JUNE 2021

National Academies Reports on DIVERSITY, EQUITY, INCLUSION AND RACISM IN STEMM EDUCATION AND WORKFORCE

This paper was prepared in the context of the June 2021 National Academies of Sciences, Engineering, and Medicine summit, ***Addressing Diversity, Equity, Inclusion, and Anti-Racism In 21st Century STEMM Organizations***. It offers a synthesis[i] of relevant National Academies consensus reports that have been published since 2010 on the composition of STEMM graduates and the workforce, attrition and underrepresentation in STEMM, and strategies for increasing representation. A hyperlinked listing of the consensus reports that were used in this synthesis, along with related consensus reports dating to the 1970s, appears at the end of the paper.

Importantly, the National Academies' portfolio on underrepresentation in STEMM extends beyond these consensus reports to include numerous recent workshop proceedings and related activities. Some of those activities are briefly described in the final section of the paper. This paper is intended to serve as a working document that will further develop and change as the National Academies continues to build its portfolio, and as national conversations on diversity, equity, and inclusion in STEMM become more textured.

Reflecting the focus of the summit, this synthesis places its emphasis on undergraduate and graduate STEMM education and the workforce. However, it also includes some information from National Academies reports on relevant structural inequalities in the K-12 education system that contribute to later underrepresentation in STEMM and recommended approaches to address those inequalities.

The summit is addressing racial and ethnic groups historically underrepresented in the STEMM workforce, including Black/African American, Hispanic/LatinX, American Indian, Alaska Native, Asian, and Pacific Islander communities. While these populations are the focus of many relevant National Academies consensus reports, some relevant reports also address other underrepresented populations, such as women, LGBTQIA individuals, persons with disabilities, first-generation college students, and the socioeconomically challenged. Members of these different groups have different histories and experiences with STEMM, but they share the fact that the current culture and structure of STEMM places them at a disadvantage relative to white and Asian American males.

THE SCOPE OF UNDERREPRESENTATION

The underrepresentation of racial and ethnic minorities and other populations in science, technology, engineering, mathematics, and medicine (STEMM) courses, majors, and careers is problematic for the individuals who are excluded from STEMM, for STEMM disciplines and the scientific endeavor, and for society. This underrepresentation is the most tangible manifestation of structural, cultural, and institutional patterns of bias, discrimination, and inequity that begin before students enter kindergarten and continue through the life course.

[i]This synthesis has as its focus all the disciplines of STEMM but uses the specific language and focus of National Academies reports when excerpting those reports.

Underrepresentation in the science and engineering workforce stems from the limited number of minorities in science and engineering at every level of postsecondary education, with a progressive loss of representation as we proceed up the academic ladder.[1]

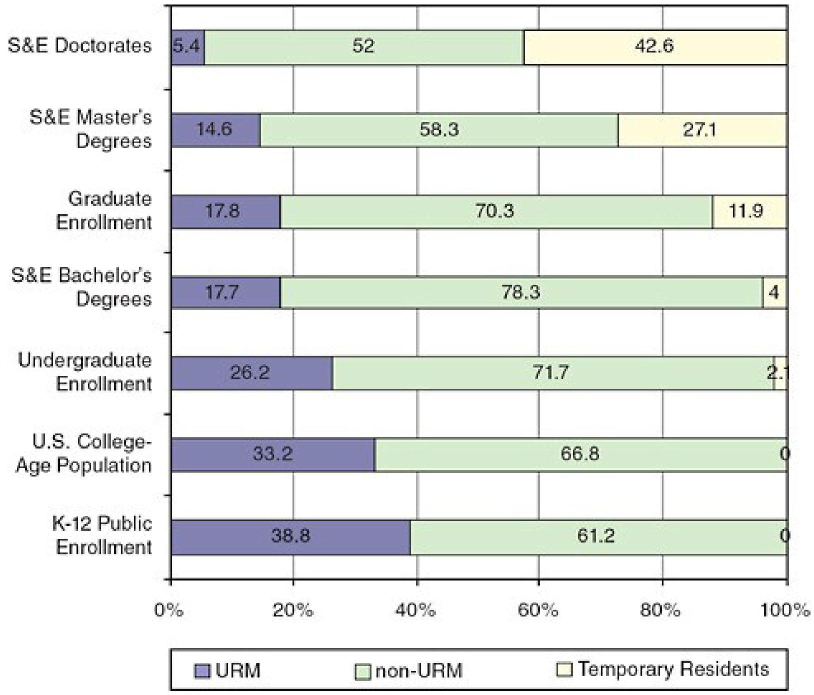

FIGURE 1 Enrollment and degrees, by educational level and race/ethnicity/citizenship, 2007.

SOURCES: NCES, Digest of Education Statistics, 2008, Table 41. NSF, Women, Minorities, and Persons with Disabilities, Tables A-2, C-6, E-3, and F-11. NSF, S&E Degree Awards, 2006, Table 3.

Figure 2-1 from Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads (2011).

Some key areas of underrepresentation in STEMM include:

- **K-12 STEM course preparation**. Mathematics and science course-taking in middle and high school not only prepares students academically for postsecondary STEM courses and majors, but it also builds students' identities as scientists and engineers. However, schools with large proportions of black and Hispanic students, English learners, and/or students in poverty typically offer fewer math and science courses and course sequences and fewer certified teachers in science content areas—particularly in physics and chemistry—than schools serving predominantly white and higher-income students.[2] Specifically[3]:
    - > High-minority schools (defined by the National Center for Education Statistics as 75 percent or higher black and Hispanic) are at least twice as likely to not offer higher level math and science courses and AP, International Baccalaureate, or dual enrollment programs as low-minority schools.
    - > High-poverty schools (defined by the National Center for Education Statistics as public schools where more than 75 percent of the students are eligible for free or reduced-price lunch); are at least 1.5 times as likely as low-poverty schools to not offer advanced coursework in math and science and to not offer AP courses or dual enrollment programs.

- **Completion of STEM degrees.** Undergraduate students who are female, Black, Hispanic, from low-income families, and single parents are as interested in STEM fields as their white peers. However, they have lower four- and five-year completion rates of STEM degrees relative to those of whites and Asian Americans. The degree completion rate for all STEM aspirants is less than 50 percent, with the lowest completion rates found among students from underrepresented groups (blacks, Hispanics, and Native Americans). Students from groups with low degree completion rates typically have the greatest economic need, are more likely to require developmental courses, and have few if any immediate family members who completed college.[4]

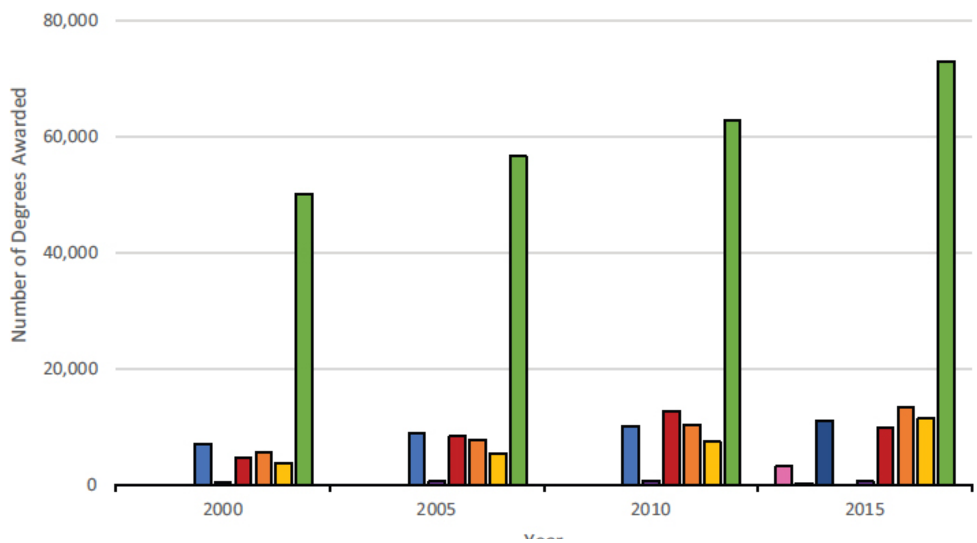

FIGURE 2 Detail of master's degrees awarded in STEM fields, for racial and ethnic minorities, 2000-2015, selected years.

