the role of historically black colleges and universities (HBCUs) in providing pathways to STEM PhDs. As noted often at Understanding Interventions conferences, African Americans make up 12 percent of the U.S. population and 11 percent of all undergraduate enrollments. However, they receive only 9 percent of STEM bachelor's degrees, 7 percent of all bachelor's degrees awarded in the biological sciences, 6 percent in the physical sciences, 5 percent in mathematics and statistics, and only 4 percent of the bachelor's degrees awarded in engineering. HBCUs constitute only 3 percent of institutions of higher education in the United States, yet they produce 19 percent of all bachelor's degrees in science and engineering awarded to blacks in 2010 (Gasman and Nguyen, 2014). Approximately one in three black students who earned bachelor's degrees in mathematics and statistics attended HBCUs, as did 37 percent of all black undergraduates who received bachelor's degrees in the physical sciences.

HBCUs also are strongly overrepresented in terms of the number of students who go on to earn PhDs, said DePass. Among black STEM PhD recipients who earned their degrees between 2005 and 2010, more than one-third were conferred their undergraduate degrees by an HBCU, and 12 percent earned their doctorates at an HBCU.

These statistics demonstrate that efficient mechanisms do exist for converting bachelor degrees into doctoral degrees for women in STEM and for producing black undergraduate and PhD degrees in STEM fields. The question is how these results translate into policy, said DePass. "Where should we be spending money? Should we be trying to squeeze more blood out of the stone by holding institutions more accountable to produce more PhDs, or should we take advantage of these engines and . . . look at things like retention, graduation, and broader issues?"

One way to answer these questions is to identify the strengths of programs and individuals and build on these strengths, said DePass. For example, the ability of HBCUs to produce students who earn PhDs in STEM fields could be studied more deeply and the lessons learned applied more broadly. However, HBCUs today have fewer resources to do such studies than they have had in the past, he added.

DePass also noted that institutions have not sufficiently documented what they have been doing, which is one reason why people have not learned as much as they could have from past successes and failures. "That's why it's so important for us to make sure that those institutions that have something to say and contribute come to this table and say it. And hopefully that would mean that they got access to other tables where decisions" are being made.

THE SHAPE OF THE DISTRIBUTION CURVE

At the conference, Clifton Poodry received the 2015 Understanding Interventions Intervener Award in recognition of his long-term sustained support of research, policy, and practice that creates organizational opportunities for individuals to prepare for and ascend to careers in science.

In his remarks at the conference, Poodry emphasized the shape of the distribution curve for degree production. Many papers talk about improvements in terms of averages, which is important, but "the average might not tell me what I need to know about the shape of the distribution." Many of the people who go on to earn PhDs come from the right tail of the distribution curve, and changing the average does not necessarily change the number of people in this part of the curve. For example, American Indians graduate from high school at a rate of about 50 percent. Therefore, one possible strategy to increase PhD degree production among this group would be to increase the high school graduation rate from 50 percent to 60 percent. But that step will not necessarily increase the number of American Indian students who pursue PhDs. Instead, it may be necessary to work more directly with students who are more likely to go on to graduate school.

In that regard, Poodry has been examining research on identifying gifted and talented students and developing their skills. Less is known about developing talent than selecting talent, he observed, but both areas could yield insights that could change the motivations and values of those who develop and implement interventions.

Poodry emphasized the importance of learning from other social programs and from past programs, even if they were not initially successful. Many programs that are being suggested today have been tried in the past. Were they successful when tried before? If not, what were the reasons for their failures? "Perhaps there are good ideas that can be retrofitted, or perhaps some of the ideas that we think are terrific today really have been done and shown not to be the best thing."

Finally, he described a problem with incentives, which is that an incentive may produce good results while it is being offered, but the results can disappear when the incentive is gone. "If we believe that incentives are necessary to motivate a change, then we really have to think about how to sustain that in the long term or to look for other ways of providing that kind of motivation."

