Promising Practices for Addressing the Underrepresentation of Women in Science, Engineering, and Medicine

OPENING DOORS

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Committee on Increasing the Number of Women in Science, Technology, Engineering, Mathematics, and Medicine (STEMM)

Committee on Women in Science, Engineering, and Medicine

Policy and Global Affairs

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[December 11, 2019 - March 31, 2020]

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[1] The members of the Committee on Understanding and Addressing the Underrepresentation of Women in Particular Science and Engineering Disciplines contributed actively to the content of the report from October 5, 2018, to December 10, 2019, and deserve special recognition for their substantial intellectual contributions. They are not responsible for the content of this report, including the findings and recommendations.

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"I hadn't been aware that there were doors closed to me until I started knocking on them."

Gertrude B. Elion, 1988 Nobel Laureate in Physiology and Medicine

Preface

In the 21st century, the fields of science, engineering, and medicine contribute significantly to supporting and advancing our nation's security, prosperity, and health. However, scientific discoveries, engineering innovations, and medical advances don't appear out of thin air; they arise from the passion, ingenuity, and hard work of dedicated individuals. To meet the challenges of today, and of those yet to come, full and productive engagement of all members of society is critical.

Unfortunately, many fields of science, engineering, and medicine continue to face a formidable shortage of talent, and women—who make up more than 50 percent of the population—are significantly underrepresented in these fields. Although the number of women pursuing education and careers in science, technology, engineering, mathematics, and medicine (STEMM) has increased in many STEMM fields, and has even reached parity in some of those fields, representation of women in STEMM is a persistent challenge. Women of color are severely underrepresented in every STEMM discipline. Notably, women are underrepresented in engineering, computer science, and physics and at every level. In those fields in which women are at parity among degree earners and early career professionals, such as medicine, they are underrepresented in senior leadership positions.

The data on underrepresentation of women in STEMM and personal stories of the adverse effects of bias, discrimination, and harassment in the scientific enterprise, underline the fact that there is much that needs to be done to improve recruitment, retention, and advancement of women in STEMM. There is reason for optimism to expect that positive change is possible. It is critical for us all to consider the lessons learned from the scholarly research presented in this report and to take note of the many success stories that are described, demonstrating that an intentional, evidence-based approach in implementing concrete policies, programs, and interventions can yield an incredibly positive impact in a relatively short period of time.

In my career I have had the privilege of considering this issue from many different perspectives: as a scientist, as the leader of a federal agency, as the leader of a scientific institute, as an advisor to government and nonprofit organizations, and, now, as the chair of this study. I come away from these experiences with a strong conviction that the challenge of realizing a more diverse, equitable, and inclusive science, engineering, and medical enterprise can be met with great success, if all stakeholders share the passion, will, and perseverance to achieve positive change.

Rita Colwell, *Chair*

Special Acknowledgment

This report is the culmination of the work of two committees: the Committee on Increasing the Number of Women in Science, Technology, Engineering, Mathematics, and Medicine (STEMM) [Rita Colwell, Chair] and the Committee on Understanding and Addressing the Underrepresentation of Women in Particular Science and Engineering Disciplines (Mae Jemison, Chair). The Committee on Understanding Underrepresentation contributed actively to the report's content from October 5, 2018, to December 10, 2019, and the Committee on Increasing Women in STEMM contributed actively to the report's content starting on December 11, 2019, through its review, completion, and publication.

Members of the Committee on Understanding Underrepresentation made substantial intellectual contributions to this report. They are not, however, responsible for the content of this report, including the findings and recommendations. The Committee on Increasing the Number of Women in Science, Technology, Engineering, Mathematics, and Medicine (STEMM) and the National Academies of Sciences, Engineering, and Medicine (the National Academies) are solely responsible for the final content of the report.

Committee Acknowledgments

This committee would like to thank the members of the Committee on Understanding and Addressing the Underrepresentation of Women in Particular Science and Engineering Disciplines for their diligent work and the substantial intellectual contributions they made to this report. Those committee members analyzed the data on the status of women in multiple STEMM disciplines, documented factors contributing to the persistence of women's underrepresentation despite decades of efforts to mitigate it, and presented examples of the intentional and unintentional resistance that women face at many levels. They also identified effective intervention programs, provided insights into the importance of institutional context in implementing successful programs, and proposed actions to increase the participation of women and girls in STEMM.

In preparing this report, we drew from the full range of resources that had been assembled for the project, including a significant existing research base, recommendations from previous National Academies reports, three individually authored papers commissioned by the National Academies, existing data sets, and substantial background research and writing by the project staff. We also examined new research and conducted our own analysis, drawing on the evidence and the expertise of committee members. In addition, the report builds significantly on the ideas, interpretations of the research, and conclusions of the members of the Committee on Understanding the Underrepresentation of Women. Their analyses are used extensively in the discussions of data and conclusions from the commissioned research papers in Chapters 2 and 3. Also, many of the strategies to implement changes in academic recruitment, retention, and advancement in Chapter 4—which presents 17 practical strategies for higher education institutions to implement change—are strategies articulated by that committee, whom we gratefully acknowledge.

The committee would also like to acknowledge the work of the consultants who have contributed to the report: Jennifer Saunders, Michelle Rodrigues, Kathryn Clancy, Evava Pietre, Corinne Moss-Racusin, Leslie Ashburn-Nardo, Jojanneke Van Der Toorn, Christine Lindquist, and Tasseli McCay. Their commissioned research and writing contributed substantially to the foundation of evidence presented in the report.

We want also to sincerely thank the staff of this project for their valuable leadership and guidance and for the extensive research and writing activities they undertook in support of the study through their work with both committees. Specifically, we would like to thank Ashley Bear, Alex Helman, and Tom Rudin.

Next, we thank the reviewers of the report. This Consensus Study Report was reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise. The purpose of this independent review is to provide candid and critical comments that will assist the National Academies of Sciences, Engineering, and Medicine in making each published report as sound as possible and to ensure that it meets the institutional standards for quality, objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

We thank the following individuals for their review of this report: Molly Carnes, University of Wisconsin; Gabriele González, Louisiana State University; Eve Higginbotham, University of Pennsylvania; Stacie Furst Holloway, University of Cincinnati; Charles Isbell, Georgia Institute of Technology; Anne-Marie Nunez, Ohio State University; Claire Parkinson, NASA Goddard Space Flight Center; Charles Phelps, University of Rochester (Emeritus); Julia Phillips, Sandia National Laboratories (Retired); and Joan Reede, Harvard Medical School.

Although the reviewers listed above provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations of this report nor did they see the final draft before its release. The review of this report was overseen by Maryellen Giger, University of Chicago, and Catherine Kling, Cornell University. They were responsible for making certain that an independent examination of this report was carried out in accordance with the standards of the National Academies and that all review comments were carefully considered. Responsibility for the final content rests entirely with the authoring committee and the National Academies.

Finally, the committee would like thank the sponsors that made this study possible: the National Institutes of Health, the National Science Foundation, and L’Oréal USA.

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Overview

In recent years, the absolute number of women earning degrees across science, technology, engineering, mathematics, and medicine (STEMM) fields has increased relative to men. Despite these gains, women—especially women of color—remain underrepresented with respect to their presence in the workforce and the U.S. population. The disparities in representation vary by discipline and field, yet even in professions in which women are at parity or overrepresented, as is the case in certain sub-disciplines within biology and medicine, there remains a dearth of women among the senior ranks.

This report reviews the current state of knowledge of factors that drive underrepresentation of women in STEMM and provides an overview of existing research on policies, practices, programs, and interventions for improving recruitment, retention, and advancement of women in these fields. The report also evaluates why promising practices have not been implemented by a greater number of institutions. Importantly, the focus of this report is not on "fixing the women," but rather on promoting systemic change in the STEMM enterprise in an effort to mitigate structural inequities, bias, discrimination, and harassment that a substantial body of literature demonstrates significantly undermines the education and careers of women in STEMM.

While several National Academies reports have addressed underrepresentation of women in STEMM fields (see Appendix B for an overview of findings and recommendations from previous National Academies reports), this report distinguishes itself by placing emphasis on the experiences of women of color and women from other marginalized groups who experience intensified biases and barriers. Moreover, the report highlights those shared and distinct barriers faced by women in STEMM disciplines—engineering, computer science, physics, biology, medicine, mathematics, and chemistry—in order to clarify why national patterns of underrepresentation differ according to discipline.

To address specific barriers, the committee obtained evidence of the efficacy of a diversity of strategies and practices that institutions can adopt to improve recruitment, retention, and advancement of primarily White women across a broad range of STEMM disciplines and multiple stages of the educational and career paths. The committee concluded that additional investigation is needed to understand how to support most effectively the participation of women of color and women of other intersecting identities in STEMM and understand better the impact of promising practices on women studying and working in a greater range of institutional contexts (e.g., minority-serving institutions, community colleges).

Research accomplished to date points to a common set of conditions that support institutional adoption of practices to improve recruitment, retention, and advancement of women in STEMM. These include: (1) committed leadership at all levels; (2) dedicated financial and human resources; (3) a deep understanding of institutional context; (4) accountability and data collection—especially as a tool to inform and incentivize progress; and (5) adoption of an intersectional approach that explicitly addresses challenges faced by women of color and other groups who encounter multiple, cumulative forms of bias and discrimination.

Based on analysis of existing evidence, the report offers to a range of stakeholders—Congress, federal agencies, faculty and administrators in higher education, and professional societies—a set of actionable recommendations on how to drive systemic change in STEMM education and careers. The recommendations are intended to work synergistically to incentivize and inform broad adoption of evidence-based promising practices for improving recruitment, retention, and advancement of women in STEMM. Specifically, the nine recommendations and their associated implementation actions support a process by which data-driven accountability, committed leadership, and tangible rewards, resources, and recognition for equity and diversity efforts drive an iterative cycle that comprises four steps: (1) an institution, school, or department collects, analyzes, and monitors quantitative and qualitative data to diagnose issues specific to recruitment, retention, and advancement of both White women and women of color; (2) institutional leaders take action to address shortcomings at the program, school, or department level by drawing upon existing research findings and practices suitable to adopt or adapt for a targeted, evidence-based approach; (3) institution, school, or department repeats the data collection and monitoring to determine whether the intervention has been effective or a new approach is needed; and (4) leaders formally institutionalize effective practices by changes in policy to sustain modification of leadership, budget, and other disruptors with the potential to undermine sustainability.

The research reviewed in this report provides a strong foundation for institutional action to improve recruitment, retention, and advancement of women in STEMM fields.

Summary

Careers in science, engineering, technology, mathematics, and medicine (STEMM) offer opportunities to advance knowledge, contribute to the well-being of communities, and support the security, prosperity, and health of the United States. Many women, however, do not pursue or persist in these careers or advance to leadership positions. The bulk of evidence indicates that underrepresentation of women in STEMM—including at leadership levels—is driven by a wide range of structural, cultural, and institutional patterns of bias, discrimination, and inequity that do not affect men of comparable ability and training.

To date, there have been seven National Academies reports published over the past two decades that have addressed causes and consequences of the underrepresentation of women in science, engineering, and medicine. Among those consequences are:

(1) A national labor shortage in many science, engineering, and medical professions, particularly in technical fields, that cannot be filled unless institutions and organizations recruit from a broad and diverse talent pool.
(2) Lost opportunities for innovation and economic gain, particularly since research shows that more diverse teams generate more innovative solutions to problems, publish higher impact articles, and raise a company's bottom line. In other words, there are opportunity costs to perpetuating a scientific workforce that lacks diversity.
(3) Lost talent as a result of discrimination, unconscious bias, and sexual harassment, which often prevents women from pursuing careers in science, engineering, and medicine.

In this report, which is based on an analysis of current research, the committee provides a range of stakeholders with actionable recommendations on how to take coordinated action to drive necessary changes to the system of science, engineering, and medical education, research, and employment. The committee's recommendations are not aimed at "fixing the women," but instead focus on changing the culture through systemic actions. To do so will require the men and women in Congress, the White House, federal funding agencies (particularly the National Institutes of Health and the National Science Foundation), colleges and universities, and professional societies to approach this issue armed with a heightened sense of urgency and an evidence-based strategy for action.

This report aims to provide both.

THE TASK

The committee was tasked by the National Institutes of Health, the National Science Foundation, and L'Oreal USA to do three things: (1) carry out an analysis and synthesis of the current research on the factors that drive gender disparities in recruitment, retention, and advancement across a range of scientific, engineering, and medical disciplines and throughout the educational and career life course; (2) review the research on evidence-based strategies and practices that research has shown can improve the recruitment, retention, and advancement of women in these fields, with a particular emphasis on improving the representation and inclusion of women of color; and (3) an exploration of why effective interventions have not been scaled up or adopted by more institutions.

In short, the report addresses four questions:

(1) What is the problem? (Chapters 1 and 2)
(2) What are possible solutions? (Chapters 3 and 4)
(3) Why don't we see more progress? (Chapter 5)
(4) What can be done to open doors for women in STEMM? (Recommendations) (Chapter 6)

See Chapter 1 for the full statement of task.

CONCLUSIONS

The committee reached six major conclusions, which are supported by the findings that appear at the end of each chapter in the report.

Conclusion 1: Although the absolute number of women 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.

Conclusion 2: 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[1] women).

Conclusion 3: While some institutions have seen improvements in the representation of women in science, engineering, and medical education and careers, national patterns of underrepresentation are still prevalent at most institutions, especially for women of color.

Conclusion 4: There are numerous effective, evidence-based strategies and practices that institutions can adopt to improve the recruitment, retention, and advancement of White women across a broad range of scientific, engineering, and medical disciplines and multiple stages of the educational and career pathway. However, additional investigation is needed specifically to understand how to support more effectively the participation of women of color and women of other intersecting identities in science, engineering, and medicine.

Conclusion 5: Improving recruitment and retention of women in STEMM throughout their education and training is important, particularly in mathematics-intensive fields such as computer science and engineering. 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).

Conclusion 6: Both research literature and the findings of focus groups that were carried out by the independent nonprofit research institute RTI International on behalf of this study point to a common set of conditions that support institutional adoption of practices to improve the recruitment, retention, and advancement of women, including:

- Committed leadership 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.
- Dedicated financial and human resources—including new or re-directed funds and appropriately compensated individuals in positions of power and authority whose work is dedicated toward opening doors to opportunity and success for women.

[1] Lesbian, Gay, Bisexual, Transgender, Queer, Intersex, and Asexual.

- Accountability and data collection—especially when used as a tool to inform and incentivize progress.
- Adoption of an intersectional approach that explicitly and concretely addresses the challenges faced by women of color and other groups who encounter multiple, cumulative forms of bias and discrimination.

THE IMPORTANT ROLE OF PUBLIC POLICY

This report has multiple audiences because underrepresentation of women in STEMM is a systemic problem that must be addressed by many actors and across many levels. However, the committee has placed significant emphasis in this report on policy change. Congress, the White House, and government agencies have both the capacity and the obligation to assume an important catalytic role in incentivizing the creation and implementation of policies, programs, and strategies to mitigate the biases and barriers currently undermining the recruitment, retention, and advancement of women in science, engineering, and medicine. Accordingly, although much of the leadership responsibility falls on faculty and administrators in the nation's colleges and universities to remedy inequities within the academic community, *the policy community has powerful levers to encourage innovation and action.*

The committee's recommendations offer guidance to leaders from multiple sectors on how to move forward with intentional, evidence-based strategies and policies to improve recruitment, retention, and advancement of women in science, engineering, and medicine and thereby significantly enhance national prosperity, security, and well-being.

RECOMMENDATIONS

The committee's recommendations are grouped into four broad categories, which are targeted at incentivizing and informing the broad adoption of evidence-based promising practices for improving the recruitment, retention, and advancement of women in science, engineering, and medicine:

1. **Driving transparency and accountability**. Institutions must articulate and deliver on measurable goals and benchmarks that are regularly monitored and publicly reported. Multiple studies have demonstrated that transparency and accountability can drive behavior change.

2. **Adopting data-driven approaches to address underrepresentation of women in STEMM**. The committee recommends a targeted data-driven approach to closing the gender gap in science, engineering, and medicine. Such an approach includes, for example, dissecting the barriers by discipline and career stage, recognizing explicitly that interventions and

strategies that generally work well for White women may not work well for women of color and, in addition, using disaggregated data collection, analysis, and monitoring as the basis for constructing specific interventions within the unique context of each institution.

3. **Rewarding, recognizing, and resourcing equity, diversity, and inclusion efforts.** 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 are most affected by these issues, will assume a leadership role in promoting positive change without appropriate compensation, authority, or promise of reward or recognition.

4. **Filling knowledge gaps.** Although scholarly research on gender disparities in science, engineering, and medicine has yielded an abundance of information that can be applied toward reaching gender equity, there are critical knowledge gaps that require closer attention.

These four broad categories are not, in fact, distinct, but rather are fundamentally interconnected components of a complex system of actors, incentives, and information. Drivers of transparency and accountability yield new information that can inform targeted, data-driven interventions, while at the same time providing incentives for greater resource allocation toward equity, diversity, and inclusion. The committee contends that the interconnectedness of these recommendations underlies their strength. This is not to say that individual recommendations, if implemented by stakeholders, cannot have a tangible impact, but that systemic change is needed to effect rapid change on this issue and is suited to a systemic approach.

In addition to high-level recommendations, for each recommendation the committee offers a series of implementation actions designed to provide stakeholders with specific practical advice. In many instances, the committee intentionally developed these implementation actions so that they can take advantage of existing infrastructure and activities and modify them in specific ways to facilitate execution of the recommendations.

I. DRIVING TRANSPARENCY AND ACCOUNTABILITY

The legislative and executive branches of the federal government have the power to serve as drivers of transparency and accountability in the scientific, engineering, and medical enterprise. In Chapter 5, the committee found that transparency and accountability are critical levers for driving positive change in equity and diversity efforts. Therefore, the committee recommends several actions that can increase public transparency and accountability so that the nature, extent, and impact of federal agency and university efforts will ensure equity, diversity, and inclusion in the scientific, engineering, and medical workforce. In addition to increasing transparency and accountability, these recommendations serve other functions. For example, if implemented with fidelity, the recommendations can highlight the extent to which each federal agency makes equity, diversity, and inclusion a priority by documenting the qualitative and quantitative impact of their efforts.

RECOMMENDATION 1: 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 existing efforts that take an intersectional approach.

Implementation Actions

Action 1-A: The director of the White House Office of Science and Technology Policy, in collaboration with the National Institutes of Health (NIH) and National Science Foundation (NSF) co-chairs of the Subcommittee on Safe and Inclusive Research Environments of the Joint Committee on the Research Environment, should annually catalog, evaluate, and compare the various efforts by the federal science agencies to broadly support the recruitment, retention, and advancement of women in science, engineering, and medicine. The director should task the subcommittee with publishing an annual, open-access report, modeled after NSF's summary table on programs to broaden participation in their annual budget request to Congress, that documents existing programs at each agency, with particular emphasis on programs that take an intersectional approach, accounting for the experiences of women of color and women of other intersecting identities (e.g., women with disabilities, LGBTQIA), and the qualitative and quantitative impact of these programs, using program evaluation metrics and data, when collected.[2]

Action 1-B: Congress should commission a study by an independent entity, such as the Government Accountability Office, to offer an external evaluation and review of the existing federal programs focused on supporting greater equity, diversity, and inclusion in science, engineering, and medicine. Such a study should result in a publication that documents the nature, impact across

[2] The committee recognizes that programs will have different metrics of success, depending on what the goals of the program are and that direct comparison of programs across agencies will not be possible. However, the evaluation will examine the data collected on the outcomes of the programs included and the extent to which the program met its goals.

various groups, and prioritization of these programs, as described above, across federal agencies.

RECOMMENDATION 2: 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.

Implementation Actions

Action 2-A: Federal funding agencies should carry out an "equity audit" for grantee institutions that have received a substantial amount of funding over a long period of time to ensure that the institution is working in good faith to address gender and racial disparities in recruitment, retention, and advancement. Institutions could be electronically flagged by the funding agency for an equity audit after a certain length of funding period is reached. An evaluation of the representation of women among leadership should be included in such an audit. Equity audits should include a statement from institutions to account for the particular institutional context, geography, resource limitations, and mission and hold that institution accountable within this context. It should also account for progress over time in improving the representation and experiences of underrepresented groups in science, engineering, and medicine and should indicate remedial or other planned actions to improve the findings of the audit. The equity audit should result in a public facing report that will be available on the agency's website.