NOTES: Asian or Pacific Islander was a category from 2000 to 2010. Starting in 2011, the two categories split into Asian and Native Hawaiian or Other Pacific Islander.

SOURCE: NSB, 2018e.

Figure 2-5 from Graduate STEM Education for the 21st Century (2018)

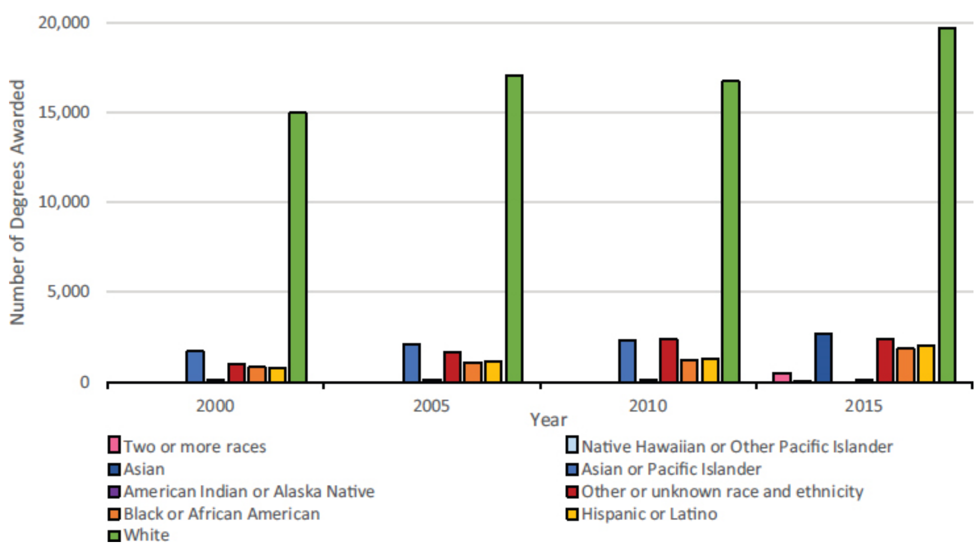

FIGURE 3 **Doctoral degrees awarded in STEM fields, by race and ethnicity, 2000-2015, selected years.**

NOTES: Asian or Pacific Islander was a category from 2000 to 2010. Starting in 2011, the two categories split into Asian and Native Hawaiian or Other Pacific Islander.

SOURCE: NSB, 2018e.

Figure 2-5 from Graduate STEM Education for the 21st Century (2018)

At the graduate level, underrepresentation is even more pronounced. Graduate programs do not attract or develop talent from all sectors of the nation's population; women and certain racial and ethnic groups remain underrepresented in many (but not all) disciplines.[5]

- **Representation in the workforce.** The attrition of STEM-interested and -qualified individuals continues into the STEMM workforce. More than 50 percent of students who complete a STEM bachelor's degree switch to jobs or graduate programs outside of STEM. Students from underrepresented populations in STEM are more likely to move on to fields outside of STEM than students from well-represented groups.[6]

  There has, however, been progress in expanding the participation of underrepresented populations in the STEMM workforce. For example, the percentage of our college-educated, nonacademic science and engineering labor force that is African American increased from 2.6 percent in 1980 to 5.1 percent in 2005, and the percentage that is Hispanic increased from 2.0 percent to 5.2 percent during that period. However, these percentages and the progress they represent remain small and insufficient, as African Americans comprise 11 percent and Hispanics 14 percent of the U.S. civilian labor force, and even higher percentages in the U.S. population. The proportion of underrepresented minorities in science and engineering would need to triple to match their share of the overall U.S. population.[7]

  Similarly, although the absolute number of women[ii] earning degrees across science, engineering, and medical fields has increased in recent years, women—especially women of color—are underrepresented relative to their presence in the workforce and the U.S. population. National patterns of underrepresentation vary by career stage, race and ethnicity, and discipline.[8]

MAJOR FACTORS CONTRIBUTING TO UNDERREPRESENTATION

The continued underrepresentation of racial and ethnic minorities and other populations cannot be explained by individual differences or inherent between-group differences in STEMM abilities or interest. Instead, it results from inequitable opportunities to learn and participate in STEMM and features of the current culture and structure of STEMM that systemically disadvantage members of these groups relative to White and Asian American males.[9]

These factors and their interactions are multiple, complex, and interrelated. This section highlights a few common, key themes from relevant National Academies reports.

Disparities in Access to STEM, K-12

The education children receive from preschool through high school is foundational and critical. For STEM, quality preparation is a prerequisite for later success. Yet at the K-12 level, access to a high-quality education in science and engineering remains determined in large part by an individual's socioeconomic class, racial or ethnic group, gender, language background, disability designation, or national origin.[10]

There are notable inequities within and among schools in terms of access to educational experiences that engage students in science investigation and engineering design, levels of exposure to STEM in K–12 schools and communities, and access to advanced coursework in middle and high school mathematics and science.[11] Many policies and structures tend to perpetuate these inequities, such as disparities in facilities and teacher expectations, experiences, and qualifications across schools and districts.[12] Likewise, tracking of students into fewer and less rigorous science and mathematics courses has excluded or marginalized many low-income and historically underrepresented students.[13]

Low learning expectations and biased stereotypical views about the interests or abilities of particular students or demographic groups also contribute, in both subtle and overt ways, to their curtailed

[ii]The underrepresentation of women in STEMM shares many features with underrepresentation of other groups in STEMM, including men of color, LGBTQIA individuals, persons with disabilities, first generation college students, and the socioeconomically challenged, in that the current culture and structure of STEMM systematically disadvantage members of these groups relative to White and Asian males.

educational experiences and inequitable learning supports.[14] Among K-12 students, an enduring perception persists of scientists as "old, white males working in a laboratory performing dangerous experiments," especially as the students get older. These perceptions mean that an ever-larger swath of the population does not see science as relevant to them or as including them.[15]

Unwelcoming STEMM Cultures

The culture that undergraduate students encounter when studying STEM has an effect on their interest, self-concept, sense of connectedness, and persistence in STEM. Many students encounter messages that success in STEM fields requires either natural ability in math or science or very early exposures to high-quality training, which tends to be associated with lower persistence among women and minorities. Academic cultures characterized by racial, ethnic, or gender stigma may lead students to assess those academic contexts as incompatible with their personal identities; they may thus dis-identify with or disconnect important aspects of their personal identity (e.g., self-esteem, self-concept, personal values) from the academic domain.[16]

Among all populations, students who enter college declaring that they are interested in pursuing STEM degrees but then decide to enroll in non-STEM majors most frequently do so after STEM introductory courses (or prerequisite introductory science and mathematics courses). These students turn away from STEM in response to the teaching methods and atmosphere they encountered in STEM classes. Indeed, many students who switch majors after their experiences in introductory STEM courses pass those courses. They may abandon their goal of earning a STEM degree due to the way that STEM is taught and the difficulty in attaining support. That support, such as tutoring, mentoring, authentic STEM experiences, or other supports, improves retention in STEM majors.[17]

The normative culture of STEMM can be a barrier for students from underrepresented groups. Not only does this culture include views of student ability as inherent or natural, related to one's genetics, and not amenable to improvement, there is a tendency for introductory mathematics and science courses to be used as "gatekeeper" courses. These highly competitive classroom environments may discourage students who are new to the fields, especially women and those from minority backgrounds. Students who persist often have to draw on personal, cultural, and co-curricular resources to counter messages about the nature of ability and stereotypes that they encounter in interactions with faculty and are embedded in organizational norms and practices.[18]