COOPERATIVE ONLINE LEARNING TOOLS FOR MIDDLE SCHOOL SCIENCE

For the past four years, a team at the University of Oregon has been working on the NSF-funded Collaborative Online Projects for English Language Learners in Science (COPELLS). Through an interactive process of development, implementation, revision, and evaluation, the project aims to design and test a collaborative online learning science curriculum for middle school students.

The formulators used a design-based approach with two case studies, a feasibility study, 212 students, and 10 teachers to determine the potential of adapting two online science units, originally developed in Spanish by curriculum developers in Mexico, for U.S. middle school English learners. Two science units were originally tested—"Let's Help Our Environment" and "What Your Body Needs"—to determine their use in helping teachers engage with students and their effectiveness in improving science knowledge. Data collection from teacher logs, student and teacher surveys, web analytics, student notebooks, content assessments, and focus groups have allowed COPELLS to continually evolve.

The project used a design-based research approach to bring together practitioners and researchers to develop effective interventions in education, explained Fatima Terrazas-Arellanes, a research associate at the Center for Advanced Technology in Education at the University of Oregon and one of the leaders of the project. This model also enabled teachers and students to provide valuable input as the project was implemented. The intervention was tested on English language learners who had just come to the United States and had entered middle school with no English background. The online curriculum is bilingual, with the entire content available in both English and Spanish.

Research on the project had four phases. In the first phase, developers analyzed the practical problems for researchers and practitioners. "The key issue that we saw was that English language learners lack knowledge of the academic English and science vocabulary," said Terrazas-Arellanes. "They have a harder time learning science because they don't have the English that they need." In addition, the literature suggests that cultural relevance is important for English language learners. "We wanted to provide a curriculum for English language learners that was going to be relevant for them, that made sense based on the culture they had."

In the second phase of the project, the team worked on developing solutions to these problems. Students could listen to the curriculum with text to speech, and the curriculum's vocabulary was supported by term definitions and translations. Students also could take notes and highlight passages while using the curriculum.

The third phase of research included interactive cycles of testing. The program was tested and improved repeatedly until effective design principles were formulated in an interactive process. In the project, the stages of the curriculum are like the chapters in a book, allowing for easy navigation. However, the content is not a science textbook put online. The content is specifically designed for online teaching, and the intervention has been adapted to follow the Next Generation Science Standards. "We are hoping that it's going to lead to a student construction of science knowledge so the students are going to have higher outcomes in science" while also improving their academic English, Terrazas-Arreles said.

The fourth phase focused on reflection to produce better design principles and enhance solutions for implementation. As the project developed, teachers and students were highly satisfied with the results. In the second case study with two teachers, there were significant gains from pre to post tests. In the first unit, "What Your Body Needs," students learned about body systems and how to be healthy. The second unit, "Let's Help Our Environment," met environmental science high school standards. After the completion of the environmental unit, general education students increased their scores by 17 percent points, and English learners increased by 14 percent points. The small percentage difference reveals the effectiveness of the unit since it worked equally well for native English speakers and English language learners, Terrazas-Arreles observed. The other unit saw even larger gains, but the projection was better for the general education participants compared with the English language learners. General education students increased their scores by 45 percent points and English language learners by 27 percent points.

The team at the University of Oregon recently received a grant from the Office of Special Education with the aim of creating an entire online middle school science curriculum. They are conducting a randomized controlled trial where they hope to find that the treatment group outperforms the control group. This is a longitudinal, large control study being conducted with 13 schools using the whole curriculum from sixth to eighth grade. The new project is called ESCOLAR and is free for anyone to access. There are three units: a life science unit on the body, an environmental science unit, and an air and space unit. Although the course is based online, students have to create models in all of the units. For instance, in the air and space unit, students must make a model of the moon phases. They collect data on moonrise and moonset at the start of the project and use that data to learn about the phases. At the end of the assignment, students present their models online.

All of the content is designed from scratch, but online resources are sometimes borrowed. Both COPELLS and ESCOLAR require a lot of time and money to design and implement. However, the online science units have been shown to be feasible to implement, usable and helpful for both teachers and students, and associated with gains in science content knowledge. The project offers a model for development of culturally relevant, constructivist, and collaborative science instructional materials for English learners using online, multimedia technology. "The value that teachers and students and all of the people involved provide to us in the design of this curriculum is critical in creating innovative interventions" Terrezas-Arreles concluded. This is a good model for thinking about how to redesign and conduct research, particularly in this era."