Action 2-B: Federal agencies should consider institutional and individual researchers' efforts to support greater equity, diversity, and inclusion as part of the proposal compliance, review, and award process. To reduce additional administrative burdens, agencies should work within existing proposal requirements to accomplish this goal. For example, NSF should revise the guidance to grantees on NSF's "Broader Impact" statements, and NIH should revise the guidance to grantees on the "Significance" section in the research plan to include an explicit statement on efforts by the prospective grantee and/or institution to promote greater equity, diversity, and inclusion in science, engineering, and medicine. While many grantees currently describe equity, diversity, and inclusion efforts as part of these sections of NSF and NIH proposals, historically, these sections of the proposals have served, first and foremost, to document the societal impact of the research (e.g. addressing climate change, curing cancer, etc.). The latter function of these sections of the proposal is critical and should not be replaced by the description of equity, diversity, and inclusion efforts. Rather this section of the proposal should be expanded to include commentary on *both* of these critical components of federally funded research. Moreover, these sections of proposals should be scored and taken seriously in funding recommendations by review panels and funding decisions by agency personnel. If such sections of proposals are given different consideration by different institutes, departments, and directorates, effort should be made to standardize the weight given to these sections of the proposal across the agency. For example, the National Science Board could carry out a review of past NSF awards to determine how the NSF Directorates have accounted for gender equity, diversity, and inclusion among the metrics evaluated in proposals submitted to NSF.

II. TARGETED, DATA-DRIVEN INTERVENTIONS BY COLLEGES AND UNIVERSITIES[3]

In many ways, the recommendations in this section represent the most direct action items of this report. These recommendations are based on the committee's comprehensive analysis of data on specific strategies and best practices that can improve the participation and advancement of women in science, engineering, and medicine.

The recommendations offered by the committee in this section also outline a change process. The process starts with an administrative unit (e.g., department, school, or university) collecting, analyzing, and monitoring quantitative and qualitative data to diagnose specific problems with recruitment, retention, and advancement and then to take action to address shortcomings by drawing upon existing research and practices to adopt targeted, evidence-based solutions. The next step in the process is to repeat the data collection and monitoring to determine whether the treatment has been effective or whether a new approach is needed. The final step in the process is to formally institutionalize effective practices through policy changes so they can sustain transitions in leadership, budget fluctuations, and other potential disruptors that could undermine the sustainability of the effort.

The committee recommends a change process, rather than a single blueprint for action, because there is no single approach that will work in every institutional context. Institutions vary in mission, student demographics, student needs, and resource constraints and a particular strategy may work well at one institution and poorly at another. For this reason, the committee recommends that institutions adopt or adapt the strategies and practices outlined in this report and iterate over time to develop an approach that will work well for their particular institution and the people it serves.

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[3] Because there is a significant academic orientation to this report—with college and university administrators being a primary audience—the committee has configured recommendations targeted directly to higher education leaders. Many of the ideas and recommendations here, however, can be easily adopted or adapted by private sector employers and government agency employers that also aim to close the gender gap in science, engineering, and medical fields.

RECOMMENDATION 3: College and university deans and department chairs should annually collect, examine, and publish[4] 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 (see Recommendations 5 and 7 for guidance on specific strategies and practices leaders can adopt or adapt to address issues with recruitment, retention, and advancement, piloting and modifying them as appropriate, such that they are effective within the particular context of the institution).

Implementation Actions

Action 3-A: College and university deans and department chairs should collect and monitor department-level demographic data, leveraging data already being collected by their institution in compliance with data reported to the Integrated Postsecondary Education Data System, annually to determine whether there are patterns of underrepresentation among students, trainees, residents, clinical fellows, faculty, and staff, including in leadership roles. Specifically, deans and department chairs should request the following types of data and track these data over time:

a. Demographic composition of the students currently enrolled and recently graduated in a given department or college. These data should be disaggregated by gender and race/ethnicity and should be tracked over time.
b. Longitudinal demographic composition of the faculty disaggregated by faculty rank, department, gender, and race/ethnicity.
c. Longitudinal demographic composition of postdoctoral researchers, residents, clinical fellows and staff scientists, disaggregated by department, gender, and race/ethnicity.

This information should be used to adopt or adapt evidence-based promising and effective practices, taking into account the particular context of the institution (see Recommendation 5).

RECOMMENDATION 4: College and university administrators should dedicate resources to carry out qualitative research on the climate in the school or department and the experiences of underrepresented groups and use this information to shape policies and practices aimed at promoting an inclusive climate and supporting underrepresented groups enrolled or employed at the institution.

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[4] Except in cases for which reporting such data would publicly identify individuals and breach anonymity. For such data, the report should indicate that the numbers are "too low to report."

Implementation Actions

Action 4-A: College and university administrators should work with an evaluator outside the relevant unit to support periodic climate research to assess the climate in the school or department in a manner that is methodologically sound, independent, objective, and free from bias and conflict of interest. Climate research can take the form of surveys, focus groups, and/or interviews.

Action 4-B: Given the extremely low representation of women of color in most science, engineering, and medical fields, administrators and external evaluators should work together to adopt a methodological approach that can protect the anonymity of such individuals and accurately capture their experiences. In some instances, interviews may serve as the most appropriate means to gather this information. It should be noted that, in some settings, researchers from a single institution may not be able to sufficiently protect the anonymity of women of color, who make up an extreme minority in certain fields, and so it may be best to conduct such research across an institutional system. Protecting sensitive, personal information will also be aided by the use of an external consultant that can hold the raw data and report only aggregated findings to the departmental leadership.

RECOMMENDATION 5: Taking into account the institutional context, college and university presidents, deans, department chairs, and other administrators should adopt or adapt actionable, evidence-based strategies and practices (see Implementation Actions 5A—5C) that directly address particular gender gaps in recruitment, retention, and advancement of women in science, engineering, and medicine within their institution, as observed by quantitative and qualitative data analysis and monitoring (see Recommendations 3 and 4 above).

Implementation Actions

Action 5-A: To work to improve the recruitment and retention of women in STEMM education, faculty and administrators in higher education and K-12 education should adopt the following approaches:

a. Reorganize STEMM courses to incorporate *active learning exercises* (e.g., having students work in groups, use clickers) and integrated peer-led team learning.
b. Promote a growth mindset by communicating to students that ability in STEMM fields can be improved by learning.
c. Challenge stereotypical assumptions about the nature of STEMM careers by communicating to students that scientists often work in teams, conduct research focused on helping others, and have lives outside of work.

d. Take steps to expose students to a diverse set of role models in STEMM that challenge the persistent societal stereotype that STEMM professionals are heterosexual, cis-gendered, White men. For example, faculty and administrators should give assignments that require students to learn about the work of women who have made significant contributions to the field; work to ensure that the faculty in the department are diverse, such that students take courses and conduct research with people from a range of different demographic groups; and invest in educational materials (e.g., textbooks and other instructional media) that highlight the diverse range of people who have contributed to science, engineering, and medicine.
e. Strive for gender balanced classroom and group composition, and take steps to promote equitable classroom interactions.

Action 5-B:[5] To address issues with the recruitment of women into academic programs and science, engineering, and medical careers, admissions officers, human resources officers, and hiring committees should:

a. Work continuously to identify promising candidates from underrepresented groups and expand the networks from which candidates are drawn.
b. Write job advertisements and program descriptions in ways that appeal to a broad applicant pool and use a range of media outlets and forms to advertise these opportunities broadly.
c. Interrogate the requirements and metrics against which applicants will be judged to identify and either eliminate or lessen the emphasis given to those that are particularly subject to bias and may also be poor predictors of success (e.g., certain standardized test scores).
d. Decide on the relative weight and priority of different admissions or employment criteria *before* interviewing candidates or applicants.
e. Hold those responsible for admissions and hiring decisions accountable for outcomes at every stage of the application and selection process.
f. Educate evaluators to be mindful of the childcare and family leave responsibilities often faced by women, especially when considering "gaps" in a resume.
g. When possible, use structured interviews in admission and hiring decisions.
h. Educate hiring and admissions officials about biases and strategies to mitigate them.
i. Increase stipends and salaries for graduate students, postdocs, nontenure-track faculty, and others to ensure all trainees and employees are paid a living wage.

[5] See Chapter 4.

Action 5-C:[6] To address issues with retention of women in academic programs and within science, engineering, and medical careers, university and college administrators should:

a. Ensure that there is fair and equitable access to resources for all employees and students.
b. Take action to broadly and clearly communicate about the institutional resources that are available to students and employees and be transparent about how these resources are allocated.
c. Revise policies and resources to reflect the diverse personal life needs of employees and students at different stages of their education and careers and advertise these policies and resources so that all are aware of and can readily access them.
d. Create programs and educational opportunities that encourage an inclusive and respectful environment free of sexual harassment, including gender harassment.
e. Set and widely share standards of behavior, including sanctions for disrespect, incivility, and harassment. These standards should include a range of disciplinary actions that correspond to the severity and frequency for perpetrators who have violated these standards.
f. Create policies that support employees during times when family and personal life demands are heightened—especially for raising young children and caring for elderly parents. For example, stop-the-clock and modified duty policies, which should be available to as wide a group as possible, should be a genuine time-out from work and should not penalize those who take advantage of the policies.
g. Provide private space with appropriate equipment for parents to feed infants and, if needed, to express and store milk.
h. Create policies and practices that address workers' need to balance work and family roles (including not only child and family care but also responsibilities for attending to children's school and extracurricular activities).
i. Limit department meetings and functions to specified working hours that are consistent with family-friendly workplace expectations.

Action 5-D: In order to be effective mentors and to create more effective mentorship relationships, faculty and staff should recognize that identities influence academic and career development, and thus are relevant for effective mentorship. As such:

a. Institutional leadership should intentionally support mentorship initiatives that recognize, respond to, value, and build upon the power of diversity.

[6] See Chapter 4.

Leaders should intentionally create cultures of inclusive excellence to improve the quality and relevance of the STEMM enterprise.

b. 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 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.
c. Mentees should reflect on and acknowledge the influence of their identities on their academic and career trajectory and should seek mentorship that is intentional in considering their individual lived experiences.

Action 5-E: Institutional leaders, as well as individual faculty and staff, should support policies, procedures, and other infrastructure that allow mentees to engage in mentoring relationships with multiple individuals within and outside of their home department, program, or institution, such as professional societies, external conferences, learning communities, and online networks, with the ultimate goal of providing more comprehensive mentorship support.

Action 5-F: Colleges and universities should provide direct and visible support for targets of sexual harassment. Presidents, provosts, deans, and department chairs should convey that reporting sexual harassment is an honorable and courageous action. Regardless of a target filing a formal report, academic institutions should provide means of accessing support services (social services, health care, legal, career/professional). They should provide alternative and less formal means of recording information about the experience and reporting the experience if the target is not comfortable filing a formal report. Academic institutions should develop approaches to prevent the target from experiencing or fearing retaliation in academic settings.

Action 5-G: Colleges and universities should create "counterspaces"[7] on their campuses that provide a sense of belonging and support for women of color and serve as havens from isolation and microaggressions. Such counterspaces can operate within the context of peer-to-peer relationships; mentoring relationships; national STEMM diversity conferences; campus student groups; and science, engineering, and medical departments. Counterspaces can be physical spaces, as well as conceptual and ideological spaces.

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[7] Researchers have defined counterspaces to be "academic and social safe spaces that allow underrepresented students to: promote their own learning wherein their experiences are validated and viewed as critical knowledge; vent frustrations by sharing stories of isolation, microaggressions, and/or overt discrimination; and challenge deficit notions of people of color (and other marginalized groups) and establish and maintain a positive collegiate racial climate for themselves" (Solorzano and Villalpando, 1998; Solorzano et al., 2000).

RECOMMENDATION 6: Federal agencies should support efforts and research targeted at addressing different profiles of underrepresentation in particular scientific, engineering, and medical disciplines throughout the educational and career life course.

Implementation Actions

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:

a. 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:

    i. those that incorporate growth mindset interventions that impress upon students that skills and intelligence are not fixed, but, rather, are increased by learning;
    ii. those that highlight that scientists and engineers are well positioned and equipped to do work that has a positive societal impact;
    iii. those that highlight the contributions of a diverse array of people to the scientific, engineering, and medical enterprise today and throughout history.

b. 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).
c. 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.

Action 6-B: Across all science, engineering, and medical disciplines, federal agencies should:

a. Address funding disparities for women researchers, particularly for women of color. For example, NIH should address disparities in success rates of Type 1 R01 awards for African American women compared with White women;
b. Directly (e.g., through supplements) and indirectly (e.g., through specific programs) support the work-life integration needs of women (and men) in science, engineering, and medicine; and
c. In addition to programs designed to support mentorship, support investigation into the impact of sponsorship on advancement of both White women and women of color into leadership roles in science, engineering, and medicine.

III. PRIORITIZE, RECOGNIZE, REWARD, AND RESOURCE

The committee recommends that institutions, both academic and governmental, sustainably allocate resources and authority to the leaders of equity, diversity, and inclusion efforts, while providing positive incentives for faculty—in the context of promotions and rewards and recognition by honorific and professional societies—that could promote culture change yielding broader recognition that fostering an inclusive scientific, engineering, and medical enterprise is a broadly shared 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.

Implementation Actions

Action 7-A: University administrators should institutionalize effective policies and practices so that they can sustain transitions in leadership by, for example, writing them into the standing budget and creating permanent diversity, equity, and inclusion-related positions.

Action 7-B: University and college administrators should appropriately compensate and recognize individuals responsible for equity and diversity oversight and equip them with sufficient resources and authority.

Action 7-C: Academic senates of universities should adopt amendments to faculty-review committee criteria that formally recognize, support, and reward efforts toward increasing diversity and creating safe and inclusive research environments. Adopting these criteria sets the expectation that promoting inclusivity is everyone's responsibility and encourages faculty involvement in university diversity initiatives. Formal recognition of efforts to promote equity, diversity, and inclusion should include consideration of effective mentoring, teaching, and service during hiring decisions, in determining faculty time allocations, and in decisions on advancement in rank, including tenure decisions.

Action 7-D: Professional and honorific societies should:

a. Create special awards and honors that recognize individuals who have been leaders in driving positive change toward a more diverse, equitable, and inclusive scientific, engineering, and/or medical workforce.
b. Monitor the diversity of nominees and elected members in the society over time.
c. Adopt policies that discourage panels of speakers composed entirely of a single demographic group (e.g., White men) at meetings.

RECOMMENDATION 8: Federal agencies and private foundations should work collaboratively to recognize and celebrate colleges and universities that are working to improve gender equity.

Implementation Actions

Action 8-A: NIH and NSF should collaborate to develop a recognition program that provides positive incentives to STEMM departments and programs on campuses to make diversity, equity, and inclusion efforts a high priority. Departments and programs would compete to be recognized for their success in closing gender gaps in STEMM. Such a program would include multiple rounds: the first to allow departments and programs to develop plans to self-assess their progress and plans toward the goal; the second to create and implement new programs and practices; and the third to show improvement from the original evaluation. In order for institutions to compete equitably for this recognition, departments and programs that apply should compete against similar institutions. For instance, departments and programs that apply could compete only against other institutions within the same Carnegie Classification. After initial exploration of this model by NIH and NSF, other federal agencies could be encouraged to adopt a similar model.

Action 8-B: Federal agencies should provide financial assistance to institutions that would like to be recognized for their efforts to improve diversity, equity, and inclusion. These grants would support the resource-intensive data collection that is required to compete for these awards, which, for example, in the United Kingdom often falls to women, and would be granted on a needs-based justification, with priority given to underresourced universities.

Action 8-C: Private foundations should require that awardee institutions complete a self-evaluation, specific to the departmental policies, similar to the New York Stem Cell Foundation's Initiative on Women in Science and Engineering, which required institutions to complete a gender-equity report card before receiving funding. To continue receiving funding from these private foundations, departments must show improvement, or plans to make improvements, to gender equity in their departments.

IV. FILLING KNOWLEDGE GAPS

Although the committee's recommendations speak to actions that leaders and employees at academic institutions and in the government can initiate immediately to promote positive change more broadly experienced by women in science, engineering, and medicine, critical knowledge gaps still exist and must be filled, with deliberate speed, to support most effectively the improved recruitment, retention, and advancement of all women in science, engineering, and medicine.

RECOMMENDATION 9: Although scholarly research on gender disparities in science, engineering, and medicine has yielded an abundance of information that can be applied toward reaching gender equity, critical knowledge gaps remain and require very close attention. These include:

- **a. Intersectional experiences of women of color, women with disabilities, LGBTQIA women, and women of other intersecting identities (e.g., age).**
- **b. Strategies and practices that can support improved recruitment, retention, and advancement of women of color and women of other intersecting identities.**
- **c. Factors contributing to the disproportionate benefit accruing to White women of practices adopted to achieve gender equity.**
- **d. Specific factors contributing to successes and failures of institutions that have adopted policies and/or implemented programs aimed at diversifying the science, engineering, and medical workforce.**
- **e. Long-term evaluation of the promising practices listed in the report—specifically, how their sustained implementation influences the recruitment, retention, and advancement of women over time.**
- **f. Strategies and practices that have been demonstrably most effective in supporting STEMM women faculty and students in nonresearch-intensive institutions, such as community colleges.**
- **g. Characteristics of effective male allies and approaches to training allies.**

1

An Introduction to the Problem of Gender Inequities in U.S. STEMM Fields[1]

In recent years, the absolute number of women earning degrees across science, engineering, technology, mathematics, and medicine (STEMM) fields has increased compared to men. For example, between 2004 and 2014, 2,924,660 women earned bachelor's degrees in science and engineering compared to 2,890,904 men. Despite this increase, women—especially women of color—are underrepresented relative to their presence in the workforce and the U.S. population (see Figures 1-1 and 1-2) (NSF, 2017). The disparities in number and proportional representation vary by discipline and field (see Figure 1-3), yet, even in professions in which women are at parity or overrepresented, as is the case in certain sub-disciplines within biology and medicine, there remains a dearth of women among the senior ranks in these fields (see Figure 1-4).

In theory, this underrepresentation of women in senior leadership roles should diminish organically over time, as the number of women earning degrees and entering the workforce increases, but past patterns indicate that time alone may be insufficient to close existing gaps. In medicine, for example, women have for the last quarter-century comprised at least 40 percent of U.S. medical students, yet, as of 2018, women accounted for only 18 percent of hospital chief executive officers and 16 percent of medical school deans and department chairs (Bickel, 2004; Holman et al., 2018; Mangurian et al., 2018). Based on an analysis of 15 years of publication patterns of 36 million authors from more than 100 countries in more than 6,000 journals, Holman et al. (2018) predicted that, absent reforms in education and publishing, gender gaps in certain STEMM specialties may persist for decades (Holman et al., 2018).

[1] This chapter builds on the significant contribution of the Committee on Understanding and Addressing the Underrepresentation of Women in Particular Science and Engineering Disciplines.

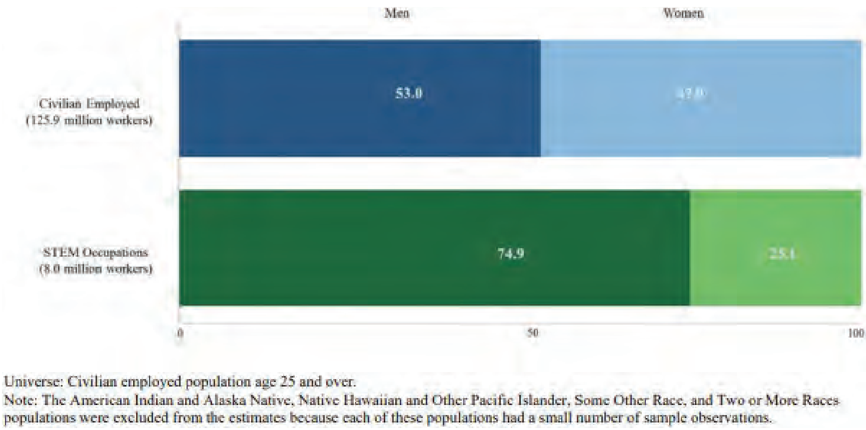


FIGURE 1-1 Percentages of the workforce that are men and women by occupational group.
SOURCE: U.S. Census Bureau, 2012–2016 American Community Survey (ACS) 5-Year Estimates, available at https://www.census.gov/content/dam/Census/library/working-papers/2019/demo/sehsd-wp2018-27.pdf.