Discrimination and Racism

Social identities are defined by a common set of norms, attitudes, traits, and stereotypes that together form a "prototype," the typical or average representation of a group member. Individuals who deviate from this prototype—in STEMM, those individuals who are not White, male, heterosexual, able-bodied, middle-class and up, or otherwise historically represented as scientists—are more likely to be marginalized within the social group and not extended full membership. This marginalization, sometimes in the form of microaggressions, has the effect of barring underrepresented students from benefiting fully from opportunities afforded to members of more well-represented and prototypical groups. Because student experiences in STEMM contexts are highly contingent upon their social identities, marginalization in and ostracization from STEMM social groups can challenge the process through which emerging scientists who may not "look the part" develop a social identity as a scientist.[19]

While there have been improvements in diversifying STEMM training and education programs, many scholars point to the continuing effects of race and racism in STEMM, including reports of students feeling alienated, having to work twice as hard to receive recognition, and working under constant scrutiny and suspicions of presumed incompetence. These feelings may also result from implicit biases of mentors or fellow students, in which attitudes or stereotypes about underrepresented students affect how they are treated even in the absence of explicit racism.[20]

Many underrepresented students experience STEMM contexts differently than their peers whose identities are well represented, either because of persistent social and racial stereotypes or as a result of unclear communication from faculty regarding strategies for student success. More broadly, under-represented students' awareness of how society and schools position them as underachieving influences how they construct their career-related identities.[21]

Stigmatizing experiences—in the form of interpersonal discrimination from instructors, peers, administrative staff, and other staff —are a common occurrence for many racial and ethnic minority students, especially those in predominantly white college and university settings. This also occurs for women in STEM fields in which they are underrepresented. Stigmatizing experiences have been characterized as microaggressions: subtle or overt statements and behaviors that intentionally or unintentionally communicate devaluing messages about a group, including expressed low expectations. They are a source of educational inequality. Experiences of microaggressions can lead to feelings of invisibility: students feel as if they are viewed only in terms of stereotypes rather than in terms of their unique identities and characteristics. These feelings can lead to a decreased sense of connectedness and community within students' academic settings.[22]

Mentors and Mentorship

Mentorship has been shown to have benefits for underrepresented students. However, underrepresented individuals enrolled in STEMM degree programs typically receive less mentorship than their well-represented peers. Indeed, underrepresented students' mentorship requests for mentoring meetings are more often ignored by mentors than those of White men. Moreover, current mentoring systems are structured to benefit the prototypical STEMM mentee—White, male, heteronormative, continuing generation, and upper or middle class.[23]

How an individual's identity as a STEMM professional fits with an individual's other social identities, such as gender, race, or socioeconomic status, has a significant effect on their career goals. Many factors—including a lack of access to effective mentorship and a need to subsume other aspects of their identities to fit into a predominantly White, male STEMM culture—keep students from underrepresented groups from choosing and remaining in STEMM disciplines. Moreover, some negative mentoring experiences have been linked to attrition, especially for underrepresented students. Mentees without access to culturally responsive mentoring can experience identity interference or identity conflict and concealment, which is the perceived or actual discordance between different aspects of an individual's identity. This can lead to self-doubt, reduced psychological well-being, and lower academic or professional performance.

Many underrepresented students prefer to have mentors of the same race and gender and who have life experiences similar to their own. However, the scarcity of underrepresented STEMM faculty may lead underrepresented students to believe they cannot find safe spaces in which they can discuss their identities and interests. Mentors, regardless of race or gender, of underrepresented students who acknowledge their students' sociocultural-based experiences may be better able to help them to navigate invalidating experiences, affirm their belonging in STEMM contexts, and reinforce their self-efficacy beliefs. However, this may involve crossing cultural boundaries and often requires culturally responsive mentorship that involves mentors moving out of familiar and prescribed ways of interacting and communicating with mentees if they are to establish equitable, reciprocal, respectful, and honorable relationships.

"Benign racism" or "benign sexism"—referred to as the "mentor's dilemma"—can occur in mentoring relationships that cross cultural lines. In such cases, faculty members are less likely to provide tough, specific feedback to minority students due to concerns about appearing biased. Instead, faculty members may overpraise performance or effort and provide vague feedback in attempts to affirm students and convey a supportive environment or to "protect" students' self-esteem. Often these actions reflect faculty's implicit biases, based in negative cultural stereotypes about ability. Consequently, underrepresented students do not access and benefit from the same high-quality feedback as do other students. In both cases, students' experiences signal perceptions of their low ability in ways that can undermine their self-concept and subsequent engagement. Unfortunately, these experiences can undermine students' own views of their ability and make them feel less valued, and subsequently, less connected to their academic settings.[24]

Implicit and Explicit Biases across the Career Life Cycle[iii]

The underrepresentation of women in STEMM shares features with underrepresentation of other groups in STEMM relative to white and Asian males. Many factors discourage women from entering science, engineering, and medicine careers, impede their progress during their careers, or influence their decision to leave STEMM after beginning their careers. Bias, discrimination, and harassment are major drivers of the underrepresentation of women in science, engineering, and medicine; they are often experienced more overtly and intensely by women of intersecting identities (e.g., women of color, women with disabilities, LGBTQIA women).[25]

Examples across the career life cycle include:

- Obtaining a Position: bias in recruitment; obstacles to accommodating family needs
- Internal Opportunities and Rewards: unequal allocation of resources; mentoring and performance evaluation (e.g., teaching); mentoring access
- Work Expectations: higher teaching loads; higher expectations of service without compensation
- External Opportunities and Rewards: lower frequency of speaking invitations; inequities in access to external funds, less likely to be on editorial boards and in editor positions
- Cross-cutting Barriers: high rates of harassment, microaggressions, and assault.

Biases have cumulative effects leading to outsized disparities at more advanced career levels. For example, when junior scientists had the opportunity to coauthor a manuscript with a well-known scientist during the first few years of their career, they experienced a "persistent competitive advantage" throughout their careers compared with those who did not have the same authorship opportunities. When biases result in identification of male students as more promising candidates for initial research experiences, the effect of that bias reverberates, continuing to provide additional opportunities for career advancement for that student.

Stereotypes Regarding Masculinity and STEMM

There is a long-standing cultural association between masculinity and objectivity in most segments of American society, which in turn, underlies the associations of masculinity with STEMM. The expectation that STEMM professionals are White and male is implicitly conveyed in cultural portrayals of STEMM and STEMM education. These stereotypical associations shape the social and educational environments of children, as well as structural patterns that occur in STEMM professions.

Traits such as assertiveness, confidence, boldness, risk-taking, independence, and self-promotion are valued, rewarded, and seen as standards in STEMM. Stereotypically "masculine traits" (e.g., assertiveness, ambition, and competitiveness) and "feminine traits" (e.g., warmth, supportiveness, and collegiality) are exhibited by both women and men and, importantly, individual men and women exhibit these traits on a spectrum. However, many women have less experience with these masculine traits because they are often socialized to be more "other-focused" than their male counterparts. When women do display these traits, they often encounter backlash in the form of social and economic sanctions. In addition to undermining the advancement of women in STEMM to positions of leadership, masculine values can signal to women that they do not belong in these fields in the first place.

The Role of Intersectionality

Intersectionality can be defined as "the processes through which multiple social identities converge and ultimately shape individual and group experiences."[26] *Structural intersectionality* refers to the

[iii]This section is drawn from Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine (2020) and focuses primarily on women.

ways in which multiple social systems intersect to shape the experiences of individuals. For women of color in particular, multiple forms of discrimination, such as racism and sexism, intersect to shape their experiences.

Many employers, including those at educational institutions, have adopted programs and the policies aimed at improving equity and diversity in STEMM without considering the complex, cumulative ways in which multiple intersecting identities influence outcomes of the interventions. Indeed, programs aimed at improving the representation of women in STEMM have mainly benefited White women, and programs intended to serve minorities mainly benefit minority males.[27] Intersecting identities can influence the efficacy of interventions to achieve gender equity and point to a need for programs that specifically serve women of color.