DEFINING THE QUANTITATIVE AND COMPUTATIONAL SKILLS OF INCOMING BIOLOGY STUDENTS

A student's quantitative and computational preparation correlates with persistence and success in the life sciences, noted Paul Overvoorde, professor of biology at Macalester College. Unfortunately, among the students who take the ACT entrance exam, only 43 percent achieve a score that indicates that they have a 50 percent chance of earning a grade of B or higher in their first college-level mathematics class. More disconcerting is that only 17 percent of high school students with an expressed interest in a STEM are considered math proficient by these standards, and this percentage is even lower for underrepresented minority students.

With funding from the Howard Hughes Medical Institute, faculty from Macalester College, Bryn Mawr College, Oberlin College, Lewis and Clark College, St. Olaf College, Harvey Mudd College, Pomona College, and Keck Science Center, along with faculty and graduate students in the Educational Psychology department at the University of Minnesota, formed the Q6 consortium. The goal of the Q6 group is to develop an assessment instrument that describes the quantitative and computational skills of students working on degrees in biology or closely allied fields.

Starting from the knowledge domains and learning objectives described in several key reports, the consortium has developed, piloted, and refined a 22-item instrument called the Biology Science Quantitative Reasoning Exam (Biosquare). The instrument measures such things as the ability to visualize data, apply appropriate statistical analyses, generate mathematical models, and demonstrate basic algebraic skills, with an emphasis on issues that are more important for biologists than other STEM students. Testing has demonstrated that the instrument "has a nice distribution for separating students who are going to be well prepared versus less well prepared," said Overvoorde, even among the top students in the small liberal arts colleges that are members of the consortium.

Biosquare serves at least three purposes, said Overvoorde. First, for students, Biosquare communicates expectations for success in upper level courses and serves as a tool to direct students to relevant resources if they lack background or knowledge of a particular topic.

Second, for faculty, Biosquare provides data on what students know, as well as when and how they gained that knowledge, allowing faculty to make intervention decisions based on evidence, rather than anecdote.

Finally, at the programmatic level, Biosquare highlights the skills biology instructors consider to be important, providing a framework to inventory and assess current curricula. "Do we agree that these are the core concepts? Where in our curricula are these ideas being presented? Are the people down the hall or across campus dealing with the math, the statistics, and the computer science that underlie all these analyses and visualizations? Do they know that these are the things we think are important?"

Overvoorde concluded with some reflections on what is required to keep a consortium such as this together. An important aspect of this issue is that it is shared across campuses. Working on the issue together also allowed for the building of relationships, networks, and mutual trust. However, maintaining the consortium requires having enough funding to get people together periodically, he said. "If you're not face to face at least a couple of times a year, these efforts tend to fall apart quickly."

CHARACTERISTICS OF EXCELLENCE IN UNDERGRADUATE RESEARCH: A FRAMEWORK FOR BEST PRACTICES

"Characteristics of Excellence in Undergraduate Research" (COEUR), developed by the Council on Undergraduate Research (CUR), is a summary of best practices that support and sustain highly effective undergraduate research environments at all types of institutions. COEUR is organized in sections that correspond to various functions or units of a typical college or university campus. Linda Blockus, director of the office of undergraduate research at the University of Missouri, discussed the different sections and some examples of how COEUR can be used.

Many institutions are working to formalize undergraduate research programs, she said, because data show that the undergraduate research experience is a high impact educational practice. The COEUR summary provides a framework for institutions and programs to discuss and self-evaluate the extent to which their environment supports this practice. It's meant to be a summary of best practices and a framework for discussion, Blockus explained.