The gender gaps that have characterized most U.S. STEMM fields for the past 50 years merit attention because such gaps exact both explicit and opportunity costs for the nation's scientific enterprise. Multiple components of STEMM fields demonstrably benefit from gender diversity. Using citation analysis to assess impact, for example, Smith-Doerr et al. (2017) demonstrated that gender-heterogeneous

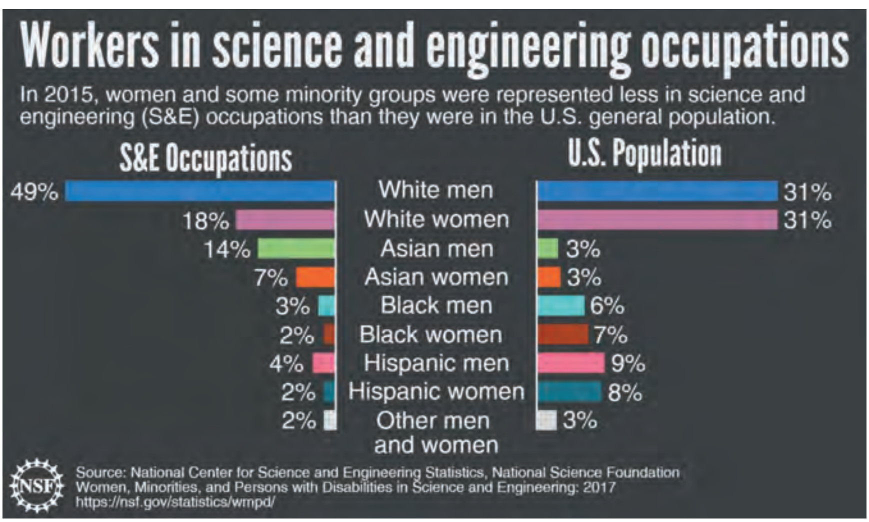


FIGURE 1-2 Percentage of women in science and engineering occupations, with a bachelor's degree and above, by discipline.
SOURCE: National Science Foundation.

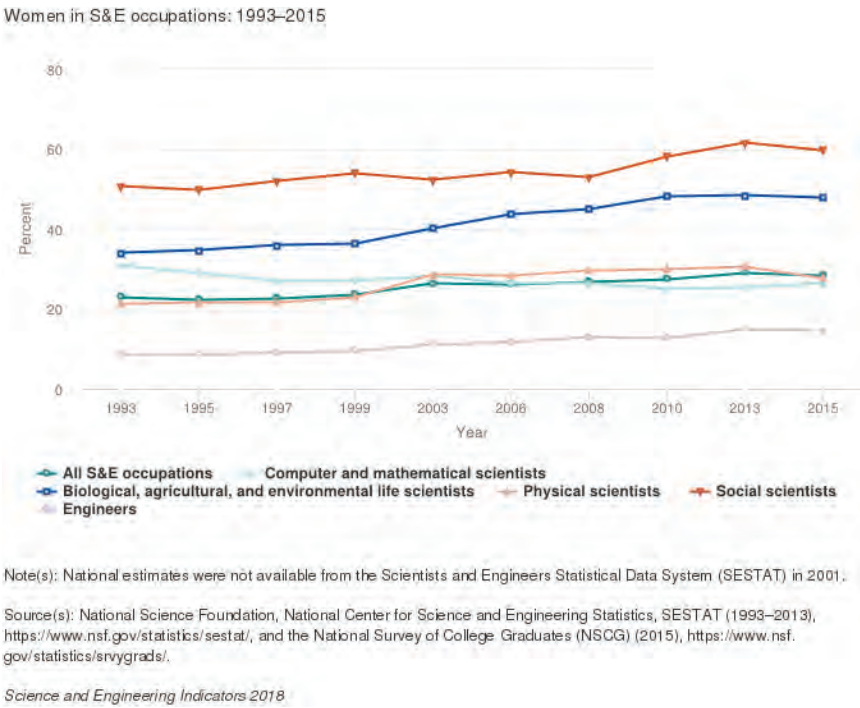


FIGURE 1-3 Percentage of women in science and engineering occupations, with a bachelor's degree and above, by discipline.
SOURCE: National Science Foundation.

problem-solving teams produce more influential scientific papers than do single-gender teams, and more diverse teams generate more innovative solutions to problems (Díaz-García et al., 2012; Page, 2019; Smith-Doerr et al., 2017). The quality of peer review (Murray et al., 2018) and productivity of collaborative science increase with gender diversity as well (Woolley et al., 2010). Moreover, in the 2011 National Research Council rankings of doctoral programs, gender diversity is positively associated with rank (as is racial diversity) (Henderson and Herring, 2013).

Long-standing gender stereotypes that attribute inequities to innate biological differences in aptitude or ability are not reinforced by an abundance of evidence (Barres, 2006; Bian et al., 2017b). Rather, no significant biological differences between the performance of men and women in science and mathematics have been found that can account for the lower representation of women in these fields (NASEM, 2007; Riegle-Crumb et al., 2012). The bulk of evidence indicates instead that underrepresentation of women in STEMM—including at leadership levels—is driven by a wide range of structural, cultural, and institutional patterns of bias, discrimination, and inequity that do not affect men of comparable ability and training (Cortina et al., 2013; Milkman et al., 2015; Moss-Racusin et al., 2012; Rodrigues, In Review).

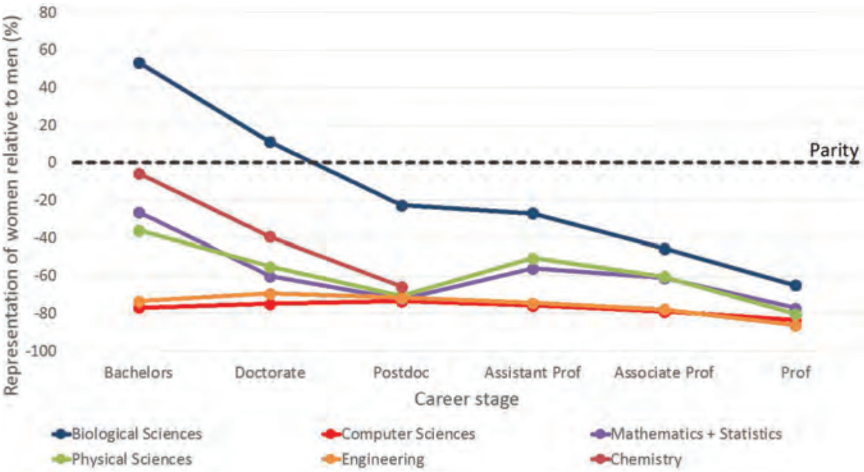


FIGURE 1-4 Representation disparity between men and women across STEM disciplines. Relative to men, women are underrepresented at all career stages (bachelor's, doctorate, postdoctorate, and professor) across nearly every STEM discipline. Representation of women is above parity at the bachelor's and doctorate levels for biological sciences, but below parity at more advanced levels. Dotted line indicates parity. Data from surveys conducted by the National Science Foundation (2016–2017).
SOURCE: National Science Foundation.

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 systemically disadvantage members of these groups relative to White and Asian-American males (Cuddy et al., 2007; Dixon and Rosenbaum, 2004; Dovidio et al., 1986; Fazio et al., 1995; Fiske, 2010; Fiske et al., 2002; Gaertner and McLaughlin, 1983; Kay and Jost, 2003; NSF, 2018). Notwithstanding moral, ethical, and justice arguments in favor of equitable participation in STEMM, the lack of diversity in many STEMM fields has consequences for the productivity and long-term sustainability of the enterprise. Specifically, there is a national labor shortage of STEMM professionals in certain disciplines (e.g., computer science)[2] that cannot be addressed by continuing to rely on the contributions of groups that are currently

[2] Labor shortages in STEMM fields are found in some disciplines and not others and change over time. In general, the academic sector is oversupplied, but there are labor shortages in government and industry in certain disciplines and sub-disciplines (e.g. cybersecurity), available at: https://www.bls.gov/opub/mlr/2015/article/stem-crisis-or-stem-surplus-yes-and-yes.htm.

overrepresented in the STEMM workforce (i.e., White and Asian American men) (see Figure 1-3) (PCAST, 2012).

In terms of identifying institutional changes that can reverse entrenched patterns of underrepresentation of women in STEMM fields, insights can be gained from examining policies and practices implemented by institutions that have in fact succeeded in narrowing gender gaps. Two early examples are Harvey Mudd College in Claremont, California, and Carnegie Mellon University in Pittsburgh, Pennsylvania: Against a pattern of steadily declining numbers of women earning bachelor's degrees in computer science, these schools substantially increased the number of women graduates in this field (Fisher et al., 1997). At Harvey Mudd College, half of students in 2016 with undergraduate degrees in computer science, engineering, and physics were women compared with 18 percent of computer science graduates nationwide (Weisul, 2017). Similarly, in the same year, nearly 50 percent of incoming classes at Carnegie Mellon University's School of Computer Science and College of Engineering were women (CMU, 2016) (see Box 1-1).

Similarly, at the University of Michigan in Ann Arbor, sustained institutional support for a range of interventions developed through the National Science

BOX 1-1
Success Stories in Computer Science and Engineering

Below are some examples of institutions that had great success in graduating women in fields where they are traditionally underrepresented by taking into account the context and needs of their institutions:

- **Harvey Mudd College** graduated more than 50 percent women computer science majors in their 2018 class by redesigning their introductory class, a move driven by campus feedback. After observing that many of the men in the introductory computer science class had grown up programming, and so were better prepared for the introductory material than most of the women, the university developed a second intro course specifically designed for students with no previous experience with computer programming. Faculty also worked deliberately to counter the stereotype that computer scientists work in isolation by developing collaborative class projects and assignments.
- At **Carnegie Mellon University**, directed efforts to recruit women resulted in an increase of representation from 7 percent to 42 percent over 5 years from 1995–2000. Changing admission criteria to avoid privileging extensive computer science experience at the high school level was effective. Overall, direct recruitment focused on admitting higher numbers of women, bridge programs between high school and undergraduate studies, and inclusive policies have been successful at improving women's representation in computer science.

BOX 1-2
Example: 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.

Foundation ADVANCE[3] program led to an increase in the percentage of women hired (as a proportion of all new faculty hired) from 13 percent in 2003 to 31 percent in 2016 (see Box 1-2).

Success stories at research intensive universities such as Carnegie Melon, Harvey Mudd, and University of Michigan offer valuable lessons learned; however, it is important to acknowledge that the vast majority of students in the United States, including women students, are post-traditional[4] students pursuing education at other kinds of institutions. Post-traditional students tend to be older, live off campus, have children and jobs, and earn their degrees over longer time

[3] The NSF ADVANCE program provides grants to enhance the systemic factors that support equity and inclusion and to mitigate the systemic factors that create inequities in the academic profession and workplaces. The goal of this program is to broaden the implementation of evidence-based systemic change strategies that promote equity for STEM faculty in academic workplaces and the academic profession.

[4] The U.S. Department of Education uses the term "nontraditional" to refer to these students. However, this committee prefers the term "post-traditional" to signal the value these students bring to their colleagues.

5. Making sustained and conscious efforts to counter potential evaluation bias, including ensuring all search committee members and department faculty have a clear and shared understanding of the criteria.
6. Providing a welcoming environment during the interview, including attempting to avoid "tokenism" in the interview pool by interviewing more than one female/minority candidate.
7. Encouraging circumstances that will allow seeing the candidates at their best, including providing complete information about the visit well in advance.
8. Ensuring that all candidates know about dual-career support and family-friendly policies.
9. Managing the decision-making process, including considering only job relevant criteria in evaluating candidates.
10. Recruiting the selected candidate, including providing detailed information to ensure that the negotiation process is positive and effective for all candidates.

The program has reported progress in recruiting women in the three colleges that employ the largest number of scientists and engineers at the university (engineering, literature, science, and the arts, and medicine). Specifically, as a proportion of all science and engineering tenure-track hires, 14 percent of all new hires were women in 2001 and 2002 (the "pre-ADVANCE" years) compared to 34 percent in 2003–2006 (a statistically-significant increase). The program also reports that prior to the ADVANCE program, the chemistry department's average representation of women in the applicant pool (1998–1999 to 2002–2003) was 10 percent. After the program, the average representation of women in the applicant pool increased to 18 percent (University of Michigan, 2019).

frames. Only 26 percent of students today fit the "traditional" profile of the student who enrolls in college or university full time in the fall after high school graduation, lives on campus, does not work while enrolled in school, and completes a bachelor's degree in 4 years (Brown, 2017) (see Box 1-3 for additional discussion of post-traditional students).

Community colleges are often well prepared to serve the needs of post-traditional students (NASEM, 2016) and many are taking an active role in increasing the number of women in STEMM. Women make up the majority of community college students (56 percent) (Horn et al., 2006) and research has indicated that community colleges can be a good training ground for women interested in entering STEMM fields (AAUW, 2013). In addition, racial and ethnic minorities are more likely to be enrolled at community colleges than in 4-year institutions (Horn et al., 2006; NASEM, 2016). This is particularly true for Hispanic students. In 2016, nearly half of all Hispanic students were enrolled in a community college, compared to 30 percent of White students (Pew Research Center, 2016). Therefore, community colleges are a critical pathway to advance women, particularly

BOX 1-3
Efforts by Community Colleges to Increase Representation of Women in STEMM

Below are select examples of some innovative efforts at community colleges to advance women in STEMM fields.

The CalWomen Tech Project program was designed to recruit and retain women in STEMM at community colleges by focusing on outreach, recruiting policies, addressing gaps in skills, and improving the culture in classrooms to promote women's participation. The program operated at eight California community colleges and was focused on the concept that most educators and employers are eager to recruit and retain women in STEMM. The project had demonstrated results as four colleges had increased the retention rates of female students substantially. Two CalWomen Tech colleges saw large increases in female completion rates early in the project. At Evergreen Valley College, the completion rate among women went from 73 percent to 100 percent in 9 months. At San Diego Mesa College, the completion rate went from 81 percent to 100 percent within a year. (CalWomen Tech Project, 2019).

The Mathematics, Engineering, Science Achievement Community College Program was established in 1993 and serves students at 36 community colleges in California with a focus on increasing the number of educationally disadvantaged community college students in STEMM. The program focuses on supporting community college students throughout their experiences, from enrollment until they successfully transfer to a 4-year institution. Several key program components address significant barriers facing women in STEMM at community colleges. While the program has enrolled less than 1 percent of the entire California community college population, in 2010, it produced 8 percent of all California transfer students in STEMM. More than 553 students, including more than 200 women, transferred to either California State University or the University of California system during this period and 40 percent of the participating students were women (AAUW, 2013).

women of color, in STEMM. See Box 1-3 for several examples of efforts by community colleges to increase representation of women in STEMM.

In addition to community colleges, minority serving institutions (MSIs), which have the most diverse student bodies in the nation, are another group of institutions that are well-equipped to prepare post-traditional students for careers in STEMM (NASEM, 2019a). The 2019 National Academies report on MSIs found that a slightly higher percentage of undergraduate students are enrolled in STEM fields at 4-year MSIs than at 4-year non-MSIs (NASEM, 2019a). Historically Black Colleges and Universities (HBCUs) are well known for producing a large number of African American scientists (NASEM, 2019a), many of whom are women. Between 1995 and 2004, 46 percent of Black women who earned STEM degrees received their degree from an HBCU (Arroyo, 2009). Additionally, among Black women students who earned doctorates in science and engineering, over 30 percent began their education at an HBCU (Arroyo, 2009). These institutions are uniquely prepared to educate and prepare a diverse STEMM workforce

BOX 1-4
Women in STEMM at Historically Black Colleges and Universities

Historically Black colleges have played an important role in increasing the number of underrepresented minorities in STEMM and there are several examples where HBCUs have also been successful in increasing the number of women in these fields. A few select examples include:

Dillard University, an HBCU, located in New Orleans, Louisiana, boasts the second highest number of African American women physics undergraduates in the nation. They also send a large number of physics undergrads to graduate school. The university's physics and pre-engineering program is primarily credited with this achievement. Through this program, students receive hands-on experience by working closely with professors on real-world projects, using major research equipment, and publishing in journals. In addition, Dillard University Women in STEM High School Experience in Summer is a summer program for high school women of color who are interested in physics and optics, the goal of which is to increase the number of African American women in STEM fields (Dillard University, 2019).

Jackson State University, an HBCU located in Jackson, Mississippi, also having a high number of women graduating with physics degrees, has developed a program through NSF ADVANCE funding that includes a number of key components, including summer writing retreats for women, mentoring, visibility through international travel to other international institutions, leadership sabbaticals for senior women, bias education initiatives, and policy reviews (NRC, 2013). The university's Bias Education Initiative was designed to assist women of color in addressing the challenges of balancing responsibilities and expectations in the context of unconscious bias (NRC, 2013).

Xavier University of Louisiana, also graduating high rates of women in physics, was recently awarded an NSF grant to develop a systematic approach to increasing the participation and advancement of women in academic STEMM careers, specifically with the goal of supporting the hiring, retention, and ultimate career success of women of color in the STEMM faculty. Primary funding for the grant is to support a diversity fellow, who will have broad responsibility for working with campus leadership to create sustainable policies and procedures that support hiring processes, retention practices, and cultural competency for women in STEMM (Xavier University of Louisiana, 2018).

(see Box 1-4 for several examples at Historically Black Colleges and Universities and Box 1-5 for an additional example).

Programs that support students as they transition from an MSI to a predominantly White institution, where they often experience a significant shift in diversity and culture, are important for improving retention in STEMM (Ong et al., 2011). The Fisk-Vanderbilt Master's to Ph.D. Bridge Program (FVBP) offers one example of an intentional bridge program between an MSI and a predominantly White institution. The FVBP is currently "on pace to become the nation's top producer of underrepresented minority Ph.D.s in physics, astronomy, and materials

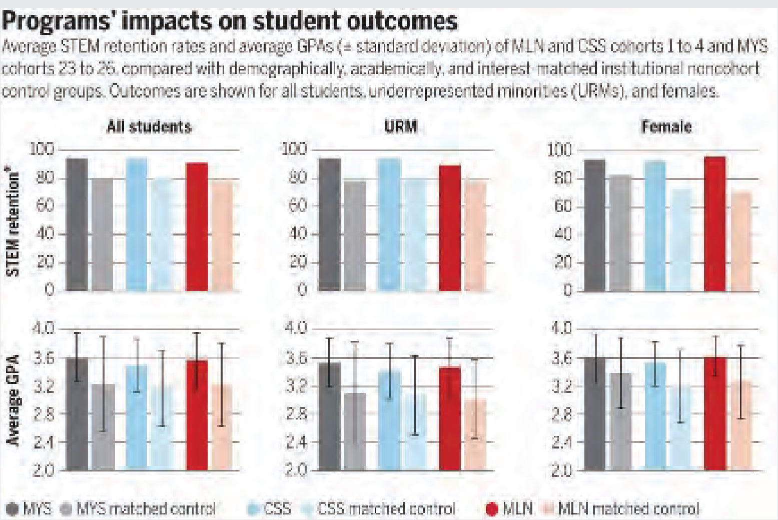
BOX 1-5
University of Maryland Meyerhoff Scholars Program

For 30 years, the University of Maryland Meyerhoff Scholars Program has been successful in advancing minorities in STEMM fields, including women. The program involves a nomination-based application process open to prospective undergraduate students of all backgrounds who plan to pursue doctoral study in STEMM fields and enrolls about 50 new students each year. It focuses on 13 key components:

Recruitment	Tutoring
Financial Aid	Summer Research Internships
Summer Bridge Program	Mentors
Emphasis on research-based Ph.D.s	Faculty Involvement
Study Groups	Administrative Involvement and Public Support
Strong Student Community	Family Involvement
Personal Advising and Counseling	

To date, 312 Meyerhoff Scholars have earned Ph.D.s, 59 have joint M.D./Ph.D.s, 141 have been awarded M.D.s, and 40 now hold tenured or tenure-track positions. An additional 265 students have received a master's degree in a STEMM field, and 258 more are now enrolled in graduate or professional schools (UMBC, 2019).

While there are limited data specifically examining the outcomes of women in the program compared to control students, women were more likely to remain in STEMM and had significantly higher average GPAs than control groups (Summers and Hrabowski, 2006).



SOURCE: Summers and Hrabowski, 2006.

science," (Stassun et al., 2011) and currently leads the nation in master's degrees in physics for African Americans. As of 2011, the number of Ph.D.s awarded to underrepresented minorities through the FVBP was up to an order of magnitude above the U.S. average—by a factor of 10 in astronomy, 9 in materials science, 5 in physics, and 2 in biology (Stassun et al., 2011).

Given that in all STEMM disciplines advancement of women into leadership roles is an issue, some institutions are taking steps to explicitly address this particular issue of underrepresentation. For example, in medicine, an intentional sponsorship program at University of Texas MD Anderson Cancer Center has led to improvements in the diversity of senior leadership. In 2007, when the program was initiated, 33 percent of the faculty and 14 percent of department chairs were women. As of 2017, 39 percent of the faculty and 29 percent of department chairs were women (Travis and Dmitrovsky, 2017) (also see Box 1-6).

In this report, the committee provides a review of the scholarship and practices that have underpinned the achievements of institutions that have succeeded in narrowing the gender gap. This review has also allowed us to define knowledge gaps, particularly with respect to identifying specific practices that can improve the recruitment, retention, and advancement of women of color and women of other intersecting identities. A persistent pattern that is widely recognized is that interventions designed to increase the representation of women in STEMM disproportionately benefit White women over women of color (Ong et al., 2011). Thus, another priority for the committee was to determine the extent to which limitations on the available body of scholarship focused on women of color in STEMM constrain the development and adoption of interventions conducive to achieving full and equitable participation of women of color and women of other intersecting identities in STEMM. The committee also compared the efficacy of interventions across disciplines within science, engineering, medicine, and mathematics and throughout career life cycles of women in STEMM to determine whether the success of particular programs and practices is context dependent.