STRATEGIES FOR INCREASING REPRESENTATION

There is an urgent national need to develop strategies to substantially increase the postsecondary and STEM degree attainment rates of Hispanic, African American, American Indian, Alaska Native, and underrepresented Asian American students. Improving recruitment and retention of women in science, engineering, and medicine (SEM) throughout their education and training is equally important, particularly in mathematics-intensive fields such as computer science and engineering. More diverse and inclusive STEMM workplaces will be more creative, innovative, and responsive to current and emerging problems because teams comprising individuals with diverse experiences and areas of expertise often ask different questions and tend to be more creative and innovative in how they answer those questions.[28]

Addressing the underrepresentation of major segments of the nation's population requires culture change driven by systemic, coordinated, and multipronged efforts involving an ecosystem of participants: Congress, the White House, federal agencies, institutional leadership, department chairs, program leaders, mentors, mentees, and professional associations. There is no single approach that will improve the educational outcomes of all science, technology, engineering, and mathematics (STEM) aspirants. Improving undergraduate science, technology, engineering, and mathematics education for all students will require a more systemic approach to change that includes use of evidence to support institutional decisions, learning communities and faculty development networks, and partnerships across the education system.[29] Similarly, producing a U.S. graduate STEM education system that better enables graduate students of all backgrounds to meet the highest standards of excellence in 21st-century STEM fields calls for a shift to a system that is student centered, placing greater emphasis and focus on graduate students as individuals with diverse needs and challenges.[30]

Committed leadership is needed at all levels, especially from those in positions of authority (such as policy makers, college and university presidents and deans, and individual faculty that manage training programs and large laboratories) who can implement, allocate resources toward, and monitor progress on new policies and strategies that close the gender gap.[31]

While all educational institutions and STEMM employers share the responsibility of increasing the participation of underrepresented groups in STEMM, several National Academies reports note the particular value of two-year colleges and Minority Serving Institutions (MSIs). Two-year colleges are accessible and affordable, serve a diverse population, and offer a wide variety of degree programs and pathways in STEM for high- and middle-skill jobs. As such they provide an opportunity to improve the diversity of STEM majors and the workforce. Likewise, with a legacy of recruiting, retaining, and graduating a disproportionate number of minorities, especially at the undergraduate level, MSIs are valuable resources for producing talent to fulfill the needs of the nation's current and future STEM workforce. MSIs are the baccalaureate origin of a large segment of minority STEM doctorate recipients, despite the fact that many are smaller than mainstream institutions and receive significantly fewer federal obligations for R&D and science and engineering.[32]

This section highlights some common themes among the recommendations of relevant National Academies reports and offers select recommendations from individual reports for broadening participation of underrepresented populations in STEMM.

Cultures of Inclusive Excellence

A common theme across the National Academies reports relates to creating cultures of inclusive excellence at the undergraduate and graduate levels and in STEMM work settings. Inclusive excellence is a philosophical approach to higher education administration and processes that means attending to both the demographic diversity of students/trainees and the need for developing climates and cultures in institutions so that all have a chance to succeed in STEMM.[33]

Cultures of inclusive excellence are more likely to support the development of diverse STEMM professionals. Creating a culture of inclusive excellence requires academic institutions to identify where student success is not equal across all demographics, discover which educational practices succeed in addressing those inequities, and work intentionally to build from those practices in a way that sustains institutional change.[34] While true at all institutions of higher education, organizational cultures play an especially significant role in promoting student success at MSIs. A welcoming and nurturing campus climate—one that supports a fundamental sense of community and an equity-oriented culture—contributes to academic attainment and professional commitment at MSIs.[35]

Given that effective mentoring relationships for individuals across career stages can strongly support mentee success in STEMM fields, creating a culture of inclusive excellence must include providing access to effective mentoring for all students.[36] Specific recommendations from The Science of Effective Mentorship in STEMM (2019) in this regard include:

- **4.1:** Institutional leadership should intentionally support mentorship initiatives that recognize, respond to, value, and build upon the power of diversity. Leaders should intentionally create cultures of inclusive excellence to improve the quality and relevance of the STEMM enterprise.
- **4.2:** Mentors should learn about and make use of inclusive approaches to mentorship such as listening actively, working toward cultural responsiveness, moving beyond "colorblindness," intentionally considering how culture-based dynamics like imposter syndrome can negatively influence mentoring relationships, and reflecting on how their biases and prejudices may affect mentees and mentoring relationships, specifically for mentorship of underrepresented mentees.
- **4.3:** Mentees should reflect on and acknowledge the influence of their identities on their academic and career trajectory, including the potential for imposter syndrome to disrupt mentorship. Mentees should seek mentorship that is intentional in considering their individual lived experiences.
- **4.4:** Professional associations should intentionally address sociodemographic factors in mentoring relationships, specifically for mentorship of underrepresented mentees. Professional associations should also intentionally create cultures of inclusive excellence to improve the quality and relevance of the STEMM enterprise.

More broadly, the STEM graduate education enterprise as a whole must seek to enable students of all backgrounds to succeed by implementing mentoring practices and pedagogies that create an inclusive institutional environment in terms of gender, age, culture, ethnicity, and nationality; that make available opportunities for productive dialogue; and that encourage diverse perspectives that can lead to a deeper understanding of how people from different backgrounds may approach learning and problem solving in different ways. To this end, Graduate STEM Education for the 21st Century (2018) recommends:

- **RECOMMENDATION 3.5—Ensuring Diverse, Equitable, and Inclusive Environments:**
  - Faculty and administrators involved in graduate education should develop, adopt, and regularly evaluate a suite of strategies to accelerate increasing diversity and improving equity and inclusion, including comprehensive recruitment, holistic review in admissions, and interventions to prevent attrition in the late stages of progress toward a degree.
  - Faculty should cultivate their individual professional development skills to advance their abilities to improve educational culture and environments on behalf of students.
  - Institutions, national laboratories, professional societies, and research organizations should develop comprehensive strategies that use evidence-based models and programs and include measures to evaluate outcomes to ensure a diverse, equitable, and inclusive environment.
  - Institutions should develop comprehensive strategies for recruiting and retaining faculty and mentors from demographic groups historically underrepresented in academia.
  - Federal and state agencies, universities, professional societies, and nongovernmental organizations that rate institutions should embed diversity and inclusion metrics in their criteria.
  - Federal and state funding agencies and private funders that support graduate education and training should adjust their award policies and funding criteria to include policies that incentivize diversity, equity, and inclusion and include accountability measures through reporting mechanisms.

Sexual Harassment of Women: Climate, Culture, and Consequences in Academic Sciences, Engineering, and Medicine (2018) offers the following, related recommendation for academic institutions as STEMM workplaces:

- **RECOMMENDATION 1: Create diverse, inclusive, and respectful environments.**
  1. Academic institutions and their leaders should take explicit steps to-achieve greater gender and racial equity in hiring and promotions, and thus improve the representation of women at every level.
  2. Academic institutions and their leaders should take steps to foster greater cooperation, respectful work behavior, and professionalism at the faculty, staff, and student/trainee levels, and should evaluate faculty and staff on these criteria in hiring and promotion.
  3. Academic institutions should combine anti-harassment efforts with civility-promotion programs.
  4. Academic institutions should cater their training to specific populations (in academia these should include students/trainees, staff, faculty, and those in leadership) and should follow best practices in designing training programs. Training should be viewed as the means of providing the skills needed by all members of the academic community, each of whom has a role to play in building a positive organizational climate focused on safety and respect, and not simply as a method of ensuring compliance with laws.
  5. Academic institutions should utilize training approaches that develop skills among participants to interrupt and intervene when inappropriate behavior occurs. These training programs should be evaluated to determine whether they are effective and what aspects of the training are most important to changing culture.
  6. Anti–sexual harassment training programs should focus on changing behavior, not on changing beliefs. Programs should focus on clearly communicating behavioral expectations, specifying consequences for failing to meet these expectations, and identifying the mechanisms to be utilized when these expectations are not met. Training programs should not be based on the avoidance of legal liability.