The COEUR tool has 12 sections:

1. Campus mission and culture
2. Administrative support
3. Research infrastructure
4. Professional development opportunities
5. Recognition
6. External funding
7. Dissemination
8. Student-centered issues
9. Curriculum
10. Summer research program
11. Assessment activities
12. Strategic planning

Blockus described some of these points in more detail, emphasizing the need for resources and community support for both students and faculty involved in undergraduate research. Peer-to-peer interactions can maximize the research experience for students, she said. CUR believes that a summer research program is essential to maintaining a strong undergraduate research institutional culture and community and therefore is included in COEUR. The guidelines also emphasize that undergraduate research should be accessible to all students.

"Our feeling is that these 12 characteristics work together to create an environment that can be excellent for undergraduate research on a campus or in a program, whatever your locus might be," she said. The COEUR guidelines are not meant to be prescriptive. Blockus offered an example of a colleague who used the document to get funding for undergraduate research ambassadors. Others use it as a checklist for grant proposals.

A new annual award, the CUR Campus-wide Award for Undergraduate Research Accomplishments (AURA), recognizes higher-education institutions that have both successfully implemented some of the characteristics of excellence and have devised exemplary programs to provide high-quality research experiences to undergraduates. The depth and breadth of the institutional commitment to undergraduate research as well as the innovative nature of a sustained, exemplary program are important criteria for award selection.

Blockus gave attendees time to discuss their own programs in small groups and addressed several questions. She also mentioned the Council of Undergraduate Research consulting program, which can do campus-wide or department-wide evaluations and consultation of undergraduate research programs.

HARNESSING THE POWER OF LONGITUDINAL QUALITATIVE DATA

In this interactive workshop, the facilitators introduced methods and strategies for longitudinal qualitative research (LQR). They introduced LQR as a very powerful way to describe and explain change over time. Qualitative data from open-ended survey questions, in-depth interviews, focus groups, and even participant observation can help researchers understand the processes and factors that influence behaviors and decision-making. By collecting and analyzing qualitative data longitudinally, program evaluations and research studies are able to capture the complex factors and conditions that lead to a particular outcome, such as a career decision.

The most basic definition of LQR is as a method that explores change over time, explained Robin Remich, Research Associate at the Northwestern University Feinberg School of Medicine. The goals of this method are to describe and explore the how and why of observed change while considering contextual elements that might influence individual experiences. One major benefit to longitudinal qualitative approaches is the ability to capture a person's thinking and decision making *in vivo*, giving researchers a chance to understand more deeply the contexts, feelings, and thoughts that factor into people's decisions or actions.

When using longitudinal methods, Remich continued, an important question is how much time is adequate to address an issue and how to choose the intervals for data collection. These factors may change over the course of the study, she explained, but thinking about them beforehand has major benefits, particularly when trying to fund a project.

Remich's colleague Christine Wood discussed the different levels of change referred to by social scientists. The top level is macro-sociological change, which happens within a national context and applies to broad swaths of society. The middle or meso-level encompasses spheres between the individual and broader society and includes studies of organizations and communities. The third level is micro-sociological change, which happens with individuals or small groups such as schools or neighborhoods. "One thing to keep in mind when you're designing a longitudinal qualitative study is how these different levels may interact with one another," she said, giving as an example the influence of societal trends on individual students.

Another important factor is sample size and the longevity of your research team, Remich said. When collecting data through face-to-face interviews, an important factor is whether the same interviewers will be with the study long term, because keeping subjects in a study is often easier when they have a good rapport with researchers. She also suggested piloting questions and getting feedback before data collection begins.

Remich, Wood, and their colleague Remi Jones presented examples from their ongoing study, begun in 2008, which examines how the career intentions of PhD students in the biomedical sciences change over time. The study uses one-on-one interviews of about an hour and a half conducted annually with more than 200 participants. Students were enrolled in the study as juniors, postbaccalaureate, and first year PhD students.

Timelines and flowcharts are tremendously useful in organizing longitudinal data, Remich explained. These allow researchers to pull out snapshots of students at one point in time and also look at patterns within the group over time. Major events that provide context can be noted in the timeline data, such as the NIH funding sequestration and natural disasters, because these might have influenced students' experiences and actions.