Our goal in presenting an overview of the research on effective and promising practices and identifying factors contributing to the successes of exemplary programs is to provide guidance to institutions on how to adopt these strategies and practices and tailor them to suit their unique institutional contexts. That there are examples of successful systemic change resulting in achieving gender equity in STEMM fields across a variety of institutions that differ in size, composition, mission, and geographic location suggests that broader positive change in the representation of women in STEMM is an attainable goal.

STUDY APPROACH

Task

To conduct this study, the National Academies formed a committee of practicing scientists, administrators, scholars of women's issues, and authorities on

BOX 1-6
MD Anderson Cancer Center Leaders' Sponsorship Program: Improving the Representation of Women and Minorities in Academic Medicine

In recent years, the corporate sector has embraced sponsorship as a mechanism for increasing the representation of women and minorities in leadership roles. More recently, programs in academic medicine have found that integrating a sponsorship component has been effective in increasing diversity among leadership positions. Sponsorship programs focus on enhancing the visibility, credibility, and professional networks of talented individuals. "A sponsor must have significant organizational influence and an ability and willingness to advocate for others regarding competitive assignments, leadership opportunities, and high-level committee membership" (Gottlieb and Travis, 2018).

The MD Anderson Cancer Center Leaders' Sponsorship Program, established in 2016, is a 6-month sponsorship initiative designed to develop a diverse group of associate professors and professors who seek leadership positions at the center. While all faculty are eligible for the program, a stated goal is to identify candidates from among female and minority faculty. Nominated by their division heads and faculty senate leadership, participants shadow the chief academic officer to gain first-hand academic leadership experience. Applications are matched with sponsors based on candidate interests, and program leadership surveys protégés and sponsors within a year of completing the program and annually thereafter to track their progress in obtaining formal leadership roles (Travis and Dmitrovksy, 2017).

Programmatic measures of success include the completion of the protégés' leadership project and increased diversity in leadership positions at the center. Program leaders at the institution have also developed and implemented an annual sponsorship workshop held among the 15 components of the University of Texas System to increase female leadership across the system (Travis and Dmitrovksy, 2017).

Formal and informal approaches to implementing sponsorship programs may be possible to implement in other academic settings. Travis and Dmitrovsky, (2017) note that "sponsorship may be as simple as current leaders working to raise the visibility of future leaders or may follow a more comprehensive approach . . . It requires dedicated effort and support from all levels of leadership, all with the goal of ensuring no one is overlooked within the next generation of potential leaders" (Travis and Dmitrovksy, 2017).

and advocates for equity, diversity, and inclusion in STEMM to address the statement of task (see Box 1-7).

Approach

In response to this task, the committee developed a set of findings and recommendations based on the evidence available. The findings and recommendations were informed by two extensive commissioned literature reviews, a series of focus

BOX 1-7
Statement of Task

The scientific, engineering, and medical communities have been working toward improved representation of women in STEMM for decades. While progress has been made, women (particularly women of color) remain underrepresented in many scientific, engineering, and medical fields, and at many levels in education and career stages. This study will seek to understand institutional barriers to implementing practices for improving the representation of women in STEMM, so that those barriers can be removed or overcome. Importantly, the study will not put the onus on women, but instead will focus on helping institutions understand how to remove the barriers that exist because of outmoded institutional structures. Considerable energy will be invested in examining the evidence behind the most successful policies, practices, and strategies that have demonstrated effectiveness in opening doors to women's participation and success in STEMM fields.

An ad hoc committee will undertake the following activities:

- A comparative examination of research on why women are more underrepresented in some STEMM disciplines than others, with a particular focus on computer science, engineering, physics, mathematics, medicine, chemistry, and biology.
- A review, analysis, and synthesis of existing research on the policies, practices, programs, and other interventions for improving the recruitment, retention, and sustained advancement into leadership roles of women in these disciplines and at different stages in career trajectories.
- An exploration of why effective interventions have not been scaled up or adopted by more institutions.
- The development of recommendations for implementing promising policies and practices to improve both the representation and leadership of women within specific STEMM disciplines.

The study will also place a strong emphasis on the intersection of race and gender by considering the accumulated research on specific barriers faced by women of color in STEMM in addition to the research on policies and practices that have had an impact on their representation.

The committee will produce a consensus report with findings and recommendations. It may also convene a workshop to gather information and another to disseminate the report's findings, each of which may result in a rapporteur-authored workshop proceedings in-brief.

groups, research presentations, and the committee's own expertise and experience. The first commissioned paper, by Drs. Michelle Rodrigues and Kathryn Clancy, focused on a comparative examination of research on why women are more underrepresented in some STEMM disciplines compared to others. The second commissioned paper, by Drs. Evava Pietri, Leslie Ashburn-Nardo, Corinne Moss-Racusin, and Jojanneke van der Toorn, focused on interventions for improving the recruitment, retention, and advancement of women in STEMM. Lastly, to help address the third objective in the statement of task, the National Academies commissioned a series of focus groups, carried out by Tasseli McKay and Dr. Christine Lindquist of RTI International. These focus groups discussed why effective interventions have not been scaled up or adopted broadly by many institutions.

Throughout the report, the committee presents data and findings disaggregated by race and gender as much as possible. Unfortunately, in many instances the research conducted on promising and effective practices in recruitment, retention, and advancement in education and the STEMM workplace fails to consider the intersectional experiences of women of color or women of other marginalized identities (e.g., LGBTQIA women, women with disabilities). In some instances, the available research is limited to the experiences of White women only, in others gender and race are treated as distinct variables.

Much of the research presented in this report is qualitative in nature, which is appropriate given the topic of study, and critically important for understanding the factors that affect women. This is particularly true for research on women of color, given that the sample sizes are usually too small for quantitative analysis. Data in many of the peer-reviewed studies on the underrepresentation of women in STEMM throughout the report are drawn from focus groups, surveys, interviews, case studies, and similar methods used frequently in the social sciences, where the results are not easily translated into numbers (Bhattacherjee, 2012). This research adheres to rigorous standards for protocol and sample design, objectivity of the questionnaire or survey instrument, protection of human subjects, and methods used for data collection and follow-up to ensure that the results are as representative of the target population, complete, and accurate as possible, with a minimum of response bias. The analysis is also rigorous—requiring explanation of ambiguous results, aggregation of data where cell sizes are too small, and careful wording of conclusions to avoid going beyond what the information will support. Information gathering that does not allow for this rigorous methodology can still yield important information from the "field," as it were, and can provide useful indications of concerns, themes, or directions; it is less useful in supporting definitive conclusions about an entire population.

In its review of the research, the committee describes unique distinctions among STEMM disciplines that create different barriers and challenges for women in STEMM. However, the research literature on promising and effective practices in different STEMM disciplines is not extensive enough to demonstrate which specific interventions work in certain disciplines and which do not. There is, however, reason to suspect that many of the interventions described throughout the report could benefit students and professionals in a range of specific STEMM disciplines and sub-disciplines, because most of these interventions have been tested across different disciplines with similar outcomes.

Further, each discipline is not a monolith. Institutional context, as opposed to disciplinary culture, may be an equally useful way to predict which policies and practices would be successful within a specific department or institution, rather than examining these interventions by discipline. Several of the recommendations in this report support institutions taking action to collect and examine demographic data, disaggregated by gender and race/ethnicity, of students, faculty, and staff at the departmental level in order to understand their own institutional context. By examining these data, departments can diagnose where there are specific problems and use this report as a resource to implement best practices to address those challenges.

For readers particularly interested in the current state of knowledge on the impact of specific interventions in the context of a specific discipline, the report contains a table in Appendix A that provides an extensive review of interventions shown to improve recruitment, retention, and advancement of women in STEMM. The table provides details on whether the intervention has been tested in STEMM and, if so, in which disciplines.

The committee largely limited the scope of the report to academia. However, the project staff reviewed research on promising practices in industry settings and found that many of the same general strategies are employed in industry as in academia (e.g. writing job advertisements inclusively, using structured interviews, bias mitigation training), although adjusted for industry settings. Most of the evidence on promising and effective practices in industry settings is not peer-reviewed, but rather exists in the form of case studies and so-called "gray literature." It is the committee's view that many of the recommendations offered in the report could be usefully adapted to industry settings, and should be used as a resource for industry leaders, as appropriate, given that in certain STEMM fields (e.g. computer science, engineering) the majority of STEMM professionals work in industry settings—settings with very poor representation of White women and extremely low numbers of women of color.

Report Organization

The committee has structured the report to align closely with the components of the statement of task. The report offers an overview of the barriers faced by women across a range of scientific, engineering, and medical disciplines (Chapter 2); describes evidence-based strategies that have positive impacts on the recruitment, retention, and advancement of women in STEMM education and careers (Chapters 3 and 4); and reviews common barriers to institutional change and factors that can overcome barriers and facilitate and support such change (Chapter 5). The report concludes with a set of actionable recommendations for a range of stakeholders on how to effect substantive change in women's experiences, representation, and leadership in STEMM (Chapter 6).

2

Factors that Drive the Underrepresentation of Women in Scientific, Engineering, and Medical Disciplines[1]

The analysis draws substantially from the research paper by Drs. Michelle Rodrigues and Kathryn Clancy, which was commissioned for this study. The full research paper can be found online at: www.nap.edu/catalog/25585.

For decades, sustained investments from foundations, nonprofits, government agencies, and others have supported efforts to improve the representation of girls and women[2] in science, technology, engineering, mathematics, and medical (STEMM) fields.[3] Why these efforts to improve recruitment, retention, and advancement have effected little improvement in gender representation in many STEMM fields remains an open question. While it is true that in many STEMM fields the situation has gotten better, many are concerned that the rate of improvement has been too slow and that progress has plateaued, or even moved backward in some cases. These fears are not unfounded. For example, even though the percentage of women earning bachelor's degrees in engineering doubled from 2001 to 2010, their numbers in 2010 were still extremely low at 16 percent, and even slightly declined by 2015 (Armstrong and Jovanovic, 2015; Nassar-McMillan et al., 2011; NSF, 2002; NSF, 2017). Similarly, even though women's

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[1] This chapter offers a comparative examination of research on why women are more underrepresented in some scientific, engineering, and medical disciplines than others, with a particular focus on computer science, engineering, physics, mathematics, medicine, chemistry, and biology. The authors wish to acknowledge the significant contribution of the Committee on Understanding and Addressing the Underrepresentation of Women in Particular Science and Engineering Disciplines to the content of this chapter.

[2] In the context of this study, "women" are defined as those who identify as women or are viewed by others as women (or female in the case of girls).

[3] Given that medicine is within the scope of this report, the acronym "STEMM" is used when referring to ideas or comments originating with this report; however, when referring to research, evidence, or programs that exist independent of this report, we use the terminology of the material cited, whether it is STEM (science, technology, engineering, and mathematics), STEAM (science, technology, engineering, art, and mathematics), or STEMM.

FIGURE 2-1 Women in academic medicine. Although women are at or near parity for medical school graduates, there continues to be a decline of women in later, more senior career stages.
SOURCE: Association of American Medical Colleges, The State of Women in Academic Medicine: The Pipeline and Pathways to Leadership, 2013-14, Courtesy of Diana Lautenberger, available at https://store.aamc.org/downloadable/download/sample/sample_id/228/.

representation in the physical sciences improved during this time period, women still accounted for only 22 percent of these disciplines in 2010 (Armstrong and Jovanovic, 2015; NSF, 2013). Even in medical disciplines, where, as of 2018, the number of women enrolled in medical schools exceeded men for the first time, there is a persistent underrepresentation of women at senior academic or leadership positions that cannot be explained by a time lag between degree completion and career trajectory (see Figure 2-1).

In this chapter, the committee reviews research on the shared experiences of women across a range of STEMM disciplines, explores the patterns of representation of women across seven specific disciplines—computer science, engineering, physics, mathematics, medicine, chemistry, and biology—and highlights the importance of considering the intersectional experiences of women of multiple marginalized identities (race, class, sexual orientation, disability status) when considering the biases and barriers facing women in STEMM.

BARRIERS TO WOMEN'S PROGRESS

It is not true that women are underrepresented in STEMM because of innate weakness in these fields (NASEM, 2007; Pawley, 2011). Rather, substantial research demonstrates that implicit and explicit biases discourage women from entering STEMM careers (Cheryan et al., 2015; Lehmann et al., 2006; Master et al., 2016) or influence their decision to leave STEMM after beginning their careers (Hunt, 2016). These factors include a spectrum of explicit and implicit biases, as well as structural and interpersonal interactions that impede women's progress (Grogan, 2018; Urry, 2015). These are factors across the career life cycle:

- **Obtaining a Position**—bias in recruitment (Milkman et al., 2015; Moss-Racusin et al., 2012); obstacles to accommodating family needs (Urry, 2015; Wolfinger et al., 2008)

- **Internal Opportunities and Rewards**—unequal allocation of resources (Bronstein and Farnsworth, 1998; Green et al., 2000); mentoring and performance evaluation (e.g., teaching) (MacNell et al., 2014; Reid, 2010a); mentoring access (Chanderbhan-Forde et al., 2012; Moss-Racusin et al., 2012)
- **Work Expectations**—higher teaching loads (Bronstein and Farnsworth, 1998; Carrigan et al., 2017; Xu, 2008); higher expectations of service without compensation (Hermanowicz, 2012; Kulis et al., 2002; Madge and Bee, 1999)
- **External Opportunities and Rewards**—lower frequency of speaking invitations (Nittrouer et al., 2018); inequities in access to external funds (Pohlhaus et al., 2011; Witteman et al., 2017), less likely to be on editorial boards and in editor positions (see, for example, Amrein et al., 2011; Cho et al., 2014; Clark and Horton, 2019; Ioannidou and Rosania, 2015)
- **Cross-cutting Barriers**—harassment and assault (Clancy et al., 2014, 2017; NASEM, 2018b; Nelson et al., 2017)

While women in all fields face bias and discrimination, the way women experience these behaviors differs by discipline and career stage, leading to similarities or differences that create unique climates for women across the STEMM enterprise.

COMMON DYNAMICS ACROSS STEMM FIELDS

Gender Bias

Across the STEMM fields, women may experience implicit bias and structural barriers at every career stage, including at critical junctures such as consideration for graduate school admission, recruitment into a laboratory for graduate research, consideration for postdoctoral positions, recruitment to fill tenure-track faculty positions, and evaluation for promotion in rank (Bronstein and Farnsworth, 1998; MacNell et al., 2014; Milkman et al., 2015; Moss-Racusin et al., 2012; Settles et al., 2006; Urry, 2015). These biases are often intensified for women of color, who encounter the double bind of race- and gender-based bias (see "Intersectionality and the Double Bind" section below).

Biases have cumulative effects leading to outsized disparities at more advanced career levels. For example, Li et al. (2019) found that, 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 (Li et al., 2019). 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. Men are more likely to be evaluated in ways that lead to opportunities for better pay and mentorship (Moss-Racusin et al., 2012). In a randomized, double-blind study, 127 science faculty at research universities rated a male applicant for a laboratory manager position as "significantly more competent and hirable" than a female applicant, even though the application materials were identical except for one factor: the name of the applicant appearing either as "John" or "Jennifer." Faculty also offered "John" a higher starting salary and more career mentoring than they offered "Jennifer" (Moss-Racusin et al., 2012). Additionally, culturally engrained biases especially favor White men over men of color and women (Milkman et al., 2015). In a study in which more than 6,500 professors at top U.S. universities, drawn from 89 disciplines and 259 institutions, were contacted by fictional prospective students wishing to discuss research opportunities with names that suggested their gender and race (White, Black, Indian, Hispanic, and Chinese), faculty were significantly more responsive to White males than to all other categories of students. These biases in favor of White males are rooted in deeply seated cultural associations between masculinity and STEMM (see "Cultural Associations Between Masculinity and STEMM" section below).

In academic positions within STEMM, women are more likely to be appointed to teaching-focused positions, where they have less access to external funding or resources and to graduate students (Hermanowicz, 2012; NASEM, 2018b). For faculty positions that focus primarily on scholarship, disparities in teaching evaluations, often rooted in implicit bias, disadvantage women, especially women of color, when being considered for tenure (Jones et al., 2015a; Pittman, 2010; Reid, 2010b). Women are also less frequently invited to be colloquium speakers than men, particularly at prestigious universities (Klein and Briggs, 2017).

With respect to publishing, women are less likely to receive authorship credit and more likely to experience harsher peer review; moreover, manuscripts with women listed as first or last authors are cited less frequently (Bendels et al., 2018; Chawla, 2018; Murray et al., 2018; West et al., 2013). In contrast, men are more likely to receive first authorship or last authorship, and are more likely to be invited by journal editors to serve as reviewers (Chawla, 2018; Lariviere et al., 2013; Murray et al., 2018). Compounding the disparity, all-male reviewing teams are more likely to reject papers from women (Chawla, 2018; Murray et al., 2018).

There are additional gender disparities in receiving grant funding (Pohlhaus et al., 2011; Witteman et al., 2017). Because women are fewer in number among biomedical research faculty, the rate of application by women for National Institutes of Health funding is therefore lower, but women are also less likely to have their funding renewed after the award has been made (Pohlhaus et al., 2011). Even in cases when women's research is evaluated favorably for funding, their performance and research accomplishments as principal investigator are likely to be evaluated more harshly than that of their male peers (Witteman et al., 2017). As a result, men continue to be funded at higher rates.

Even within fields where women are well represented or overrepresented at lower ranks, they do not have equivalent representation at higher ranks (Addessi et al., 2012; Carnes, 2008; Carr et al., 2017; Isbell et al., 2012; Sheltzer and Smith, 2014). The gendered divisions of labor that exist within academia may be responsible for this disparity. Women shoulder the burden of teaching, mentoring, and service (Armstrong and Jovanovic, 2015; Hermanowicz, 2012; Kulis et al., 2002; Madge and Bee, 1999; Urry, 2015), particularly White women in male-dominated fields and minority women in all fields, who, as Johnson and Lucero (2003) describe, pay a "cultural tax," whereby they are expected to perform additional service work related to their identity (Armstrong and Jovanovic, 2015). Furthermore, women are often marginalized in low-status jobs such as nontenure-track positions or unstable research associate positions dependent on soft money (Kulis et al., 2002). Across a variety of fields, as women increase in representation, the status and compensation associated with these fields decreases (Kulis et al., 2002; Reskin, 1988). Even as women rise to higher ranks, they themselves often contribute to the perpetuation of culturally ingrained biases—women are just as likely as men to evaluate female candidates negatively, and high proportions of White women and minorities exhibit gender biases in evaluating prospective students (Milkman et al., 2015; Moss-Racusin et al., 2012).

Women also disproportionately deal with the impact of being a member of a "dual-career couple." Such couples face the challenge of finding employment at the same institution or city, as well as the impact of inadequate maternal/paternal leave and childcare policies (Urry, 2015). For example, Rivera (2017) found that hiring committees for junior faculty positions considered women's relationship status but not men's relationship status when making hiring decisions. Hiring committees excluded heterosexual women with partners who held academic or other high-status jobs that were not easily movable when there were male or single female alternatives. Rivera (2017) also found that committees rarely discussed the relationship status of male faculty and saw their female partners as movable. While the exit of women from STEMM has been framed as a choice based on prioritizing relationships and/or motherhood by some (Ceci and Williams, 2011), gender inequities in cultural expectations combined with bias against women who have children, or may potentially have children, often heavily influence these decisions (Wolfinger et al., 2008).

Women faculty at Historically Black Colleges and Universities (HBCUs), Tribal Colleges, and other Minority-Serving Institutions also experience the gender bias-related issues outlined in this report. With the exception of HBCUs, where roughly half of faculty are Black, the faculties in STEMM disciplines of Minority-Serving Institutions, including Tribal Colleges, Hispanic-Serving Institutions, and Asian American and Native American Pacific Islander-Serving Institutions, have demographics that are similar to demographics of faculty in majority institutions (NASEM, 2019a), with a majority of White faculty. Moreover, African American women faculty experience the same issues of bias, discrimination, and uncivil climate at HBCUs as they do at majority institutions (Bonner, 2001).

Although negative biases are more frequently reported, absences of hiring biases and biases favoring women in academic sciences have been reported (NRC, 2010; Williams and Ceci, 2015). According to the 2010 National Academies report *Gender Differences at Critical Transitions in the Careers of Science, Engineering, and Mathematics Faculty*, female applicants generally fared better than their male counterparts in tenure-track applications to research-intensive universities (NRC, 2010). In all six STEMM fields studied, the percentage of women increased—often substantially—from the applicant pool to interviews to job offers. In electrical engineering, for example, women comprised 11 percent of applicants for tenure-track positions, but 32 percent of those who received job offers. Additionally, a rigorous quantitative synthesis of the experimental literature on gender bias in job-related decisions such as evaluations of competence and hirability showed that, in general, men were preferred for male-dominated jobs, whereas no strong preference for either gender was found for female-dominated jobs (Koch et al., 2015).