Equity of Access to Evidence-Based STEM Educational Programs and Experiences

There is an opportunity to expand and diversify the nation's science, technology, engineering, and mathematics (STEM) workforce and STEM-skilled workers in all fields if there is a commitment to appropriately support students through degree completion and provide more opportunities to engage in high-quality STEM learning and experiences.[37] These experiences and supports include instructional strategies, mentoring, and co-curricular supports such as peer tutoring, research experiences, and living-learning communities.

Instructional Strategies

Evidence-based instructional strategies in STEM include a range of approaches, including making lectures more interactive, having students work in groups, providing formative feedback, and incorporating authentic problems and activities.

When designing STEM instruction at the K-12 level, it is important to attend to factors that may motivate or fail to motivate students from particular demographic groups.[38] Inclusive pedagogies can support the learning of all students by situating differences as assets, building on students' identities and life experiences, and leveraging local and dynamic views of cultural life for the study of science and engineering.[39] Including traditionally excluded groups in science learning opportunities allows students to develop skills and interests that greatly broaden their perspectives on career opportunities and possibilities and that open the doors to make those opportunities real.[40]

Instructional strategies also matter in undergraduate STEM classrooms. Comparatively low completion rates among students who aspire to a STEM degree has led to questions about the quality of the educational experiences for STEM students. Research has shown that all students learn more in STEM classrooms where instructors use active learning strategies rather than traditional lecturing, and these strategies seem especially beneficial for students from traditionally underrepresented groups. For example, students from traditionally underrepresented groups taking a course with active learning methods are less likely to fail or withdraw.

The use of evidence-based practices is especially important for improving outcomes for students in the critical high-enrollment "gateway" courses that are required for STEM majors and that often act to discourage students from persisting in STEM majors.[41] Moreover, educational strategies that challenge stereotypes about the essential attributes of a successful STEMM professional and about the nature of work in STEMM can increase interest, improve performance, and instill a sense of belonging in these fields among White women, women of color, and other underrepresented groups (e.g., first-generation college students and men of color).[42]

Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine (2020) recommends the following:

Implementation Action 6-A: Given that women are underrepresented in computer science, engineering, and physics as early as the undergraduate level, agencies that support research, training, and education in these fields should incentivize institutions to adopt educational practices that research shows can improve interest and sense of belonging in these fields among women. For instance, the NSF director should direct the deputy directors of the NSF Directorates for Engineering, Computer and Information Science and Engineering, and Mathematical and Physical Sciences to set aside funding and work collaboratively with the Education and Human Resources Directorate to support education grants that address the following:

- Adoption by college and university faculty and administrators of classroom and lab curricula and pedagogical approaches that research has demonstrated improve interest and sense of belonging in computer science, engineering, and physics among women, such as:
    1. those that incorporate growth mindset interventions that impress upon students that skills and intelligence are not fixed, but, rather, are increased by learning;

2. those that highlight that scientists and engineers are well positioned and equipped to do work that has a positive societal impact;
3. those that highlight the contributions of a diverse array of people to the scientific, engineering, and medical enterprise today and throughout history.

- Research and development of new models of curriculum development in engineering, computer science, and physics that take into account the experience level that different students bring to introductory courses and draw upon the lessons learned from successful programs at other institutions (e.g., Harvey Mudd, Carnegie Mellon).
- Development of new media (e.g., podcasts, videos, television, graphics, and instructional materials [e.g., textbooks, syllabi]) that provide students with a diverse array of role models and feature the diversity of individuals whose contributions to science, engineering, and medicine are substantial but may not be as well known by the public. Such an effort could benefit from an interagency collaboration between NSF and the National Endowment for the Arts, which could operate under an existing memorandum of understanding (MOU) between these two agencies.

Co-Curricular Supports for Success

Co-curricular supports are activities, programs, and learning experiences that complement, in some way, what students are learning in the classroom. If done well, these supports provide authentic disciplinary experiences while also taking into account the social and relational aspects of learning that have been shown to influence students' academic engagement and persistence in the sciences. Specifically, co-curricular programming can mitigate the negative psychological and academic impacts of a stigmatizing STEM academic culture by affirming students' self-perceptions of competence and sense of community in the college setting. Thus, such programming can serve important roles both in promoting motivation and achievement and in protecting students when they experience stigma and exclusion.[43]

While many strategies for academic support and social integration apply equally to students in STEM fields regardless of their racial or ethnic background, for underrepresented minority students these can be critical for opening doors of opportunity. Proven, intensive interventions for underrepresented minorities in STEM include:[44]

- **Summer Programs:** Summer programs that include or target minority middle and high school and undergraduate students provide experiences that stimulate interest in these fields through study, hands-on research, and the development of a cadre of students who support each other in their interests.
- **Research Experiences:** At the undergraduate and graduate level, engagement in rich research experiences allows for the further development of interest and competence in and identification with STEM and enhances academic competitiveness.
- **Professional Development Activities:** Opportunities for undergraduate and graduate students to engage in networking, participation in conferences, and presentation of research provide opportunities to develop and socialize students within a discipline and profession.
- **Academic Support and Social Integration:** Success may also hinge on the extent to which undergraduate and graduate students participate in activities—such as peer-to-peer support, study groups, social activities, tutoring, and mentoring programs—that can promote academic success and social integration.
- **Mentoring:** Engaged mentors can provide undergraduate and graduate students with information, advice, and guidance and support generally and at critical decision points.

The development of programs to stimulate student interest and success in STEM, in general and for programs that target minorities, requires substantial and sustained resources. Students who have not had the same degree of exposure to STEM and to postsecondary education require more *intensive* efforts at each level to provide adequate preparation, financial support, mentoring, social integration, and professional development. A successful program may be innovative or replicative and will draw on the lessons of best and worst practices in program development and implementation, but it will be tailored to its particular institutional and disciplinary context. Coordination and integration of efforts can make the aggregate of individual programs greater than the sum of their parts.[45]

Barriers and Opportunities for 2-year and 4-year STEM Degrees (2016) offers the following recommendation related to co-curricular supports:

- **RECOMMENDATION 8:** Institutions should consider how expanded and improved co-curricular supports for science, technology, engineering, and mathematics (STEM) students can be informed by and integrated into work on more systemic reforms in undergraduate STEM education to more equitably serve their student populations.

Mentoring

Research on undergraduate students shows that mentors play a critical role in contributing to the development of science identity, an important factor in retaining underrepresented students in STEMM. Effective mentorship for underrepresented students also enhances recruitment into and retention in research-related career pathways. Thus, mentorship will likely constitute a significant component of the complex solutions required to increase representation in STEMM. Specific recommendations from *The Science of Effective Mentorship in STEMM* include:

- **RECOMMENDATION 4: Recognize and Respond to Identities in Mentorship.** All participants in the mentorship ecosystem should recognize that identities influence academic and career development and thus are relevant and significant for effective mentorship.
- **RECOMMENDATION 7: Mitigate Negative Mentorship Experiences.** Mentorship education for both mentors and mentees can help to reduce or prevent negative mentoring experiences. However, negative mentoring experiences do and will occur, and direct steps should be taken to mitigate harm from such occurrences.

Each of these elements of postsecondary STEM education is important in its own right. However, better alignment of science, technology, engineering, and mathematics (STEM) programs, instructional practices, and student supports is needed in institutions to meet the needs of the populations they serve. Programming and policies that address the climate of STEM departments and classrooms, the availability of instructional supports and authentic STEM experiences, and the implementation of effective teaching practices together can help students overcome key barriers to earning a STEM degree, including the time to degree and the price of a STEM degree.[46]

Several National Academies reports also note the importance of ongoing, constructive evaluation of programs designed to increase the participation of underrepresented minorities. Program designers, managers, and participants benefit from the dissemination of information about practice derived from these evaluations and other research.