Another tool that the researchers demonstrated is a coding rubric, which they used to organize and identify subgroups in their large data set. Remich and her colleagues used a scale from –2 to +2 to assess career intention at each interview for three kinds of academic careers (research-focused, teaching-focused, and research/teaching), industry, and other careers. The coding rubric served as a more quantitative way to analyze the data and to identify sub-groups for more in-depth qualitative analysis. After using the rubric, the researchers displayed their data using Excel and Adobe Illustrator to map career decisions over time. "This was a process for us to see possible patterns that we have with these 200 people that would allow us to ask interesting questions," Remich said.

At this point, Remich introduced the workshop participants to the work of Saldaña (2003), who proposes seven descriptive questions for interrogating longitudinal data effectively. These questions guide researchers to examine their data for instances of things such as what emerges, accumulates, and stays consistent over time, and when an epiphany occurs. The facilitators concluded the workshop by reflecting on the patience and multiple reading of data involved in longitudinal qualitative analysis and distributed an LQR methods resources list.

EVALUATION AS A TOOL TO STRENGTHENING PROGRAMS: A PRIMER FOR THE NON-EVALUATOR

Finally, DePass explained some of the reason for evaluating programs. Evaluation plays a critical role in determining how many program objectives have been accomplished. It helps determine if specific activities or approaches are contributing to a program's success. As STEM educators move towards more integrative and active modes of teaching and learning, evaluation can help them ensure that the experiences they are designing are leading to the intended student learning outcomes.

Evaluations should be considered from the beginning of a project, DePass explained. The first step is to identify appropriate and essential measures, and the measurements should be designed so that they do not themselves impact the program. "Simply because you can measure something doesn't necessarily mean it's important," DePass said.

As an example involving recruitment, DePass suggested that a program might go beyond the number of students recruited to measuring the success of different forms of recruitment, such as advertisements, mailings, or word of mouth. Knowing which avenue was most successful, he said, will help improve recruitment in the next go-round, either by abandoning weaker methods or by finding ways to make methods more effective.

Evaluations should be part of every grant proposal, he added, because they can help reveal if a project is well organized and realistic in what it aims to achieve.

Elisabeth Russell McKenzie, a program administrator at Temple University, discussed the use of logic models to build evaluations. A logic model begins by identifying the situation: the need a program is addressing, symptoms and problems, and which groups of stakeholders are most important. It then looks at the mission, vision, and goals of the program.

A model also needs to incorporate resources: funding, laboratories, programmatic support, materials, equipment, and people. The final piece is the intended outcomes of the project. In this last area, Russell McKenzie pointed out, time becomes a factor. Short-term outcomes happen quickly, medium-term outcomes are achievable within two or three years, and long-term outcomes look at the big picture and are aligned more with the vision for the project or program.

A logic model makes evaluation and planning easier by laying out framework and timeline for a program. For example, an implementation evaluation, which should happen shortly after a program begins, can take stock of whether all the expected resources are in place. A process evaluation can look at whether the program is working as predicted. An outcomes evaluation can determine whether the goals have been met.

"At the end of the day it's all about alignment," DePass said. Priorities, goals and resources all need to work together to give a program the best chance of success.

Both qualitative and quantitative measures have value, DePass explained, but whereas quantitative measures can be fairly straightforward, qualitative evaluation often seems more complex. He suggested looking for both interview and survey questions and other instruments that already have been validated. However, the groups used to validate a tool need to be similar to the group being evaluated.

The people who run the programs are not usually the best people to do qualitative evaluation, he added. Also, having some level of anonymity for survey respondents can be valuable in getting truthful responses.

DePass encouraged workshop participants to make sure that they disseminate the information learned through evaluations. Dissemination gives programs credit for adding to the body of literature and leads to a more disciplined approach to evaluation.

References

American Association for the Advancement of Science. 2011. *Vision and Change in Undergraduate Biology Education: A Call to Action.* Washington, D.C.; AAAS.

Bluestone, B., and A. Clayton-Matthews. 2013. Life sciences innovation as a catalyst for economic development: the role of the Massachusetts Life Sciences Center. Northeastern University: The Kitty and Michael Dukakis Center for Urban and Regional Policy.