However, biases against hiring women still exist in some contexts, such as in hiring laboratory managers (Moss-Racusin et al., 2012) and postdoctoral associates (Eaton et al., 2019). These two contexts are notable because such hiring decisions are often made by individual principal investigators with little administrative oversight and formal monitoring.

Preference for hiring women in tenure-track positions may be explained by the competitiveness and accountability of such positions by them. Because dozens or even hundreds of candidates may apply for certain types of tenure-track positions, search committees typically select only the most outstanding candidates to create a short list of individuals to invite for interviews (Carpenter and O'Neal, 2013). Competition has become more intense, particularly since 2000, as the number of STEMM Ph.D. earners has continued to rise, while the availability of tenure-track positions has remained unchanged (Gould, 2015; NASEM, 2018a). The competition for laboratory manager and postdoctoral positions is likely less intense, and competency of short-listed candidates may be less easily defined than in tenure-track hiring contexts. In a meta-analysis of gender stereotypes and bias in experimental simulations of employment decision-making, Koch et al. (2015) found applicant competence is a critical moderator of gender bias.

Another consideration is that tenure-track hiring at academic institutions involves more accountability than does hiring into other positions. Koch et al. (2015) reported that for male-dominated jobs, no significant difference in average gender bias could be detected when raters "felt accountable for their decisions, believed their decision had real-life consequences, or were reminded of equity norms." Accountability may arise from pressure from deans and administrators to hire more female faculty in STEMM (NASEM, 2007). In other words, professors are often held accountable to work toward diversity goals in tenure-track hiring, but likely encounter less administrative oversight in other contexts, such as laboratory manager hiring (NASEM, 2007). Goals for diversifying the professoriate might even create a preference for outstanding women applying to tenure-track positions over equally qualified men, creating a favorable hiring bias for women (NRC, 2010). However, it is likely that these studies underestimate the processes by which many women are excluded from participation in the field at early stages and the ways that small biases in treatment accumulate over time (Ginther, 2006; Mason and Goulden, 2004; Rigney, 2010; Valian, 1998).

Cultural Association Between 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 (Bejerano and Bartosh, 2015). When Carli et al. (2016) asked study participants to list traits they associate with scientists and with men and women irrespective of profession, the traits identified for scientists and men overlapped to a greater extent that did the traits identified for scientists and women. Moreover, nonscientists are less likely to believe a woman is a scientist if she has a feminine (rather than masculine) appearance (Banchefsky et al., 2016). This expectation that STEMM professionals are White and male is implicitly conveyed in cultural portrayals of STEMM and STEMM education (Banchefsky et al., 2016). These stereotypical associations shape the social and educational environments of children, as well as structural patterns that occur in STEMM professions (Banchefsky et al., 2016).

Traits such as assertiveness, confidence, boldness, risk-taking, independence, and self-promotion are valued, rewarded, and seen as standards in STEMM (Diekman and Steinberg, 2013). 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 (Diekman and Goodfriend, 2006). However, many women have less experience with these masculine traits because they are often socialized to be more "other-focused" than their male counterparts (Eagly and Mladinic, 1994; Eagly and Riger, 2014). When women do display these traits, they often encounter backlash in the form of social and economic sanctions (Rudman, 1998; Williams and Tiedens, 2016). 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 (Bian et al., 2017a).

In reality, a range of traits and competencies, independent of associations with stereotypes, can be differentially advantageous or disadvantageous depending on situations. Negotiation styles of women, for example, tend to be more relationship driven (or more focused on the quality of relationships) than the more stereotypically male outcome-driven style (focused on specific outcomes). Relationship-driven negotiation has been associated with better outcomes in business negotiations, dispute resolution, social movements, marriage reconciliation, crisis resolution, or peacekeeping. For this reason, scholars have increasingly noted the tendency for women to conceptualize issues such as security and the use of military force in different and more productive ways than their male counterparts (Babcock and Laschever, 2003; Boyer et al., 2009). Also, women perform as well as, or better than, men in leadership competency (Folkman, 2015), not only with respect to characteristics typically associated with women (i.e., "nurturing competencies such as relationship building and developing others"), but also for characteristics typically associated with men (i.e. "takes initiative," "practices self-development," "displays high integrity and honesty," and "drives for results" (Zenger et al., 2012). Finally, Tsugawa (2017) noted that, when treated by female physicians, more than 1 million elderly hospitalized patients were less likely to die within 30 days of admission or to be readmitted within 30 days of discharge than those cared for by male physicians. The author estimated that, if male physicians could achieve the same outcomes as their female colleagues, there would be 32,000 fewer deaths each year among Medicare patients and offered as a conclusion the following statement:

> *There was ample evidence that male and female physicians practice medicine differently. Our findings suggest that those differences matter and are important to patient health. We need to understand why female physicians have lower mortality so that all patients can have the best possible outcomes, irrespective of the gender of their physician.*

Further, cultural expectations and biases about which jobs and careers are held, or *should* be held, by women and men can limit men's opportunities in certain STEMM fields. Gender discrimination, biases, stereotypes, and microaggressions against men have been well documented, primarily in health fields, such as nursing and other health sciences, where men are not well represented. According to the Kaiser Family Foundation, as of April 2017, only 333,530 of the 4 million nurses in the United States identified as male (KFF, 2017). In a survey examining reasons for this lack of male participation in the field, respondents widely cited stereotypes as a top challenge. Other barriers cited included a lack of career support, few male nurse educators and mentors, a feeling of being unwelcome in the clinical setting, and sex-related bias in obstetric rotations (Hart, 2004). Men have also reported experiencing microaggressions, particularly if they demonstrate an aptitude or interest in a STEMM field that is primary dominated by women, such as nursing. This can contribute to a lack of men pursuing careers in the field (Hart, 2004).

Similarly, there is male gender segregation in a number of medical specialties. This has been the case, in particular, in medical subspecialties where women are well represented and the field has thus faced a corresponding drop in prestige and pay. For example, despite being a female-dominated field, obstetrician-gynecologists who are women face barriers to advancement to leadership positions and earn $36,000 per year less than men in obstetrics and gynecology

(Hughes and Bernstein, 2018). Similarly, men in obstetrics and gynecology may be negatively affected by unconscious bias and socially prescribed roles for men and women (Hughes and Bernstein, 2018). In another study examining performance and gender representation in obstetrics and gynecology clerkships, male students reported that their gender negatively affected their experience during the clerkship (Craig et al., 2018). Additionally, there are fewer male students applying for obstetric and gynecology residency (Craig et al., 2018). As Hughes et al. (2018) notes, “For the obstetrician-gynecologist, sexism is not just a ‘women’s issue.’”

Sexual Harassment

Women experience high rates of sexual harassment in science, engineering, and medical education and careers (NASEM, 2018b). Sexual harassment consists of three forms: gender harassment (verbal and nonverbal behaviors that convey hostility, objectification, exclusion, or second-class status about members of one gender); unwanted sexual attention (unwelcome verbal or physical sexual advances, which can include assault); and sexual coercion (when favorable professional or educational treatment is conditioned on sexual activity) (NASEM, 2018b).

Women commonly and disproportionately experience sexual harassment at multiple career levels. Surveys from a university system and a university with multiple campuses demonstrate that 20–50 percent of women students experience sexual harassment from faculty or staff, depending on their stage of education and field (Krebs et al., 2016; Swartout, 2018). The best meta-analysis of surveys to date indicates that more than 50 percent of women employees (faculty and staff) in academia experience sexual harassment (Ilies et al., 2003). Research shows that these numbers are far worse for women with intersecting marginalized identities (Buchanan et al., 2008; Clancy et al., 2017; Cortina, 2004; Cortina et al., 1998; Konik and Cortina, 2008; Rabelo and Cortina, 2014). Although men can and do experience sexual harassment (*APA Handbook of the Psychology of Women*, 2018; Berdahl, 2007; Rabelo and Cortina, 2014), they do so at considerably lower rates (*Sexual Harassment in the Federal Workplace: Trends, Progress, Continuing Challenges*, 1995; Ilies et al., 2003; Kabat-Farr and Cortina, 2014; Magley et al., 1999).

Of the three types of sexual harassment, gender harassment is the most common and can be as harmful as the other forms of sexual harassment (NASEM, 2018b). Examples of gender harassing behavior include comments that denigrate women as a group or as individuals in gendered terms, and comments about women that are crude or sexist. Gender harassing behavior can also include visual behavior such as leaving porn or lewd images in group spaces. Gender harassment is often *ambient*, meaning it is “not clearly targeted at any individual or group of individuals” (Parker, 2008) and can include behavior that extends beyond the direct target of the harassment (Glomb et al., 1997). Gender harassment can include uncivil and disrespectful behavior sometimes described as "microaggressions" (Sue et al., 2007) (discussed more in-depth below). Additionally, sexual harassment often takes place within environments in which incivility occurs (Lim and Cortina, 2005).

A 2018 National Academies consensus study report concluded that the cumulative result of sexual harassment in academic sciences, engineering, and medicine is significant damage to research integrity and a costly loss of talent in these fields (NASEM, 2018b). Research across workplace sectors shows that sexual harassment "undermines women's professional and educational attainment and mental and physical health," leading to negative career outcomes (NASEM, 2018b). When women experience sexual harassment in the workplace, the professional outcomes include increases in job stress (Barling and Cooper, 2008; Fitzgerald et al., 1997); declines in job satisfaction, performance, or productivity (Bond et al., 2004; Cortina et al., 2002b; Fitzgerald, 1997; Glomb et al., 1999; Harned and Fitzgerald, 2002; Holland and Cortina, 2013; Lim and Cortina, 2005; Magley and Shupe, 2005; Morrow et al., 1994; Munson et al., 2000; Piotrkowski, 1998; Ragins and Scandura, 1995; Schneider, 1997), and withdrawal from the organization and disengagement from their work (Barling et al., 2001; Cortina et al., 2002a; Culbertson and Rosenfeld, 1994; Fitzgerald et al., 1997; Glomb et al., 1999; Holland and Cortina, 2013; Lonsway et al., 2013; Schneider et al., 1997; U.S. Merit Systems Protection Board, 1995; Wasti et al., 2000). When students experience sexual harassment, the educational outcomes include greater truancy, dropping courses, receiving lower grades, or dropping out (Duffy et al., 2004; Fitzgerald, 1990; Lee et al., 1996; Reilly et al., 1986). As the 2018 *Sexual Harassment of Women* report (NASEM, 2018b) concluded, sexual harassment is a significant factor influencing the recruitment, retention, and advancement of women in STEMM, and its persistence in the workplace and education environments is putting at risk the gains made in improving the representation of women in these fields.

Microaggressions

"Microaggressions" refer to "the everyday verbal, nonverbal, and environmental slights, snubs, or insults, whether intentional or unintentional, which communicate hostile, derogatory, or negative messages to target persons based solely upon their marginalized group membership. In many cases, these hidden messages may invalidate the group identity or experiential reality of target persons, demean them on a personal or group level, communicate they are lesser human beings, suggest they do not belong with the majority group, threaten and intimidate, or relegate them to inferior status and treatment" (Sue, 2017). Though the gender harassing form of sexual harassment commonly overlaps with microaggressive behaviors (Sue et al., 2007), microaggression is a broader form of discrimination that can extend beyond gender into race, identity, religion, and many other legally protected characteristics. Microaggressions can contribute to feelings of alienation, pressure to work twice as hard to receive recognition, and work environments in which one is under constant scrutiny and presumed incompetent (Johnson et al., 2011; McGee, 2016; McGee et al., 2019; Ong et al., 2011). Importantly, microaggressions have devastating short- and long-term effects on both targets and bystanders (Ruder et al., 2018; Torres et al., 2010; Wilkins-Yel et al., 2019; Yang and Wright, 2018).

The extent to which microaggressions specifically are present in STEMM is unclear (Harrison and Tanner, 2018), although a few research studies indicate that it is a barrier for women in these fields. In one study using interviews with 21 women in physics and astronomy programs, Barthelemy et al. (2016) found that the majority of subjects experienced microaggressions. In another study examining women STEMM faculty at a large Midwestern institution, 68.8 percent of those interviewed reported experiencing a workplace microaggression (Rockinson-Szapkiw and Wade-Jaimes, 2019). Furthermore, faculty rank did not predict faculty experiences with microaggressions, indicating that women experience microaggressions at all stages of their faculty career.

One reason there may not be many studies on microaggressions in STEMM conexts is that use of the term "microaggression" to characterize these behaviors is considered by some researchers to be misleading. *Micro* implies insignificant, minor, or imperceptible; many behaviors that are categorized as "microaggressions" are actually overtly offensive and extremely damaging. Further, *aggression* is a term most commonly reserved for behavior that carries intent to harm (Lilienfeld, 2017), which is not always the case with the behaviors included under the term "microaggressions"—as the definition above makes clear. An alternative term more commonly used in workplace aggression literature, and throughout the 2018 National Academies consensus study report on the *Sexual Harassment of Women*, is the term "incivility," which refers to "low-intensity deviant behavior with ambiguous intent to harm the target, in violation of workplace norms for mutual respect" (Andersson and Pearson, 1999). Regardless of the term used—microaggressions or incivility—the behavior is harmful and a barrier to the progress of women and particularly women of color.

INTERSECTIONALITY AND THE DOUBLE BIND

Intersectionality can be defined as "the processes through which multiple social identities converge and ultimately shape individual and group experiences" (McCall, 2005; Museus and Griffin, 2011). *Structural intersectionality* refers to the ways in which multiple social systems intersect to shape the experiences of individuals (Crenshaw, 1991). 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. For women of color in particular, multiple forms of discrimination, such as racism and sexism, intersect to shape their experiences.

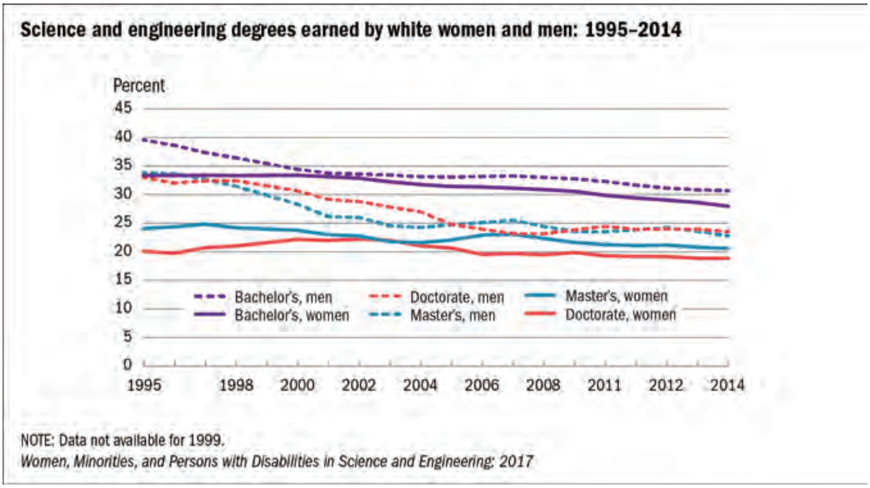
Research demonstrates that programs aimed at improving the representation of women in STEMM have largely benefited White women and that intersecting identities can influence the efficacy of interventions to achieve gender equity. Ong et al. (2011) suggested that the absence of sustained efforts to serve and support women of color in STEMM may be "possibly due to the misguided idea that burgeoning efforts by the NSF [National Science Foundation] and other institutions aiming to serve women or minorities would, consequently, serve minority women." The authors further note that "history has borne out the reality that programs intended to serve women disproportionately benefit white women, and programs intended to serve minorities mainly benefit minority males" (Ong et al., 2011).

Women of Color[4]

Strategies and practices with potential for improving the retention, persistence, and achievement of women in STEMM, particularly women of color, have been developed and deployed. The strongest indicator of the effectiveness of such strategies and practices is the changing number of women of color entering and remaining in STEMM. That said, even though the share of science and engineering degrees earned by underrepresented minority women has more than doubled over the past two decades at all levels of higher education (bachelor's, master's, and doctorates) (see Figure 2-2), women of color (with the exception of Asian American women) remain underrepresented in these fields relative to their representation in the U.S. population (NSF 2013, 2017) (see Figure 1-2). Minority women have been awarded more STEMM degrees as measured in absolute numbers since the 1970s but remain underrepresented at advanced education and career stages in most fields relative to White women (Ong et al., 2011).

In a groundbreaking paper relating to underrepresentation of women of color, Malcolm (1979) presented the problem as a "double bind," where women of color are excluded for biases related to both their gender and their race and ethnicity (Malcom, 1979). In spite of the attention called to the double bind over 40 years ago, it remains a major issue for women in STEMM. As recently as 2019, in a

[4] We include in our definition of women of color African Americans, Hispanics, Latinas, American Indians, Asian Americans, Alaska Natives, Native Hawaiians, and other Pacific Islanders. Although Asian American women are overrepresented among STEM degree earners, they remain underrepresented in ranks of full professor and in university leadership (e.g., deans or university presidents) (U.S. Department of Education, 2019). Similarly, Asian American women are poorly represented on corporate boards of trustees and among managers in industry or government (Deloitte, 2018). For this reason, we include Asian American women in our analysis.



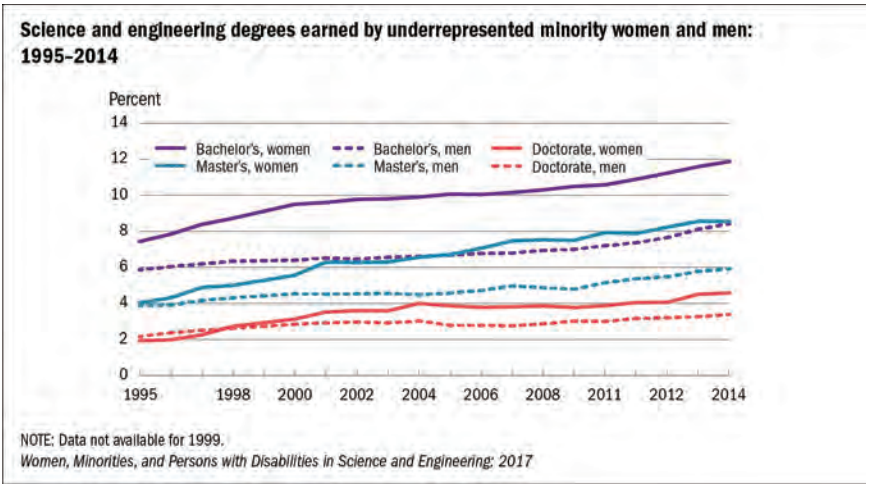


FIGURE 2-2 While the share of science and engineering degrees earned by underrepresented minority women has more than doubled at all levels of education, the percentage of underrepresented minority women earning science and engineering degrees remains lower than that of White women. The plotted lines represent the percentage of science and engineering degrees among all degrees for the specific category shown.
SOURCE: NSF, National Center for Science and Engineering Statistics, *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2017.*

study of postdoctoral hiring bias, researchers examined how perceptions of race and gender influence evaluation of postdoctoral candidates (n = 251) from eight large research universities. Professors were asked to read one of eight identical curricula vitae (CV) of a hypothetical doctoral graduate applying for a postdoctoral position, and rate them for competence, hirability, and likeability. The candidate's name on the CV was used to suggest race (e.g., Asian, Black, Latinx, and White) and gender (female or male). Physics faculty rated the CVs of Black women and Hispanic women lower than the CVs of women and men from any other racial/ethnic group (Eaton et al., 2019). That said, gender gaps in STEMM can vary in unpredictable ways across racial and ethnic lines. Women with multiple marginalized group identities, such as women of color, can experience both advantages and disadvantages compared with those with a single subordinate group identity (Purdie-Vaughns and Eibach, 2008). Black women may be overlooked or marginalized due to "intersectional invisibility"—a lack of visibility because they do not embody expectations of "women" or "Black people" (Bell, 1992; Davis, 1981; Purdie-Vaughns and Eibach, 2008). But this invisibility can also protect racial minority women by making them less conspicuous targets of common biases and stereotypes (Biernat and Sesko, 2013). Along the same lines, Black and Hispanic men often face negative stereotypes about tendencies for engaging in criminal or violent behavior; Black and Hispanic women encounter these stereotypes far less frequently (Ghavami and Peplau, 2012). As well, in a study on callbacks for jobs, Mullainathan and Bertrand (2004) found that Black women were less disadvantaged than Black men—although there was a bias against Black relative to White applicants.