BOX 1

**University of Michigan STRIDE Program:
Strengthening Recruitment and Hiring Practices for Increasing Diversity**

The University of Michigan's Committee on Strategies and Tactics for Recruiting to Improve Diversity and Excellence (STRIDE) was established under the auspices of the university's National Science Foundation ADVANCE grant in 2002. The program promotes best practices for science and engineering search committees and others to help with the recruiting and retention of women and other groups underrepresented among the faculty. The STRIDE committee is composed of a diverse group of faculty who are able to advise "individuals and departments on hiring practices aimed at increasing both the diversity and excellence of the faculty through presentations, detailed and targeted advice, or focused discussions as needed" (University of Michigan, 2019). The STRIDE Committee promotes best practices to strengthen recruitment and retention of a diverse faculty that could be translated to other settings (University of Michigan, 2019).

These include:

1. Building an effective search committee, including requiring and rewarding a high-level commitment to diversity and excellence.
2. Actively developing a diverse pool of applicants, including fostering connections with institutions that train diverse students and connecting with professional organizations that support underrepresented groups in the field.
3. Defining the disciplinary area for the search as broadly as possible.
4. Asking for information needed from applicants, including ensuring that all applicants know the criteria on which they are being evaluated and providing clear instructions about the application process.

Source: *Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine* (2020).

Faculty and Mentor Diversity and Capacity

One effective mechanism by which to address issues of equity and diversity in undergraduate education is to cultivate and retain a diverse cadre of instructors, including tenured and tenure-track faculty, adjunct and part-time instructors, and graduate student instructors. Instructor diversity provides educational benefits to all students and particularly for students of color.[47] As the number of underrepresented minorities in faculty positions increases, the more role models underrepresented minority students have who 'look like them' and the higher rate at which underrepresented minority students enroll and graduate.[48] (see Box 1 for an example of hiring practices to strengthen diversity)

Faculty should cultivate their individual professional development skills to advance their abilities to improve educational culture and environments on behalf of students.[49] It is equally necessary to equip mentors with the skills to recognize and respond to the identity-based experiences of these students that affect their academic and career development. Effective mentoring relationships employ competency-based, inclusive practices to help students see themselves as STEMM scholars with the potential to contribute meaningfully to their disciplines. However, this involves competency-based mentorship preparation or education shown to help mentors and mentees advance their skills in multiple areas.[50]

Graduate STEM Education for the 21st Century (2018) offers the following recommendation to improve teaching and mentoring:

- **RECOMMENDATION 3.2—Institutional Support for Teaching and Mentoring:** To improve the quality and effectiveness of faculty teaching and mentoring, institutions of higher education should provide training for new faculty and should offer regular refresher courses in teaching and mentoring for established faculty.
  - > Institutions should require faculty and postdoctoral researchers who have extensive contact with graduate students to learn and demonstrate evidence-based and inclusive teaching and mentoring practices.
  - > Graduate programs should facilitate mentor relationships between the graduate student and the primary research advisors, as well as opportunities for students to develop additional mentor or advisor relationships, including with professionals in industry, government laboratories, and technical societies.
  - > Graduate schools should provide extra-departmental mentoring and support programs.
  - > Graduate students should seek multiple mentors to meet their varied academic and career needs.

The Science of Effective Mentorship in STEMM (2019) provides more specific guidance related to quality mentorship:

- **RECOMMENDATION 2: Use an Evidenced-Based Approach to Support Mentorship**
  - > **2.1:** Institutional and departmental leadership should support the use of evidence-based mentoring practices by both mentors and mentees, starting with new faculty and student orientation. Support should include tested mentorship education curricula, resources, and tools (guided discussions, mentoring compacts, individual development plans, and mentor maps) as well as time for professional development and mechanisms for feedback, improvement, and accountability.
  - > **2.2:** Program leaders should support mentorship by ensuring there are evidence-based guidelines, tools, and processes for mentors and mentees to set clear expectations, engage in regular assessments, and participate in mentorship education. Program design should take into account the stages of mentoring relationships and ensure that the evolving needs of undergraduate and graduate students are met as they shift to career stage–appropriate independence.
  - > **2.3:** Department chairs should deliver professional development on effective mentorship to support mentors and mentees in understanding how successful mentoring relationships can be created, cultivated, and nurtured; addressing challenges such as those caused by biases and micro- and macroaggressions; encouraging self-reflection; and mastering critical skills over time.
  - > **2.4:** Mentors should learn about and employ evidence-based mentorship tools and strategies through a process that includes exploring evidence-based mentorship resources, dedicating time for mentorship education, and participating in relationship-level, department-level, and institution-level mentoring accountability mechanisms.
- **RECOMMENDATION 3: Establish and Use Structured Feedback Systems to Improve Mentorship at All Levels**
  - > Assessment and evaluation of mentorship are necessary to identify areas of strength and opportunities for improvement. Evaluation through structured systems may reduce unintentional bias and protect mentees who are in inherently more vulnerable positions as students and trainees.

Incentives and Rewards

Equity, diversity, and inclusion efforts by institutions are often hindered by a lack of sufficient resources and by the expectation that individuals, particularly women and men of color, who care about these issues will take the lead on promoting positive change without compensation or real authority. Even more concerning is the fact that those individuals who take responsibility for promoting equity, diversity, and inclusion efforts may be penalized for devoting time and energy to such efforts if they take time away from other activities the institution prioritizes and rewards, such as securing research grants and publishing peer-reviewed papers.[51]

Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine (2020) recommends that institutions, both academic and governmental, sustainably allocate resources and authority to the leaders of equity, diversity, and inclusion efforts and provide incentives that communicate that the promotion of an inclusive scientific, engineering, and medical enterprise is everyone's responsibility:

- **RECOMMENDATION 7.** Leaders in academia and scientific societies should put policies and practices in place to prioritize, reward, recognize, and resource equity, diversity, and inclusion efforts appropriately.
- **RECOMMENDATION 8.** Federal agencies and private foundations should work collaboratively to recognize and celebrate colleges and universities that are working to improve gender equity.

These recommendations, and the implementation actions associated with them, are consistent with *Graduate STEM Education for the 21st Century* (2018):

- **RECOMMENDATION 3.1—Rewarding Effective Teaching and Mentoring:** Advancement procedures for faculty, including promotion and tenure policies and practices, should be restructured to strengthen recognition of contributions to graduate mentoring and education.
  - Federal and state funding agencies should align their policies and award criteria to ensure that students in the programs they support experience the kind of graduate education outlined in this report and achieve the scientific and professional competencies articulated here, whether they are on training or research grant mechanisms.
  - Institutions should increase priority and reward faculty for demonstrating high-quality teaching and inclusive mentoring practices for all graduate students, including the recognition of faculty teaching in master's degree programs, based on the results of restructured evaluations.
  - Institutions should include teaching and mentoring performance as important considerations for reappointment, promotion, annual performance review, and tenure decisions. Institutions should also nominate faculty for external awards (such as those from technical societies) that reward teaching excellence.

A related recommendation in *The Science of Effective Mentorship in STEMM* (2019) focuses on how to reward mentorship:

- **RECOMMENDATION 6: Reward Effective Mentorship**
  - **6.1:** Institutional leadership should reward and visibly recognize mentors for documented, effective, and inclusive mentorship in the same manner as effective teaching is recognized, including through annual awards. Consideration should be given to all forms of mentorship, including informal and formal relationships that occur beyond the research advisor or other academic advisor and the student. Leaders should also structure job recruitment, application, and selection procedures to make evident an applicant's commitment to and success with mentorship and ensure mentorship quality and potential are weighed in hiring decisions, possibly through the inclusion of mentoring statements in applications.