Borden, V. M. H. 2010. The top 100 bachelor's degrees conferred. *Diverse: Issues in Higher Education.* 27(9):26-43.

Carlone, H. B., and A. Johnson. 2007. Understanding the science experiences of successful women of color: science identity as an analytic lens. *J Res Sci Teach.* 44(8):1187-1218.

Eagan, M. K., Jr., and C. B. Newman. 2010. Investing in human capital: underrepresented racial minorities' intentions to attend graduate school in STEM fields. Paper presented at the American Educational Research Association Annual Conference, Denver, CO.

Flaherty, C. 2014. Unequal all around. *Inside Higher Education*, October 1.

Girod, S., M. Fassiotto, D. Grewal, M. C. Ku, N. Sriram, B. A. Nosek, and H. Valantine. 2016. Reducing implicit gender leadership bias in academic medicine with an educational intervention. *Acad Med.* Jan. 27.

Gasman, M., and T. Nguyen. 2014. Historically black colleges and universities: leading our nation's efforts to improve the science, technology, engineering, and math pipeline. *Tex Ed Rev.* 2(1):75-79.

Humes, K. R., N. A. Jones, and R. R. Ramirez. 2011. Overview of race and hispanic origin: 2010. U.S. Census Bureau.

Pritchard, P. A., and C. S. Grant. 2015. *Success Strategies for Women in STEM: A Portable Mentor, Second Edition.* Waltham, MA: Academic Press.

Kahneman, D. 2011. *Thinking, Fast and Slow.* New York: Farrar, Straus and Giroux.

Lautenberger, D. M., V. M. Dander, C. L. Raezer, and R. A. Sloane. 2014. The state of women in academic medicine: the pipeline and pathways to leadership, 2013-2014. Washington, D.C.: Association of American Medical Colleges.

Mead, M., and R. Métraux. 1957. Image of the scientist among high-school students. *Science.* 126:384-390.

Mooney, G. M., and D. J. Foley. 2011. Community colleges: playing an important role in the education of science, engineering, and health graduates. NSF InfoBrief 11-317.

McMillan, D. W., and D. M. Chavis. 1986. Sense of community: a definition and theory. *Am J Commun Psychol.* 14(1):6-23.

Moss-Racusin, C. A., J. F. Dovidio, V. L. Brescoll, M. J. Graham, and J. Handelsman. 2012. Science faculty's subtle gender biases favor male students. *Proc Natl Acad Sci USA.* 109(41):16474-9.

National Science Foundation, Division of Science Resources Statistics. 2011. Women, minorities, and persons with disabilities in science and engineering. NSF Special Report 11-309.

Page, S. E. 2007. *The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools, and Societies.* Princeton: Princeton University Press.

Powell, W. W., D. R. White, K. W. Koput, and J. Owen-Smith. 2005. Network dynamics and field evolution: the growth of interorganizational collaboration in the life sciences. *Am J Sociol.* 110(4):1132-1205.

Saldaña, J. 2003. Longitudinal qualitative research: analyzing change through time. *Arts Learn Res J.* 20(1):201-205.

Slaughter, J. B. 2009. African American males in engineering: past, present, and a future of opportunity. In H. T. Frierson, J. H. Wyche, and W. Pearson, Jr., Eds. *Black American Males in Higher Education: Research, Programs and Academe.* United Kingdom: Emerald.

Tinto,V. 1975. Dropout from higher education: A theoretical synthesis of recent research. *Rev Educ Res.* 45:89-125.

Valantine, H. A., D. Grewal, M. C. Ku, J. Moseley, M. C. Shih, D. Stevenson, P. A. Pizzo. 2014. The gender gap in academic medicine: comparing results from a multifaceted intervention for Stanford faculty to peer and national cohorts. *Acad Med.* 89(6):904-11.

Wigfield, A., and J. S. Eccles. 2000. Expectancy–value theory of achievement motivation. *Contemp Educ Psychol.* 25:68–81.

Index