In addition to experiences of heightened bias, women of color in STEMM frequently experience isolation (i.e., experience a sense of invisibility or hypervisibility), macro- and microaggressions, and a sense of "not belonging" in STEMM (Ong et al., 2011). Beyond feelings of isolation, there is evidence to indicate that both women of color and White women in STEMM have more limited social network supports than men, which can tangibly and negatively impact their career trajectory (Collins and Steffen-Fluhr, 2019; Etzkowitz et al., 1994; Feeney and Bernal, 2010). In other words, women may not only *feel* isolated but, may actually *be* isolated.

Experiences of bias, isolation, microaggressions, and not belonging in STEMM can lead to "racial battle fatigue," a term coined by William Smith (Smith et al., 2007). Racial battle fatigue is the "cumulative result of a natural race-related stress response to distressing mental and emotional conditions" that adversely affects the health and achievements of students and faculty of color (Corbin et al., 2018; Smith et al., 2007). While this term was coined to describe the experiences of Black men in predominately White spaces, it has been since expanded to be inclusive of women of color in historically and predominantly White spaces, particularly for Black and Latina women (Corbin et al., 2018; Franklin et al., 2014). Women of color also experience more harassment than White women, which manifests as both racial harassment and intensified forms of sexual harassment (Berdahl and Moore, 2006; Buchanan and Fitzgerald, 2008).

While most women report career-life balance as a challenge to working in STEMM fields, for women of color, this may be a critical factor contributing to why they remain underrepresented in these fields (Kachchaf et al., 2015). Academic STEMM work environments often require a commitment to the job through long hours, stagnant career trajectories, and constant availability and visibility—that is, the "ideal worker norm" (Acker, 1990; Williams, 2000). These expectations assume that there will be gendered separation of work and family duties (Traweek, 1988; Williams, 2000), which further reinforces the image of the scientist as a man. Adherence to these ideal worker norms disadvantages both men and women who have commitments and duties outside of work (Acker, 1990; Williams, 2000). The ideal worker norm has a disproportionate impact on women of color because their multiple identities and their small numbers in STEMM departments contribute to an even greater perception that they do not demonstrate the characteristics of the "ideal worker" (Turner, 2002).

Women of color may also contend with cumulative disadvantage, such as interest on debt, and disadvantages, such as lower salary and delayed promotion, which accrue over time. Those who differ from the norm experience a cycle of disadvantage—the further from the norm, the more cumulative the disadvantage (Kachchaf et al., 2015). Kachchaf et al. (2015) report that women of color must work harder, including working extended hours, to fit the ideal worker norm despite having had fewer role models who have successfully managed these expectations, fewer culturally competent mentors, and less access to informal professional networks.

Women with Disabilities

People with disabilities are underrepresented in STEMM from K-12 through higher education and continuing within the workforce. Although individuals with disabilities report nearly identical interest in pursuing STEMM as those without disabilities (~25 percent) (Thurston et al., 2017), far fewer persons with disabilities graduate with STEMM degrees (NSF, 2017).

Beyond the barriers faced by women in STEMM in general, women with disabilities encounter unique obstacles related to their disabilities that may be responsible for their disproportionate underrepresentation in STEMM careers. These barriers may include lack of physical access to laboratory and classroom spaces, lack of equipment that can be used by persons with sensory and motor disabilities, a shortage of disabled role models in STEMM, and a higher likelihood of negative mentoring interactions (Duerstock and Shingledecker, 2014). Teaching styles in undergraduate classrooms can also contribute to attrition; for example, large lecture-style courses, particularly when inclusive pedagogy is not prioritized, may serve as a "weeding" class for students with disabilities (Moriarty, 2007).

Despite these barriers, there are a number of direct interventions that can vastly improve outcomes for students with disabilities. For example, providing students with assistive and adaptive technology, such as software that makes printed pages more accessible and facilitates writing, equipment that supports auditory and visual comprehension, and laboratory environments that are designed to be accessible greatly improve the educational experiences for students with disabilities (Duerstock and Shingledecker, 2014; NASEM, 2019b). Other interventions include first-year college transition programs to provide supplemental support for students with disabilities, access to culturally sensitive mentorship, access to tutors (particularly for disciplines that require complex computational methods and concepts), and access to individualized advising (Duerstock and Shingledecker, 2014; NASEM, 2019b). However, few if any studies have identified factors that influence career retention for female scientists with disabilities.

Women with LGBTQIA Identities

Women who identify as LGBTQIA face significant barriers in STEMM, in part due to their intersectional identities—being both a woman and a sexual minority. What has been studied on this topic indicates that women who are LGBTQIA are particularly marginalized across STEMM fields, and that while some interventions and recruitment efforts have increased representation of this population, the reality is that the numbers are not improving, and, in some cases, are getting worse.

For example, Yoder and Mattheis (2016) conducted a survey of 1,427 individuals who identify as LGBTQIA working in STEM fields, known as the "Queer in STEM" survey. Participants completed a 58-item questionnaire to report their professional areas of expertise, levels of education, geographic location, and gender and sexual identities and rated their work and social communities as welcoming or hostile to queer identities. Almost one-half of participants identified as female (48 percent); 44 percent identified as male, 7 percent as transgender, 4 percent as androgynous, and 9 percent as genderqueer. LGBTQIA participants reported that they felt excluded from STEM workplaces and professional culture. Faculty level also appeared to be a factor in their comfort in being open to colleagues about their sexuality. The authors found that early-career academics (for example, postdoctoral researchers, medical residents, laboratory technicians, or managers) reported lower openness to colleagues than survey participants at later career stages (e.g., assistant, associate, and full professors, or emeritus/retired) (Yoder and Mattheis, 2016).

This level of openness also varied by STEM field. Participants working in earth sciences, engineering, mathematics, and psychology reported being less out to colleagues, and participants working in the life sciences, physical sciences, and social sciences reported being more out (see Figure 2-3) (Barres et al., 2017; Yoder and Mattheis, 2016). Similarly, in another study that examined LGBTQIA scientists in physics found that LGBTQIA scientists may feel the need to remain

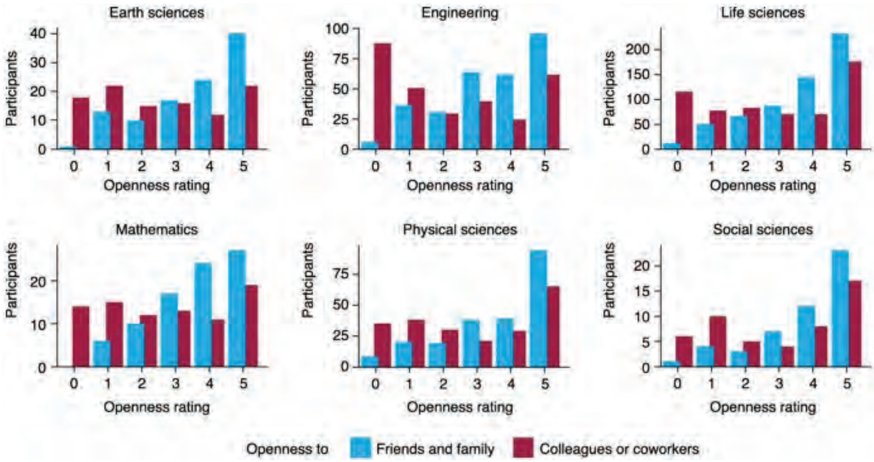


FIGURE 2-3 STEM professionals ranking of openness about LGBTQIA identities in various STEM fields. 0 = no one knows, 5 = everyone knows.
SOURCE: Barres et al., 2017.

closeted if they are unsure of their advisor's perspective on their rights and personhood (Atherton et al., 2016).

Yoder and Mattheis's (2016) research suggests that better representation of women in STEMM is associated with greater inclusion of those who are stereotyped as not conforming to gender roles, in that LGBTQIA scientists working in STEMM fields with better representation of women were more likely to disclose their identities to their colleagues.

In addition to openness, individuals with minority genders, sexual orientation, or both experience higher rates of sexual harassment and assault than cisgender straight women (Brewster et al., 2012, 2014; Eliason et al., 2011). In a recent survey of sexual and gender minorities (n = 474) in astronomy and planetary sciences, LGBTQIA women and gender minorities were more likely to experience homophobic and transphobic remarks from their peers, were more likely to feel unsafe at work due to their racial, gender, and/or sexual identities compared with cisgender straight women, and were more than twice as likely to experience assault at work. All of this leads to a loss of opportunity and contributes to the underrepresentation of LGBTQIA individuals in astronomy and planetary sciences (Richey, 2019).

Regarding retention in STEM, Hughes et al. (2018), using national longitudinal survey data, examined whether students who identified as a sexual minority were more or less likely to persist after 4 years in STEM fields, as opposed to switching to a non-STEM program compared with their heterosexual peers. The authors found that LGBTQIA students were 9.54 percent less likely to be retained in STEM than their heterosexual peers. However, they also noted that this group was also far more likely to report participating in undergraduate research programs. In fact, LGBTQIA students were nearly 10 percentage points more likely to participate in undergraduate research than their heterosexual peers. This may indicate that LGBTQIA students are interested in participating in STEMM research at the undergraduate level, but are more likely than their non-LGBTQIA peers to leave these fields at later career stages (Hughes, 2018).

While the committee identified few interventions targeted to LGBTQIA women in STEMM, preliminary research indicates that raising intersectional bias awareness in college classes can encourage positive changes in attitudes and beliefs (Case and Lewis, 2012). It will be critical for future work to continue exploring how interventions impact this population, including individuals who identify as gender nonbinary.

Generally, the committee found few studies designed to examine and address the underrepresentation of LGBTQIA women in STEMM. More research is needed to understand the intersectional experiences of LGBTQIA women and practices that would be most effective to increase participation and retention of this group in STEMM.

International Women in STEMM in the United States

Research indicates that international women students in U.S. institutions, along with their male counterparts, face discrimination in STEMM fields as a result of their national origin and cultural differences. Overall, the number of non-native men and women entering STEMM fields has generally increased over time (NSF, 2016). For example, the number of international students in U.S. doctoral programs in specific STEMM fields has been rising, particularly in computer science, engineering, and physics, where international students constitute 51 percent, 56 percent, and 45 percent of Ph.D. recipients in those fields, respectively (NSF, 2016). In fact, the percentage of international doctorate recipients has risen by over 30 percent since 2000 in almost all STEM fields (NSF, 2015). The majority of international students in Ph.D. programs in the United States come from China, India, and South Korea (NSF, 2010).

From 1996 to 2006, the number of doctorates awarded to temporary visa holders increased in every scientific discipline (Figure 2-4). During this time, the number of female doctoral recipients also grew from 45 percent to 51 percent among U.S. citizens and permanent residents, and from 23 percent to 34 percent among temporary visa holders (NSF, 2016). While the numbers vary by specific field, foreign-born women are anticipated to continue to join STEMM as students in the U.S. system at increasing rates.

Despite increasing numbers of women born and raised outside the United States joining STEMM, there is relatively little known about how they are faring and the barriers they are facing in these fields (Hayes and Bigler, 2015; King

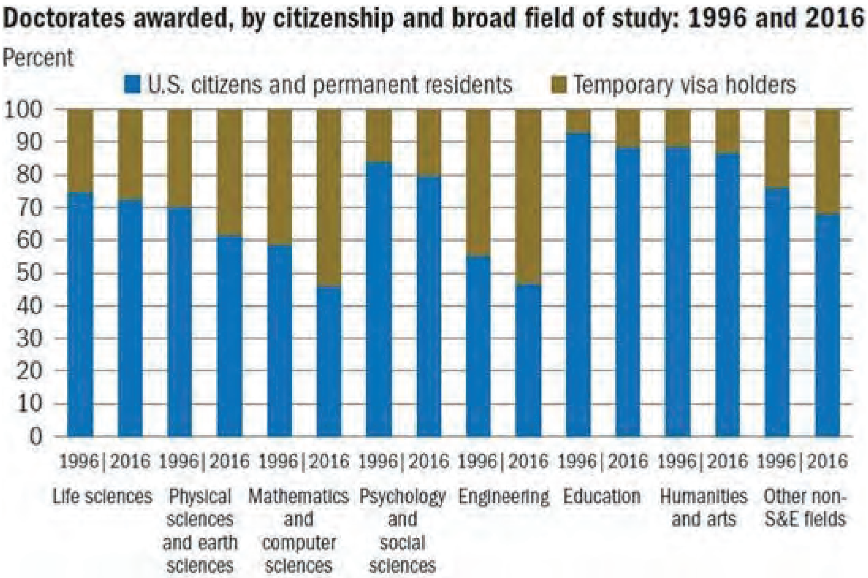


FIGURE 2-4 Between 1996 and 2016, the number of doctorates awarded to temporary visa holders has increased across every discipline.
SOURCE: National Science Foundation, 2016.

Miller, 2017). Additionally, little is known about the treatment of women by foreign born men. Due to the increasing number of international students in the U.S. STEMM enterprise, climate surveys that examine a cross-cultural perspective are important to better understand the experiences of these students. As described below, what is known about the issues facing these women in STEMM is complicated.

Cultural differences exist between U.S. and international students characterizing their experiences in STEMM. Hayes and Bigler (2013, 2015) found that women who are born and raised outside the United States, especially in regions marked by potentially less progressive gender roles, may have more traditionally feminine occupational values than their U.S. counterparts (Hayes and Bigler, 2013, 2015). The authors noted that the converse of this might also be true: "International women have presumably sacrificed a good deal to pursue STEM training in the U.S. (e.g., increased financial cost and separation from family) and thus they may be more similar to men in their occupational values than to their U.S.-born female colleagues" (Hayes and Bigler, 2015). Hayes and Bigler (2015) also found that, among international groups, women who are targets of gender discrimination in their department report lower satisfaction with their graduate training (Hayes and Bigler, 2013, 2015).

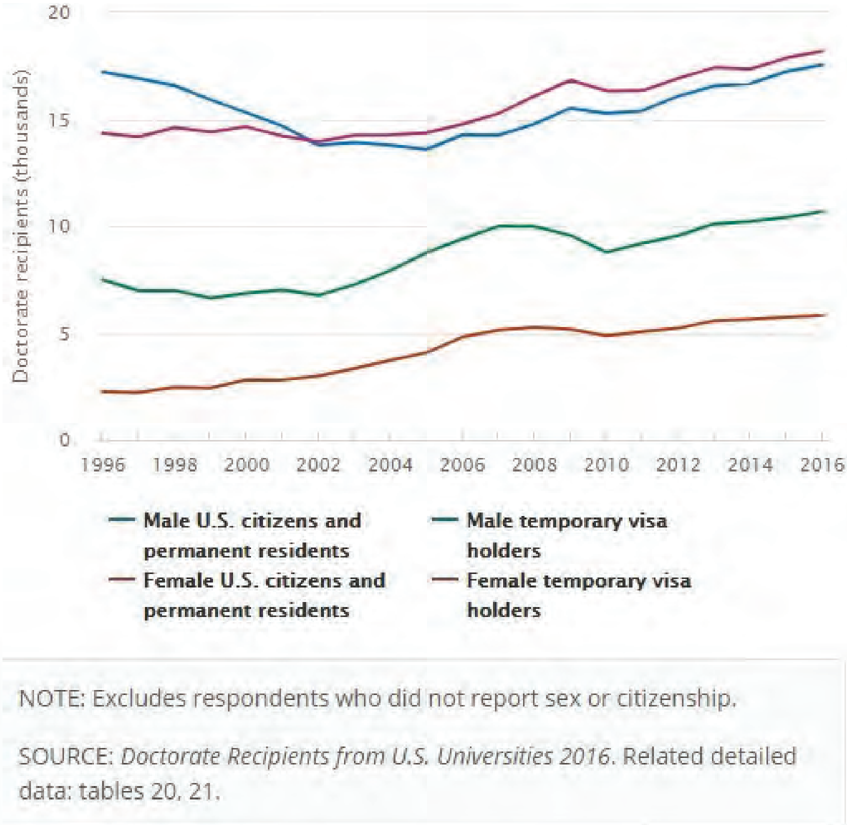


FIGURE 2-5 Sex and citizenship of U.S. doctorate recipients, 1996-2016.
SOURCE: National Science Foundation, 2016.

While the literature has highlighted the underrepresentation of African American and Hispanic women in STEMM, data are significantly lacking regarding the experiences of women of African descent in these fields (King Miller, 2017). As this group is racialized as Black, they experience similar struggles for inclusion as African American women (Burton et al., 2010; Fries-Britt et al., 2014; King Miller, 2017). For example, the data that are available do not differentiate African Americans from foreign-born Blacks. Therefore, data on the number of Black women in STEMM may not exclusively represent the percentage of African Americans present in STEMM in comparison with foreign-born members of African descent. Instead, these data may be representative of all Black women inclusive of immigrants employed in STEMM careers within the United States (i.e., Afro Caribbeans and Africans) (King Miller, 2017).

In terms of discrimination that Africans and Afro Caribbeans face in STEMM, the "racialization rooted in American society and the emphasis on race is often unfamiliar to black immigrants because their racial identity is shaped from a country other than the United States" (Fries-Britt et al., 2014; King Miller, 2017). In many of the countries that Black immigrants emigrated from, identity is shaped by ethnicity rather than race (King Miller, 2017).

Several studies suggest that the U.S. educational system may begin to marginalize students based on skin color once they become assimilated into American culture, resulting in a disparity between those who have recently immigrated and those who may look and sound like African Americans. For the second generation and those who arrived in the United States at a very young age, there may be "pressure from their African American peers to conform in speech and behavior" (King Miller, 2017; Woldemikael, 1989). In addition, because Afro Caribbeans, for example, share the same racial classification as African Americans, they are vulnerable to the same forms of racial discrimination (Rogers, 2006).

Similarly, Tseng (2006) found that first-, second-, and third-generation immigrants who were European, African, Afro Caribbean, Asian, and Latin American entered STEM fields at similar rates, but in the second and third generation, students from each ethnic group showed a significant decrease in selecting STEM. The authors posit that, as the immigrant population becomes more assimilated into the U.S. education system, the likelihood that they will abandon the pursuit of STEMM-related subjects and careers increases (Tseng, 2006). Generally, the lack of data on the experiences of Afro Caribbeans and Africans and other international students in U.S. STEMM fields highlights this as a critical research need.

DIFFERENCES ACROSS STEMM FIELDS

While many barriers to full and equitable participation are shared across all STEMM fields, their form varies with the history, culture, and context of disciplines. In disciplines where much of the work takes place outside traditional professional spaces—astronomical observatories where data collection takes place at night, remote field sites that require camping or extensive hiking, laboratory experiments that require daily attention, including weekends—incivilities, harassment, or assault can be more common (Clancy et al., 2014; Nelson et al., 2017). The culture of these disciplines also matters. In physics, astrophysics, and planetary science, for example, invited speakers are often interrupted during their talks, whereas in the biological sciences such interruptions are atypical (NASEM, 2018b). Biology and physics also have very different histories. As sociologist of science Joseph Hermanowicz (2009) writes, "Physicists possess a recognizable genealogy of immortals—the likes of Kepler, Newton and Einstein—who promote a sense of scientific heroism and define a 'model' career for those who follow."

One of the downstream effects of these cultural histories is that success in physics is presumed to hinge on innate brilliance, whereas in biology success is perceived to require effort and empathy (Leslie et al., 2015). In those disciplines where successful practitioners are expected to have "raw, innate talent" women are less well represented, a phenomenon that led to the development of "the field specific abilities hypothesis" by Leslie et al. 2015.

In a nationwide survey of academics across STEM and the humanities, Leslie et al. (2015) found "evidence that the field-specific ability beliefs hypothesis can account for the distribution of gender gaps across the entire academic spectrum." The authors found that negative stereotypes about women's innate aptitude in certain STEM (e.g., math, physics, computer science, engineering) and humanities fields (e.g., philosophy, economics) better explained their underrepresentation in these fields relative to other potential explanations, such as willingness to work long hours required in certain fields or selectivity of graduate programs (as evidenced by estimated percentage of graduate applicants admitted to the department each year and 2011-2012 Graduate Record Examination (GRE) scores). In fact, fields that were more selective (according to these criteria), appeared to have had higher representation of women, although the difference was not statistically significant. Additionally, the authors found that the field-specific abilities belief hypothesis could explain the patterns of underrepresentation of African Americans across STEM and humanities fields; they did not, however, publish intersectional data on African American women specifically. The authors did directly confront the question of whether "women and African Americans [are] less likely to have the natural brilliance that some fields believe is required for top-level success?" and conclude that "the case has not been made that either group is less likely to possess innate intellectual talent (as opposed to facing stereotype threat, discrimination, and other such obstacles)." The authors' conclusion is supported by a detailed analysis in the 2007 National Academies report *Beyond Bias and Barriers* (NASEM, 2007).

The "ideal worker norm" culture of effort and "hustle" in biology is not necessarily healthier than one that relies on assumptions of raw talent. Cultures of hustle encourage a work-life blurring, as well as the transgressing of other boundaries (Clancy et al., 2014; NASEM, 2018b; Nelson et al., 2017). In the hustle culture, stereotypes about women who nurture, as well as actual responsibilities they may have for childcare or elder care, may violate the ideal worker norm expectations in certain STEMM fields. When professional boundaries are blurred, harassment and assault can be intentionally perpetrated in the name of collegiality or over-friendliness (NASEM, 2018b; Wurth, 2018).