> **6.2:** Department chairs, in consultation with institutional leadership, should use promotion, tenure, and performance appraisal practices to reward effective mentorship. Elements of a promotion or tenure package could include descriptions of approaches and resources used in mentoring, reflective statements of ways the candidate has worked to improve their mentoring over time, evidence of mentored scientists as coauthors on manuscripts and grants and their placement into positions, letters from program leaders and testimonies from students, institutional and national awards for mentorship, and process measures that assess mentoring relationship quality from the perspective of the mentee and the mentor.

> **6.3:** Professional associations should provide visible recognition of effective mentorship through prominent rewards for documented, effective, and inclusive mentorship, such as certifications for completing substantive mentorship education, named awards for sustained contributions to mentorship, and noteworthy track records of effective mentorship supported with assessment data.

Sexual Harassment of Women (2018) provides guidance about how institutions and external agencies can drive the needed cultural changes:

- **RECOMMENDATION 9: Incentivize change.**
    1. Academic institutions should work to apply for awards from the emerging STEM Equity Achievement (SEA Change) program. Federal agencies and private foundations should encourage and support academic institutions working to achieve SEA Change awards.
    2. Accreditation bodies should consider efforts to create diverse, inclusive, and respectful environments when evaluating institutions or departments.
    3. Federal agencies should incentivize efforts to reduce sexual harassment in academia by requiring evaluations of the research environment, funding research and evaluation of training for students and faculty (including bystander intervention), supporting the development and evaluation of leadership training for faculty, and funding research on effective policies and procedures.

Data Collection and Reporting

Transparency and accountability are powerful drivers of behavior change. Thus, institutions must articulate and deliver on measurable goals and benchmarks related to creating cultures of inclusive excellence and diversifying STEMM that are regularly monitored for progress and publicly reported.[52] Several National Academies reports offer recommendations about data collection and reporting for institutions of higher education and for statistical and funding agencies.

For institutions of higher education, National Academies reports recommend that:

- College and university deans and department chairs should annually collect, examine, and publish data on the number of students, trainees, faculty, and staff, disaggregated by gender and race/ethnicity, to understand the nature of their unit's particular challenges with the recruitment, retention, and advancement of women and then use this information to take action. (***Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine*, Recommendation 3**)
- Academic institutions should work with researchers to evaluate and assess their efforts to create a more diverse, inclusive, and respectful environment, and to create effective policies, procedures, and training programs. They should not rely on formal reports by targets for an understanding of sexual harassment on their campus. (***Sexual Harassment of Women*, Recommendation 8**)
- Data collection systems should be adjusted to collect information to help departments and institutions better understand the nature of the student populations they serve and the pathways these students take to complete science, technology, engineering, and mathematics (STEM) degrees. (***Barriers and Opportunities for 2- and 4-Year STEM Degrees*, Recommendation 1**)

The data at the institutional level has particular significance for leadership and administration to understand the local nature of issues on campus and identify both issues and where efforts are working. The use of local data at the institutional, department, or program level can be part of a continuous improvement model to measure progress. Data can also include climate surveys to understand the way individuals experience and feel the effect of practices, policies, and other changes.[53]

In terms of funding and statistical agencies:

- To monitor progress toward equity, diversity, and inclusion of science, technology, engineering, and mathematics students and instructors, national data systems will need to include demographic characteristics beyond gender and race and ethnicity, including at least disability status, first-generation student status, and socioeconomic status. (***Indicators for Monitoring Undergraduate STEM Education*, Conclusion 4**)
- States and federal agencies should consider how the information they require institutions to collect might enable better tracking of students through pathways they take to earn a STEM degree within and especially across institutions. In addition, they should consider expanding measures of success, which increasingly inform funding formulas, beyond graduation rates. (***Barriers and Opportunities for 2- and 4-Year STEM Degrees*, Recommendation 1**)
- Federal and state funding agencies should require institutions that receive support for graduate education to develop policies that require data collection on a number of metrics, including but not limited to demographics, funding mechanisms, and career outcomes, on current students and alumni at regular intervals for 15 years after graduation. Institutions should make these data available to qualify for traineeships, fellowships, and research assistantships. (***Graduate STEM Education for the 21st Century*, p. 131**)
- The legislative and executive branches of the U.S. government should work together to increase transparency and accountability among federal agencies by requiring data collection, analysis, and reporting on the nature, impact, and degree of investment in efforts to improve the recruitment, retention and advancement of women in STEMM, with an emphasis on those existing efforts that take an intersectional approach. (***Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine*, Recommendation 1**)
- Federal agencies should hold grantee institutions accountable for adopting effective practices to address gender disparities in recruitment, retention, and advancement and carry out regular data collection to monitor progress. (***Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine*, Recommendation 2**)
- Federal and state educational agencies, state legislators, and other entities that utilize indicators of institutional success, including for accountability purposes, should reassess and refine methods of measuring student outcomes to take into consideration institutional missions, faculty investment, student populations, student needs, and institutional resource constraints. (***Minority Serving Institutions*, Summary of Recommendation 10**).
- The National Center for Science and Engineering Statistics should develop for [its] surveys core questions and a more in-depth module on harassment and discrimination.[54]
- Private funders of graduate education should adjust their grant award policies and funding criteria to include policies that incentivize diversity, equity, and inclusion and include accountability measures through reporting mechanisms. (***Graduate STEM Education for the 21st Century*, p. 132**)

Nongovernmental organizations that rate institutions also should embed diversity and inclusion metrics in their criteria.

The Role of Funding Agencies

Federal and state funding agencies have a particularly important role to play because their funding and support policies are often cited as being critical to the overall context and climate in which academic institutions are situated. Those policies are influential in shaping the incentive systems under which research institutions operate and researchers are rewarded. As such, the role of funding agencies in diversifying STEMM and encouraging and supporting effective mentorship practices is essential, and several National Academies reports offer recommendations involving these important stakeholders.

Broadly speaking, various National Academies reports call for public and private funding to support:

- programs and supports targeted at increasing the advancement and participation of underrepresented populations in STEMM and at preventing and stopping sexually harassing behavior, and research on the efficacy of those interventions;
- evidence-based mentorship practices; and
- qualitative and quantitative research to understand the nuances of exclusion and underrepresentation in different disciplines, for different populations, and at different stages of the academic and career life cycles.

Beyond these general recommendations, *Minority Serving Institutions* (2019) concludes that substantial resources are needed to help promote, sustain, and advance the success of MSIs and their students. Such investments include support that enables MSIs to recruit and retain high-quality faculty, to procure and maintain state-of-the-art laboratories and facilities, to offer extraordinary academic and social support services to students, and to compete effectively for access to the federal grants and contracts that fuel important research discoveries, innovation, and scientific advancement for the nation (See Recommendations 4, 5, and 8). Along similar lines, *Expanding Underrepresented Minority Participation* (2011) recommends that the federal government should increase funding for the operating expenses of tribal colleges and universities and increase the level authorized under the Tribally Controlled College or University Assistance Act of 1978 (Recommendation 5), and increase funding for infrastructure, research, curriculum development, and professional training at minority serving institutions through such programs as HBCU-UP, TCU-UP, RISE, MARC/MBRS, and CREST (Recommendation 6).

RELATED NATIONAL ACADEMIES ACTIVITIES

In addition to the consensus reports synthesized above, the National Academies has published proceedings from several recent workshops on diversity, equity, and inclusion in STEMM. Workshop proceedings document discussions of the important issues raised during the workshops and do not contain consensus conclusions and recommendations.

Specifically,

- a workshop addressing racism as a barrier for African American men in the STEMM fields yielded two proceedings:
  - *An American Crisis: The Growing Absence of Black Men in Medicine and Science: Proceedings of a Joint Workshop* (2018)
  - *The Impacts of Racism and Bias on Black People Pursuing Careers in Science, Engineering, and Medicine: Proceedings of a Workshop* (2020); and
- a workshop on the effects of racism in neuroscience resulted in *Racial Justice, Diversity, Equity, and Inclusion in Neuroscience Training: Proceedings of a Workshop—in Brief* (2020).