These features lead to variability in women's representation in STEMM disciplines and across educational and career stages. With the exception of biology and medicine, fields in which women are at parity at degree-granting stages, women are below parity in STEMM at all academic training and career stages. Although women are disproportionately underrepresented in computer science and engineering at all levels, women who pursue these fields have a high likelihood of persisting across the academic career trajectory, making up about 20 percent of bachelor's degree earners and professors. In contrast, in biology, physics, mathematics, and chemistry, attrition of women occurs at every additional step in the academic career pathway—from postdoctoral associate to assistant professor to associate professor to full professor (Mangurian et al., 2018). In medicine, like biology, women are overrepresented; as of 2018 women outnumbered men among medical school students (Mangurian et al., 2018). Notwithstanding their overrepresentation at early career stages, women remain underrepresented among senior leadership roles in medicine (see Figure 2-1). As of 2018, women accounted for only 18 percent of hospital chief executive officers and 16 percent of deans and department chairs (Mangurian et al., 2018).

Dichotomies in Diversity Issues

The fields defined in the statement of task—physics, engineering, computer science, mathematics, biology, chemistry, and medicine—can be divided into two broad categories: those in which disparities in participation arise by the time students enter college and those in which underrepresentation occurs primarily at more senior career stages. Computer science, engineering, and physics are fields where women and girls are underrepresented relatively early on (before graduate school), and the life sciences and chemistry are fields in which barriers and biases prevent equal representation at the faculty level and block advancement into leadership positions. Mathematics and medicine do not fit cleanly into either of these categories, so the committee has separated them out into their own sections.

Computer Science, Engineering, and Physics

Computer science, engineering, and physics are fields with extremely low representation of women (Cheryan et al., 2017). In 2016, fewer than 20 percent of bachelor's degrees were awarded to women in both computer science and physics and 21 percent of bachelor's degrees were awarded to women in engineering (NSF, 2019). However, within sub-branches of the physical sciences and engineering, there is significant variation in the representation of women. For example, astronomy has twice the percentage of women than physics does (Urry, 2015), and nearly half of all bachelor's degrees in environmental and biomedical engineering were awarded to women (ASEE, 2016; Yoder and Mattheis, 2016).

Computer Science. There is a widespread perception that girls and women are uninterested in computing and programming (Fisher et al., 1997). This perception, however, is not supported by a large body of evidence. Research on cultural attitudes suggests that adolescent girls are bombarded with stereotypes that computer science is a masculine field (Urry, 2015). Both girls and boys receive the message that computer science is a field ideal for "geeks" who are by archetype male, brilliant, socially awkward, isolated, and fond of science fiction; there are even physical elements of the archetype, including pale skin and myopia (Beyer, 2014; Cheryan et al., 2015; Master et al., 2016; Rasmussen and Håpnes, 1991). Such stereotypes influence the decisions students make about programs of study and classes to take, particularly if they have not had early exposure to these disciplines (Cheryan et al., 2017). For example, according to Nord et al. (2011), when computer science classes are offered in high schools, boys are more likely than girls to enroll. Such gender imbalances at the high school level lead to imbalances at the undergraduate level, an issue that first emerged 20 years ago (Fisher et al., 1997; Master et al., 2016). Although stereotypical attitudes contributed to the perceptions of girls that they do not belong in computer science, interventions to alter classroom environments, such as including more examples of female scientists in wall art, can counter impacts of stereotypes (Master et al., 2016). This finding suggests that interventions at the high school level may be effective in increasing the numbers of women who are interested in and prepared for computer science courses at the undergraduate level. However, the widespread male-dominated culture that prevails at the undergraduate level may still lead to departures of women from the field (Fisher et al., 1997) (see Chapter 3 for further discussion). In fact, historical surges in computer science enrollment are often followed by decreases in representation of women, indicating that the culture of academic computer science during periods of growth may crowd out of the field.

Other programs focused on increasing women in computer science include those that aim to change the masculine stereotypes of the discipline, changing disciplinary content, altering the educational environment to be more inclusive and less hostile, and increasing the numbers of women in computer science (Fisher et al., 1997; Lagesen, 2007; Roberts et al., 2002) (see Chapter 3). A number of nonprofit organizations, such as code.org, Girls Who Code, Black Girls Code, and TECHNOLOchicas, have as a mission to increase the number of women in computer science and change the stereotypical image of programmers by exposing adolescent girls to computer science and programming.

At the transition from undergraduate to graduate programs, White women are retained at high percentages; in 2017, for example, the percentages of White women awarded Ph.D.s (10.9 percent among all computer science Ph.D.s) was slightly higher than the percentage awarded bachelor's degrees (8.35 percent of all bachelor's degrees in computer science) (NSF, 2016a,b). However, the numbers for women of color are extremely low. For example, like White women, Asian/Pacific Islander women slightly increased representation at the Ph.D. level, comprising 2.5 percent of Ph.D.s awarded compared to 1.6 percent of bachelor's degrees awarded (Ong et al., 2011). However, overall representation was much lower than the percentages of Asian/Pacific Islander men awarded bachelor's degrees (6.8 percent) and Ph.D.s (10.5 percent) (Ong et al., 2011).

The absolute number of underrepresented minorities in computer science has decreased over time. A longitudinal analysis (1960-2009) of the U.S. computing labor force found that diversity decreased during this period. Whereas White women were 69 percent less likely than White men to work in computing in 1980, by 2009 the odds against working in computing increased to 71 percent. Underrepresented minority women were also 71 percent less likely than White men to work in computing throughout the period.

Because the problem in computer science is often characterized as a "pipeline" problem (Alper, 1993; Berryman, 1983; Ivie and Ray, 2005), only a few studies offer insight into broader cultural problems in that field. Women of color in computer science experience isolation and are marginalized beyond what White women experience (Charleston et al., 2014; Ong et al., 2011). Women of color, particularly Black women, are challenged by their peers regarding their academic competence and credentials (Charleston et al., 2014). Moreover, Black women in computer science are marginalized by both White women and Black men who prioritize gaining acceptance from the White men who hold cultural capital (Charleston et al., 2014). For example, Charleston et al. (2014) noted that "despite sharing similar racial experiences, participants noted how Black men and women were not always valuable sources for social support or camaraderie. As one participant elaborated, 'Just cause there's another Black brother [in class] doesn't mean they want to work with you either.' In sum, participants felt that Black men placed a strong emphasis on developing relationships with White males, whereas Black women were less inclined to do so" (Charleston et al., 2014).

Engineering. Like computer science, the engineering profession is characterized by stereotypes associated with masculinity and "geeky," antisocial tendencies (Cheryan et al., 2015). The low representation of women, context of masculinity, and stereotypical expectations all perpetuate an atmosphere that can be hostile to women (Cheryan et al., 2015; Hunt, 2016). Compared with other science disciplines, engineering has been characterized as particularly resistant to diversity and inclusion efforts (Burack and Franks, 2004).

Early socialization provides the first departure point in gender disparities in engineering. In interviews, male engineers are more likely to report early experiences with building and taking apart toys, whereas women engineers are more likely to refer to role models who specifically encouraged them to pursue engineering, as well as targeted opportunities such as science camps and middle school competitions (Chanderbhan-Forde et al., 2012). At the high school level, stereotypical expectations play a role in deterring women from gaining the necessary prerequisite coursework, and girls generally receive less encouragement to apply to undergraduate programs in engineering than boys receive (Cheryan et al., 2015; Hunt, 2016).

At the undergraduate level, the masculine context and social exclusion create barriers. Although male engineering students also reported a dearth of mentoring, a majority were able to obtain mentoring from upperclassmen, whereas, as described above, female students relied more on family members who were engineers. This pattern suggests that the likelihood of pursuing a career in engineering is higher for those with backgrounds that give them access to mentoring.

Women are also substantially underrepresented as engineering faculty and professionals (Bejerano and Bartosh, 2015). In the same positions as men, female engineers make less money, receive less support for their research and ideas, and have fewer opportunities for advancement (Bejerano and Bartosh, 2015; Hunt, 2016; Xu, 2008). Compared with other scientists in other STEMM fields, engineers are more likely to be employed in the field for which they were trained, but departures from the field are characterized by high rates of gender disparity (Fouad and Santana, 2017; Hewlett et al., 2010; Hunt, 2016). Women who leave engineering careers cite three major factors: (1) gender disparities in pay in conjunction with difficult working conditions, (2) dissatisfaction with the ways their experience and skills are underutilized, and (3) lack of recognition or advancement opportunities (Fouad and Santana, 2017). The gender disparities in pay and advancement opportunities point to patterns of underlying structural discrimination in hiring and promotion (Hunt, 2016).

Women of color in engineering experience intensified marginalization relative to men (Chanderbhan-Forde et al., 2012; Foor et al,, 2007; Ong et al., 2011; Tate and Linn, 2005). Black female students have few faculty role models with respect to both race and gender (Chanderbhan-Forde et al., 2012). Like Black women in computer science, Black women in engineering are likely to experience marginalization from both White female and Black male peers (Charleston et al., 2014). This intersectional status results in amplification of barriers to obtaining access to prerequisite education in high school as well as of messages of social exclusion at the undergraduate and graduate levels (Chanderbhan-Forde et al., 2012; Foor et al., 2007; Ong, 2011). Minority women, particularly Black and Latina women, are told throughout their careers, by their peers, colleagues, and students, and by the ambient environment, either explicitly or implicitly, that they do not belong (Foor et al., 2007). Because faculty and peers may be unwelcoming, minority women often seek social support from sources outside their discipline and create separate social and academic peer groups (Cross et al., 2017; Mendenhall et al., 2018; Ong et al., 2011; Tate and Linn, 2005).

Physics. Physics fields are strongly male dominated and are characterized by many of the preconceptions of aptitude and brilliance that occur in other male-dominated sciences (Leslie et al., 2015). As is the case in computer science and engineering, enrollment in undergraduate physics programs and preparation for these programs reflect high school experiences. Despite the fact that female students on average have higher high school grade point averages than their male counterparts, as well as equivalent mathematics preparation, male students enter introductory college physics courses with better preparation from high school physics classes (Hazari et al., 2006; Kost-Smith et al., 2010). This may be due to girls being discouraged from taking physics courses, or teachers directing their pedagogy toward male students (Hazari et al., 2006; Kost-Smith et al., 2010).

Female physics undergraduates experience the same challenges as computer science and engineering undergraduates in finding mentors, role models, and peer support (Aycock et al., 2019). However, they experience other challenges that their male counterparts experience with much lower frequency; Aycock et al. (2019) reported survey results indicating that 74 percent of female physics majors experience sexual harassment, the majority of which is gender harassment perpetrated by their peers. Women in physics graduate programs experience frequent microaggressions, in which they are treated negatively compared with male graduate students, and receive demeaning comments from both peers and faculty; and their complaints about their experiences with differential treatment are often dismissed (Barthelemy et al., 2015, 2016). These experiences have both racial and gender components for women of color (Clancy et al., 2017; Johnson, 2017; Ko et al., 2014). In a survey of women in astronomy and planetary science (fields closely related to physics), 40 percent of women of color felt unsafe in their workplace environments, and both White women and women of color avoided professional events due to safety concerns (Clancy et al., 2017).

A 2020 report by the National Task Force to Elevate African American Representation in Physics and Astronomy (TEAM-UP), which examined the reasons for the persistent underrepresentation of African Americans in these fields (AIP, 2020), offers additional insights. By conducting student and department chair surveys, interviews with students, site visits to five high-performing physics departments, and a review of the relevant literature, the task force identified five key factors responsible for the success or failure of African Americans in physics and astronomy:

1. Belonging
2. Physics identity
3. Academic support
4. Personal support
5. Leadership and structures.

The authors noted that the persistent underrepresentation of African Americans in these fields is due to "(1) the lack of supportive environments for these students in many departments, and (2) to the enormous financial challenges facing them individually, as well as the financial challenges faced by the programs that have consistently demonstrated the best practices in supporting their success" (AIP, 2020).

The task force discussed a number of barriers that African Americans, including women, face in these fields, particularly as a result of their intersecting identities. These can include stereotypes about who is interested or capable of entering physics or astronomy. To reduce some of these factors, student peers can play an important role in improving a sense of belonging in physics by mitigating microaggressions, the imposter phenomenon, and stereotype threat. Retention in these fields is further improved by an increase in the number of faculty who get to know these students and support their success (AIP, 2020) (see Chapter 3 for additional discussion of the important role faculty can play in instilling physics identity in African American physics students).

In physics careers, gender differences in salary emerge mid-career. For recent physics graduates, there were no gender differences in salary 1 year after graduation; however, men had salaries that were 10 percent higher than salaries of women 10–15 years after graduating with a physics doctorate. Also, compared with men, women reported that their careers progressed more slowly and that they received fewer career resources and opportunities. In addition, women were more likely to make career compromises for family reasons (Porter and Ivie, 2019).

Biology and Chemistry. Women are generally not underrepresented in biology and its sub-disciplines, including biophysics and computational biology, and chemistry at the undergraduate level. Yet, in both of these fields, the proportion of women declines at subsequent professional stages (Addessi et al., 2012; Crangle, 2009; Ledin et al., 2007; Nüsslein-Volhard, 2008).

The percentage of women among the students earning bachelor's degrees in biology peaked at 62 percent in 2003–2006 (APS, 2018). Since then, it has remained steady, fluctuating between 59 and 61 percent from 2007 to 2017. The percentages of women obtaining master's degrees and enrolling in doctoral programs in the biological and biomedical sciences in 2017 were 52.6 percent (NSF, 2018a), 45 percent (Martinez et al., 2007)[5] and 38 percent (Plank-Bazinet et al., 2017), respectively.

Chemistry has gender parity at the undergraduate level (Grunert and Bodner, 2011); from 2000-2017, with the proportion of women among all students receiving undergraduate degrees in chemistry fluctuated between 48 percent and 52 percent (APS, 2018). The percentages of women obtaining master's degrees and enrolling in doctoral programs in chemistry are lower than the percentages of women obtaining bachelor's degrees: In 2008 women received 36.1 percent of chemistry doctorates and 23.6 percent of postdoctoral fellowships, and women comprised 18 percent of faculty applicants to research-intensive institutions (Grunert and Bodner, 2011; NSF, 2011).

The popular images of biologists and chemists are not as male-oriented as in fields such as computer science, engineering, and physics (Cheryan et al., 2017). Negative stereotypes about women's innate abilities are also less prominent in biology and chemistry (Cheryan et al., 2017). In many institutions, however, biases and barriers undermine success and increase the desire to leave at later educational and career stages.

[5] Data on postdocs and faculty refer to women in the biomedical sciences only.

Biology. Although women are not underrepresented in biology in general, they face biases and barriers that drive them out of the discipline over the course of their careers with greater frequency than their male counterparts. In 2014, the SAFE (Survey of Academic Field Experiences) team published its first findings on sexual harassment in the field sciences, most of which are biological sciences (Clancy et al., 2014). Researchers distributed an online survey through a variety of channels (e.g., Facebook, Twitter, LinkedIn, professional societies, and through science and service blogs in two waves: the first, aimed at biological anthropologists included 124 respondents, and the second (N = 542) that allowed respondents to provide their professional discipline). They found that most, or 72.4 percent, of women observed sexual harassment; a large number, 64 percent (N = 423/658), experienced sexual harassment, and a significant minority were sexually assaulted while conducting fieldwork. In this sample, when women were harassed the perpetrator was more likely to be senior to them in the workplace hierarchy; when men were harassed, the perpetrator was more likely to be a peer. Few (18 percent) respondents reported field experiences where there was a clear reporting mechanism for sexual harassment, and, of the hundreds who shared that they experienced sexual harassment, only a handful (N = 37) reported, and only seven were satisfied with the outcome of that report. One of the initial hypotheses proposed by Clancy et al. (2014) for why field researchers were so often sexually harassed was that the harassment was coming from "locals" in countries with sexist views about women; however, data demonstrated that women were much more often harassed by their co-workers, not the "locals" whom they encountered in the field.

In 2017, the SAFE team published a follow-up study based on 26 interviews with field scientists (Nelson, 2017). The team found evidence that the culture of the field sciences is characterized by unclear boundaries, few sanctions for bad behavior, and unequal access to resources for women. As respondents shared, many were implicitly or explicitly told that they could not communicate with colleagues about their experiences with inappropriate behavior at their field sites. Respondents who reported incidents, spurned advances, or otherwise fought back in their harassing environment faced significant personal and professional consequences, from sabotage of their research to posttraumatic stress symptoms that interfered with publication of the results of their field research.

Women in biology also face substantial hiring disparities. Sheltzer and Smith (2014) found that at the trainee level, on average, male principal investigators ran laboratories that had 36 percent female postdocs and 47 percent female graduate students, significantly lower than was observed in laboratories headed by women, who employed on average 46 percent female postdocs and 53 percent female graduate students. Women are also hired at the faculty level less frequently at prestigious institutions, and instead are directed toward less prestigious, more teaching-focused positions (Sheltzer and Smith, 2014). These findings point to lost opportunities for advancement for women in biology across the career stages.

Chemistry. Chemistry is a discipline that has gender parity at the undergraduate level (Grunert and Bodner, 2011), but has unique cultural challenges that act as barriers for women later in their education and careers. In a survey of British doctoral students in chemistry, female students reported more issues with lack of mentoring and social marginalization compared to male students (Newsome, 2008). Furthermore, women were more likely to perceive their research group's culture as inhospitable (Newsome, 2008). They also raised concerns about the isolating nature of their doctoral study as well as about warnings they received suggesting that they would have to sacrifice relationships and family in order to remain competitive in the postdoctoral and academic job markets.

Many women who obtain academic positions in chemistry find them unwelcoming (Greene et al., 2010). Typically, men have higher salaries, are given better or larger research space, and are more likely to be promoted at all career stages (Greene et al., 2010). Men receive greater recognition from the university, are more respected by students, and have an easier time gaining administrative assistance. In contrast, women are more likely to have higher teaching and service loads (Greene et al., 2010), which they believed were among the departmental barriers to recruiting and hiring other women faculty (along with overt opposition to hiring female faculty).

Mathematics. Like computer science and physics, mathematics is a discipline where aptitude is assumed to be due to innate brilliance and this belief is compounded with culturally ingrained, sexist stereotypes (Cvencek, 2011; Leslie et al., 2015; Master et al., 2016). By second grade, children form implicit and explicit associations between boys and math, and girls are less likely to state explicitly that they like math (Cvencek, 2011). Even for girls and women who are motivated to study math and excel at math, negative stereotypes hinder their mathematical performance. Stereotype threat is the phenomenon where awareness of a negative stereotype about identity leads to anxieties about confirming that stereotype (Spencer et al., 1999; Steele and Aronson, 1995). Middle school girls who are told that they are taking a test that measures mathematical skills underperform on those tests when they are alone or in a mixed-gender group, but not when they are in a group of girls (Huguet and Régner, 2007). Asian American girls experience competing stereotypical pressures: on the one hand, some stereotypes associate female identity with poor mathematical aptitude, and on the other, some stereotypes associate Asian identity with excelling at math (Ambady et al., 2001). The impact of gender socialization and stereotypical association persist through high school and undergraduate studies.

Early studies indicate that gender differences in math performance emerged in high school, but that gap has now closed (Hyde et al., 1990a, 1990b, 2008). Because girls and boys are similarly prepared by high school math courses, undergraduate women are theoretically well prepared for mathematics curriculum at the college level. The number of undergraduate degrees awarded to women in mathematics reached a high of 48 percent in 1999–2000, but since then the proportion of degrees awarded to women has steadily declined to 41 percent in 2017 (Herzig, 2004b; APS, 2018).

These patterns raise the question as to how a significantly greater proportion of women students graduate with undergraduate degrees in math than in other physical science STEMM majors, despite similar negative associations and stereotypes about women's abilities. There are at least two possibilities that might work separately or in conjunction to explain why math is more gender balanced. First, negative stereotypes about girls' abilities in math may be weaker than negative stereotypes in other more male-dominated fields (Cheryan et al., 2017). Second, pre-college math is mandatory in most curricula, and girls perform as well as boys in these courses. Mandatory courses—if taught well for girls—may reduce gender disparities in later participation because they provide girls with an opportunity to try a field (in a classroom that is gender balanced) instead of relying on stereotypes about girls or about the field to guide their decisions.