These workshops were conducted under the auspices of two standing bodies at the National Academies: The Roundtable on Black Men and Black Women in Science, Engineering, and Medicine and The Action Collaborative on Neuroscience Training: Developing a Nimble and Versatile Workforce.

- a workshop series on neuroscience training addressing many issues related to racism, diversity, equity, and inclusion in the field of neuroscience:
  > *Racial Justice, Diversity, Equity, and Inclusion in Neuroscience Training* (2020)
  > *Neuroscience Training in Challenging Times* (2021)
  > *Fostering Diversity, Equity, and Inclusion in Neuroscience Training* (2021)
  > *Re-envisioning Postdoctoral Training in Neuroscience* (2021)
  > *Evolving the Culture of Science and Training to Meet a Changing World* (2021).

These workshops were conducted under the auspices of two standing bodies at the National Academies: The Roundtable on Black Men and Black Women in Science, Engineering, and Medicine and The Forum on Neuroscience and Nervous System Disorders.

CONCLUSION

The consensus reports synthesized here, together with recent workshops and related ongoing activities, offer an evidentiary basis and recommendations for addressing longstanding, systemic patterns of racism and bias in STEMM. The reports offer richer elaborations of the causes and consequences of underrepresentation in STEMM, and more conclusions and recommendations than this paper could include. Readers are encouraged to explore the specific reports listed below for additional detail and supporting research on this critically important topic. In addition, the National Academies Press has compiled a Diversity, Equity, and Inclusion Collection that includes some of these and other reports.

List of Relevant Consensus Reports

K-12 STEM Education

- *Science and Engineering for Grades 6-12* (2019)
- *Monitoring Educational Equity* (2019)
- *English Learners in STEM Subjects* (2018)
- *A Framework for K-12 Science Education* (2012)

Undergraduate and Graduate STEMM Education

- *Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine* (2020)
- *Minority Serving Institutions: America's Underutilized Resource for Strengthening the STEM Workforce* (2019);
- *The Science of Effective Mentorship in STEMM* (2019)
- *Graduate STEM Education for the 21st Century* (2018)
- *Indicators for Monitoring Undergraduate STEM Education* (2018)
- *Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways* (2016)
- *Review of Army Research Laboratory Programs for Historically Black Colleges and Universities and Minority Institutions* (2014)
- *Adapting to a Changing World: Challenges and Opportunities in Undergraduate Physics Education* (2013)

- *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads* (2011)
- *A Data-Based Assessment of Research-Doctorate Programs in the United States* (with CD) (2011)

Earlier reports

- *Who Will Keep the Public Healthy? Educating Public Health Professionals for the 21st Century* (2003)
- *The Path to the Ph.D.: Measuring Graduate Attrition in the Sciences and Humanities* (1996)
- *Retention of Minority Students in Engineering* (1977)

The STEMM Workforce

- *Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine* (2020)
- *Measuring the 21st Century Science and Engineering Workforce Population: Evolving Needs* (2018)

Reports with relevant content, though not with DEI as a central focus

- *The Next Generation of Biomedical and Behavioral Sciences Researchers: Breaking Through* (2018). Provides potentially useful contextual information about the general challenges to establishing long-term research careers in academia.
- *Research Training in the Biomedical, Behavioral, and Clinical Research Sciences* (2011)

Earlier reports:

- *Beyond Bias and Barriers Fulfilling the Potential of Women in Academic Science and Engineering* (2007) (NOTE: covers much of the same ground as Promising Practices for Addressing the Underrepresentation of Women... and is 13 years older, so not included in this round of the review)
- *Opportunities to Address Clinical Research Workforce Diversity Needs for 2010* (2006)
- *Assessment of NIH Minority Research and Training Programs: Phase 3* (2005)
- *In the Nation's Compelling Interest: Ensuring Diversity in the Health-Care Workforce* (2004)
- *Addressing the Nation's Changing Needs for Biomedical and Behavioral Scientists* (2000)
- *Building a Diverse Work Force: Scientists and Engineers in the Office of Naval Research* (1997)
- *Balancing the Scales of Opportunity: Ensuring Racial and Ethnic Diversity in the Health Professions* (1994)
- *Minority Access to Research Careers: An Evaluation of the Honors Undergraduate Research Training Program* (1985)
- *Employment of Minority PhDs: Changes Over Time* (1981)
- *Women and Minority Ph.D.'s in the 1970's: A Data Book* (1977)
- *A Selected, Annotated Bibliography on Employment of Minority Engineers* (1975)

Earlier, More Broadly Focused Reports

- *Measuring Racial Discrimination* (2004)
- *America Becoming: Racial Trends and Their Consequences: Volume I & II* (2001)
- *A Common Destiny: Blacks and American Society* (1989)
- *Fairness in Employment Testing: Validity Generalization, Minority Issues, and the General Aptitude Test Battery* (1989)

[1]Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads (2011)

[2]Science and Engineering for Grades 6-12 (2019)

[3]Monitoring Educational Equity (2019)

[4]Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways (2016); Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads (2011)

[5]Graduate STEM Education for the 21st Century (2018)

[6]The Science of Effective Mentorship in STEMM (2019)

[7]Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads (2011)

[8]Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine (2020)

[9]A Framework for K-12 Science Education (2012); Science and Engineering for Grades 6-12 (2019); Indicators for Monitoring Undergraduate STEM Education (2018); Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine (2020)

[10]A Framework for K-12 Science Education (2012)

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[12]Science and Engineering for Grades 6-12 (2019)

[13]Science and Engineering for Grades 6-12 (2019)

[14]A Framework for K-12 Science Education (2012)

[15]Science and Engineering for Grades 6-12 (2019)

[16]Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways (2016)

[17]Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways (2016)

[18]Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways (2016)

[19]The Science of Effective Mentorship in STEMM (2019)

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[23]The Science of Effective Mentorship in STEMM (2019)

[24]Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways (2016)

[25]Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine (2020)

[26]Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine (2020)

[27]Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine (2020)

[28]Minority Serving Institutions: America's Underutilized Resource for Strengthening the STEM Workforce (2019); The Science of Effective Mentorship in STEMM (2019); Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine (2020)

[29]Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways (2016)

[30]Graduate STEM Education for the 21st Century (2018)

[31]Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine (2020)

[32]Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways (2016); Minority Serving Institutions: America's Underutilized Resource for Strengthening the STEM Workforce (2019); Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads (2011); The Science of Effective Mentorship in STEMM (2019); Review of Army Research Laboratory Programs for Historically Black Colleges and Universities and Minority Institutions (2014); Adapting to a Changing World: Challenges and Opportunities in Undergraduate Physics Education (2013); Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine (2020)

[33]The Science of Effective Mentorship in STEMM (2019)

[34]The Science of Effective Mentorship in STEMM (2019)

[35]Minority Serving Institutions: America's Underutilized Resource for Strengthening the STEM Workforce (2019)

[36]The Science of Effective Mentorship in STEMM (2019)

[37]Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways (2016)

[38]A Framework for K-12 Science Education (2012)

[39]Science and Engineering for Grades 6-12 (2019)

[40]Science and Engineering for Grades 6-12 (2019)

[41]Indicators for Monitoring Undergraduate STEM Education (2018); Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways (2016)

[42]Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine (2020)

[43]Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways (2016)

[44]Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads (2011)

[45]Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads (2011)

[46]Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways (2016)

[47]Indicators for Monitoring Undergraduate STEM Education (2018)

[48]Graduate STEM Education for the 21st Century (2018)

[49]Graduate STEM Education for the 21st Century (2018)

[50]The Science of Effective Mentorship in STEMM (2019)

[51]Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine (2020)

[52]Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine (2020)

[53]Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine (2020)

[54]Measuring the 21st Century Science and Engineering Workforce Population: Evolving Needs (2018)

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