In academia, women are disproportionately lost from mathematics careers at two key points: the transition from undergraduate to graduate school and the transition from graduate school to faculty. In 1996, 46 percent of bachelor's degrees in mathematics were awarded to women, yet women comprised only 33 percent of entering graduate students. By 2002, the proportion of women hired into tenure-track mathematics positions had declined to 22 percent. Representation of Black, Latina, and Native American women among doctoral recipients is extremely low. Like other STEMM fields, women leave mathematics at the doctoral and postdoctoral levels due to isolation and a lack of mentoring in their graduate experiences (Herzig, 2002, 2004b). Negative experiences from faculty in mathematics, such as exclusion from social networks and gender harassment, play a role in driving women to leave their profession (Herzig, 2004b). Those who stay in mathematics are more likely to access cultural capital and mentoring networks due to family members in mathematics or involvement in undergraduate research experiences (Herzig, 2002).

Medicine. The absolute numbers of women who are medical school applicants, admitted students, and medical school graduates has steadily increased from around 10 percent in 1973 to gender parity today, although there are gender imbalances in some specializations (AAMC, 2016b). Generally, women are well represented in specialties that involve women and children or are associated with nurturing, whereas men are represented in higher proportions in specialties that require technical specialization (Carnes et al., 2008). Like biology, chemistry, and math, women are more likely to exit the profession at higher ranks. For example, in 2015, women comprised 51 percent of M.D. instructors, but their representation declined at the assistant professor level (43 percent), associate professors level (33 percent), and full professor level (20 percent) (Kenyon College, 2019). Moreover, a gender gap exists in several aspects of scholarly publication. Women have low proportions of first authorships (29.3 percent) and senior authorships (19.3 percent) relative to male peers (Jagsi et al., 2006). As well, women in academic medicine receive less institutional funding and administrative support compared with male colleagues (Carr et al., 2003).

Women in the field of medicine, as in other STEMM fields, experience conflicts between biological and professional clocks, as well as challenges of traditional gendered division of domestic labor. Women physicians report challenges of optimally timing childbearing in relation to their careers and of obtaining childcare, particularly during residency years (Jagsi et al., 2007). Women physicians reported spending 8.5 more hours a week on domestic activities than male peers and were more likely than male peers to have spouses or domestic partners who were employed full-time (Jolly et al., 2014). Additionally, faculty with both childcare and clinical responsibilities were significantly more likely to report low satisfaction with work-life balance and career than were colleagues without children and/or clinical responsibilities (Beckett et al., 2015).

Women of color face a double bind in medicine and are more underrepresented at higher academic ranks. Although minority women make up 18 percent of the U.S. population, they represent 3.2 percent of full professors in medicine. Additionally, women of color face higher workplace discrimination rates and work-family conflict, contributing to a negative climate (Carapina et al., 2017).

Of the disciplines examined in the 2018 National Academy of Sciences report, *Sexual Harassment of Women: Climate, Culture, and Consequences in Academic Sciences, Engineering, and Medicine*, medical students had the highest rates of sexual harassment compared with students in engineering, the sciences, and the nonsciences (NASEM, 2018b). The hierarchical and hostile work environments in many academic medical centers lead to greater bullying, intimidation, and harassment from patients, peers, and superiors. In fact, one-third of women in academic medicine experience gender harassment, and many reported that discrimination hindered their careers (Foster et al., 2000). Harassment is a particular concern in medicine because it takes place in "environments with little structure or accountability for the faculty member, and a decreased ability for students to leave without professional repercussions" (NASEM, 2018b). In a qualitative study at 23 medical schools, members of the Group on Women in Medicine and Science and the Group on Diversity and Inclusion of the Association of American Medical Colleges were interviewed. Despite the increase in numbers of women in medicine since the 1980s, only modest improvements were seen in the academic climate for women over the past 20 years, and there was a reported lack of institutional oversight and substantial variations by department (Carr et al., 2015).

Bias and discrimination in medicine can directly harm those not even employed in the field. The hierarchical and hostile training landscape many physicians experience introduces considerable bias, which is harmful to both patients and the physicians themselves. Hostility and incivility have adverse effects on medical teams' efficacy in diagnosis and treatment, possibly even greater in magnitude than adverse effects caused by sleep deprivation (Riskin et al., 2015). Physician biases regarding weight, gender, race, and other factors lead to missed diagnoses, delayed treatments, and poorer outcomes for many patients. Women and non-White males frequently receive less aggressive care than White males (Dressler et al., 2005; Geronimus et al., 2006; Gravlee, 2009; Suite et al., 2007). The ways in which these hierarchical and discriminatory practices influence the treatment landscape likely also have consequences for women and non-White male physicians who work in these cultural contexts.

CONCLUSION: SYSTEMIC ISSUES IN STEMM CULTURE

Across the science enterprise, widespread instances of active and passive actions, as well as implicit and explicit biases, hinder women's careers in STEMM. Women of multiple marginalized identities are confronted with amplified forms of these biases and barriers throughout all STEMM fields. The result is that many women leave STEMM or stall out in positions of lower educational attainment, rank, prestige, and pay compared to male colleagues. Based on many years of research, it is fair to conclude that many White women and women of color make rational decisions to leave environments in which they are subject to harassment, believe that their careers are stalled, and/or that they are discriminated against in pay and promotions. While research demonstrates that many White women and women of color report that they "feel" unwelcome, isolated, or unfairly held back, the objective reality is that they work in cultures and climates that often exclude them and push them out. The fact that these patterns exist broadly, including in fields that have large numbers of entering White women, points to systemic problems that cannot be solved simply by recruiting more women. Disrupting the forces at play in STEMM are necessary to create an inclusive environment that will enliven American science, engineering, and medicine. The chapters that follow describe the current state of research on educational and workplace interventions that show promise in supporting improved recruitment, retention, and advancement of women across STEMM, while pointing out where there are important gaps in knowledge.

FINDINGS: CHAPTER 2

FINDING 2-1: Evidence does not support the longstanding perception that women are underrepresented in STEMM because of a lack of innate ability in these fields.

FINDING 2-2: Implicit and explicit biases contribute to the underrepresentation of women in STEMM. These biases manifest in multiple ways at all stages of STEMM career life cycles. Across STEMM fields, biases often affect

women's educational and career trajectories at critical junctures, such as recruitment into lab management positions, consideration for graduate admissions, consideration for postdoctoral positions, and in promotion decisions. Women of multiple marginalized identities (e.g., women of color, women with disabilities, LGBTQIA women) experience intensified forms of bias and discrimination in STEMM as a result of the complex, cumulative ways in which multiple forms of discrimination (e.g., racism, sexism) intersect.

FINDING 2-3: In addition to experiences of heightened bias, sexual harassment, and microaggressions, women of color in STEMM frequently experience:

a. **isolation (i.e., experience a sense of invisibility or hypervisibility) and exclusion from social network supports usually available to men**
b. **a sense of "not belonging" in STEMM**
c. **"racial battle fatigue," which is the "cumulative result of a natural race-related stress response to distressing mental and emotional conditions" that adversely affects the health and achievements of students and faculty of color**
d. **racial harassment**
e. **cumulative disadvantage; such as interest on debt, and disadvantages, such as lower salary and delayed promotion, which accrue over time**
f. **expectations that they must work harder, including working extended hours, to fit the ideal worker norm despite having had fewer role models who have successfully managed these expectations, fewer culturally competent mentors, and less access to informal professional networks**

FINDING 2-4: There is less research on the factors that drive the underrepresentation of women with disabilities, LGBTQIA women, and international women, but the available research suggests that these groups face significant barriers in STEMM due to their intersectional identities.

FINDING 2-5: While bias, discrimination, and harassment exist across all STEMM disciplines, the form that these phenomena take varies with the history, culture, and context of the specific discipline, as does women's representation. In fields such as physics, engineering, and computer science, disparities in participation are seen by the time students enter college. In contrast, in the fields of biology, medicine, and chemistry, women encounter barriers and biases that prevent equal representation at the faculty level and block advancement into leadership positions. Mathematics has a slightly different pattern of underrepresentation, in that women comprise around 40 percent of undergraduate degree earners, but are lost at the transition from undergraduate to graduate school and the transition from graduate school to faculty.

FINDING 2-6: The number of women medical school applicants, admitted students, and graduates has steadily increased from around 10 percent in 1973 to gender parity today, although gender imbalances still exist in some specializations. Generally, women are well represented in specialties that involve women and children or are associated with nurturing, whereas men are represented in greater numbers in specialties that require technical specialization.

FINDING 2-7: Notwithstanding their overrepresentation at early career stages, women in medicine remain underrepresented among senior leadership roles in medicine. As of 2018, women accounted for only 18 percent of hospital CEOs and 16 percent of deans and department chairs.

FINDING 2-8: Although women are disproportionately underrepresented in computer science, engineering, and physics at all levels, women who pursue these fields have a high likelihood of persisting across the academic career trajectory, making up about 20 percent of bachelor's degree earners and professors. In biology, mathematics, and chemistry, attrition of women occurs at every additional step in the academic career pathway—from postdoctoral associate to assistant professor to associate professor to full professor.

FINDING 2-9: 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. This expectation that STEMM professionals are White and male is implicitly conveyed in cultural portrayals of STEMM and STEMM education and these stereotypical associations shape the social and educational environments of children, as well as structural patterns that occur in STEMM professions. The popular images of biologists and chemists are not as male-oriented as in fields such as computer science, engineering, and physics.

FINDING 2-10: Cultural expectations and biases about which jobs and careers are held, or *should* be held, by women and men present biases and barriers that limit both women's and men's opportunities in STEMM (for instance, biases and stereotypes can limit men's opportunities in certain medical fields).

FINDING 2-11: The culture of disciplines matters as one of the downstream effects of these cultural histories is that success in physics, engineering, and computer science is presumed to hinge on innate brilliance, whereas in biology success is perceived to require effort and empathy. In both STEMM and the humanities, disciplines where successful practitioners are expected to have "raw, innate talent," women are less well represented—most likely because of sexist beliefs about women's innate "brilliance" that is not supported by evidence (see discussion of the field-specific abilities hypothesis).

FINDING 2-12: Fields such as the biological sciences and medicine have a culture of "hustle" that encourages a work-life blurring. Such STEMM work environments often require a commitment to the job through long hours, stagnant career trajectories, and constant availability and visibility—i.e., the "ideal worker norm" that implicitly assumes that there will be gendered separation of work and family, further reinforcing the stereotypical image of the scientist or physician as a man. Adherence to these ideal worker norms disadvantages both men and women who have commitments and duties outside of work and has a disproportionate impact on women of color because their multiple identities and their small numbers in STEMM departments contribute to an even greater perception that they do not demonstrate the characteristics of the "ideal worker."

3

Educational Interventions to Improve Recruitment and Retention[1]

The analysis draws substantially from the research paper by Drs. Evava Pietri, Leslie Ashburn-Nardo, Corinne Moss-Racusin, and Jojanneke van der Toorn, which was commissioned for this study. The full research paper can be found online at: nap.edu/catalog/25585.

Recruiting and retaining more women in science, technology, engineering, mathematics, and medicine (STEMM) fields will require changes to the status quo in STEMM education, both in terms of the way students are taught and the experiences they have with faculty, role models, and mentors. Though White women are well represented among degree earners in certain STEMM fields (e.g. life sciences, chemistry), women remain particularly underrepresented in math-intensive STEMM disciplines such as engineering, computer science, and physics as early as the undergraduate level. Further, women express waning interest and self-efficacy in these fields at even earlier educational stages, despite the fact that there are no differences in average math performance between girls and boys in K-12 education or women and men in college math performance (see Chapter 2). Women of color remain underrepresented among undergraduate degree earners in all STEMM fields, including those disciplines in which White women are well represented. Given the national need for a greater number of STEMM professionals in many disciplines (particularly computer science and engineering), it is critical to identify strategies to improve recruitment and retention of women in educational programs in these fields. Fortunately, research offers a picture of the strategies educators and administrators can use to improve recruitment and retention of girls and women in STEMM education.

In the sections below we review the current research on interventions that can serve to promote recruitment and retention of women in STEMM with a

[1] This chapter builds on the significant contribution of the Committee on Understanding and Addressing the Underrepresentation of Women in Particular Science and Engineering Disciplines.

particular focus on effective educational strategies used throughout K-12 and undergraduate STEMM education and the positive impact of role models and mentors (see Chapter 4 for a discussion of the important role of sponsors). Many of these interventions are effective because they challenge stereotypes about *who* can be a successful scientist, engineer, or medical professional, and about the nature of work in STEMM (see Chapter 2 for a discussion of "Cultural Association Between Masculinity and STEMM") in ways that can mitigate biases against women and improve self-efficacy, belonging, and performance in these disciplines. Interestingly, research shows that many of the interventions described in this chapter, such as growth mindset interventions, active learning, and communicating the societal impact of STEMM, can serve to make these fields more attractive to both women and men and can benefit a range of additional underrepresented groups in STEMM, including underrepresented minority men and first generation college students (i.e., whose parents did not attend college).

It is worth noting, however, that much of the research presented in this chapter has not taken an intersectional approach; rather, it has tended to examine gender and race as distinct identities. While limitation in sample sizes may explain the paucity of reported research on women of color, it is difficult to evaluate the efficacy of specific interventions on women of color without these disaggregated data. The committee also acknowledges that there is not currently research on each of these interventions in the context of every STEMM discipline. However, as noted in Chapter 1, many of these interventions will likely be efficacious in a range of STEMM disciplines, as the research presented in this chapter does, for the most part, demonstrate similar positive outcomes associated with these intervention across different STEMM disciplines, including STEMM disciplines with very distinct cultures (e.g. biology vs. computer science). For those readers particularly interested in the current state of knowledge on the impact of specific interventions in the context of a specific discipline, the report offers a table that appears in Appendix A that provides an extensive review of interventions that have improved the recruitment, retention, and advancement of women in STEMM. This table provides detail on whether the intervention has been tested in STEMM and if so, in which disciplinary contexts.

EDUCATIONAL INTERVENTIONS IN STEMM CLASSROOMS

Active Learning

Reorganizing STEMM courses to incorporate *active learning exercises* (i.e., having students work in groups, using clickers) generally improves learning among all students (Freeman et al., 2014; Handelsman et al., 2007), and is particularly beneficial for women in STEMM. As one example, in a traditional lecture-based biochemistry class there was an achievement gap between male and female students, and incorporating active learning exercises alleviated this grade disparity (Gross et al., 2015). Moreover, when women students took an introduction to computer science class with multiple group activities, African American, Hispanic, and White women persisted longer in the computer science major than those who took a traditional lecture-based introductory course (Latulipe et al., 2018). Thus, ensuring STEMM courses integrate active learning is one strategy to help retain women in STEMM majors throughout college. Research has also found that active learning can decrease the achievement gap between educationally and/or economically disadvantaged students (predominantly students of color) and advantaged students (predominantly White) in introductory biology courses (Haak et al., 2011).

Peer-led team learning (PLTL), where students work in small groups to solve course-related problems with a peer mentor (a student who has previously been successful in the course), is another active learning strategy that improves outcomes for women in STEMM (Dennehy and Dasgupta, 2017). Incorporating PLTL improves learning outcomes generally in STEMM classes (Streitwieser and Light, 2010; Wilson and Varma-Nelson, 2016), and is particularly beneficial for students that have been underrepresented in STEMM (i.e., women and underrepresented minorities; (Horwitz et al., 2009; Thiry and Hug, 2012). For example, when PLTL was implemented in introductory STEMM courses, it improved the completion rate of all students and specifically enhanced Latinx students' completion rate (Hug et al., 2015; Thiry and Hug, 2012). Providing additional evidence, across eight universities, Horwitz and colleagues (2009) found that relative to female students who took a traditional lecture-based introduction to programming course, those who took a class with PLTL were more likely to enter, persist, and earn higher grades in computer science majors. PLTL also may encourage students to participate in helpful research experiences. In particular, Gates et al. (2015) examined the effectiveness of PLTL across primarily Hispanic serving institutions in introductory computer science classes, and found that PLTL not only improved students' problem-solving skills, but also increased the likelihood of students assisting with computer science research (Gates et al., 2015).

Aside from the pedagogical benefits of active learning, working together on a task (via active learning exercises) can promote social connection with other students, engagement with a task, and belonging in the STEMM environment (Carr and Walton, 2014). The benefits of working in groups also has been demonstrated with pre-school children. Relative to pre-school children working on a STEMM task alone, children who worked in a group showed higher engagement and interest in the task (Master and Walton, 2013; Master et al., 2017). This research with pre-school children demonstrates that interventions to recruit women into STEMM majors and careers can be implemented early in the educational system. Indeed, one large-scale strategy to spark girls' interest in STEMM disciplines where they are least represented (e.g., computer science, physics, engineering) is ensuring that girls are exposed to classes dispelling masculine

STEMM stereotypes in the fields early in their educational development (Cheryan et al., 2017) (see Chapter 2 for a discussion of stereotypical associations between STEMM and masculinity).

Growth Mindset

With regard to STEMM ability, students can either have a *growth mindset/incremental mindset* (i.e., have beliefs that they can improve and get better) or a *fixed/entity mindset* (i.e., have beliefs that their ability is fixed and cannot change) (Dweck, 1995). Across many years of research, Dweck and colleagues have demonstrated that having a growth mindset increases academic performance among middle school, high school, four-year college students, and community college students (Dweck, 2006; Yeager and Dweck, 2012). For example, Chen and Pajares (2010) found that middle school students with a growth mindset (as opposed to a fixed mindset) had higher self-efficacy and learning-focused goals, and that middle school boys were more likely to have growth mindsets than girls. Indeed, the more female high school students believe they have the capacity to be successful after setbacks, the more likely they are to major in physics, engineering, mathematics, and computer science in college (Nix et al., 2015). Moreover, compared to those who have a fixed mindset, women college students with a growth mindset about math ability indicated higher belonging in math, reported more attraction to math careers, and earned higher grades in math classes (Good et al., 2012).

Researchers also have demonstrated the benefits of implementing short *mindset interventions*, which provide evidence that ability is not fixed and can improve. For instance, middle school students who took part in a workshop discussing how the brain is malleable and intelligence is not fixed had increased motivation in math and improved math grades relative to students who did not complete the workshop (Blackwell et al., 2007). This mindset intervention was effective because it encouraged students to value learning and effort, and respond more positively to challenges (Blackwell et al., 2007). In another example, female seventh grade students who were mentored by college students promoting a growth mindset performed better on standardized math tests compared to students who did not receive this growth-focused mentoring (Good et al., 2003). Thus, having female middle school students undergo a growth mindset intervention may be one way to recruit them into STEMM majors.

Aside from women students, mindset interventions help other students who traditionally have been underrepresented in STEMM. For example, relative to those in a no intervention control condition, Black college students who underwent a growth mindset intervention had higher academic motivation and grade point averages (Aronson et al., 2002). Specifically, Aronson et al. (2002) found that after three sessions of advocating the malleability of intelligence, African American study participants were found to have "created an enduring and beneficial change in their own attitudes about intelligence." Further, this change resulted in improvements in their academic profile. As compared to control group participants, African American participants reported more enjoyment and value in their academics and received higher grades. While the intervention also positively impacted White students, the results were not as striking. The authors noted that over time, "African American students appeared to become more convinced of the expandability of intelligence, the White students' attitude change did not persist" (Aronson et al., 2002).

In a larger-scale experiment involving 90 percent of first-year college students attending a public university, researchers found that compared to students in a control group, a mindset intervention increased the grades of Latinx students and reduced the achievement gap between Latinx and White students. Testing the effectiveness of this intervention across multiple academic environments (i.e., at a high school, public university, and selective private university), Yeager et al. (2016) also demonstrated that this growth mindset intervention improved the academic performance of first generation and underrepresented minority students relative to those who did not complete the intervention (Yeager et al., 2016). Taken together, this research provides compelling evidence that mindset interventions are scalable (i.e., can be implemented across multiple academic contexts) and have the potential to be beneficial for women with multiple negatively stereotyped identities in STEMM.

Communicate to Students the Societal Impact of STEMM

Steinberg and Diekman (2018) found that encouraging students to introspect on *why* (e.g., improving society) as opposed to *how* (i.e., running experiments) scientists conduct research in STEMM increases beliefs that STEMM careers broadly satisfy communal ambitions and enhance both male and female students' positive attitudes toward those careers. Illuminating one such intervention, STEMM classes can incorporate helping-focused projects to encourage beliefs that STEMM fields value communal aims (Belanger et al., 2017). Both male and female students are more likely to believe that engineering classes that have a service learning component (i.e., during which students use what they learn in class to help their local communities) fulfill communal goals and in turn are more interested in taking these classes (Belanger et al., 2017). Incorporating service learning projects in STEMM classes, therefore, helps promote perceptions that STEMM fields advance communal goals, which can serve to recruit women into STEMM classes. In another study, explicitly describing biomedical research as aiming to improve lives sparked students' motivation, among both women and men, to conduct biomedical research (Brown et al., 2015). Similarly, when class lectures are structured to emphasize how STEMM research and careers help others, female first year college students believed that STEMM careers advance communal goals and expressed more interest in these careers (Fuesting and Diekman, 2017).

Educators can also personally emphasize how their work in a STEMM field satisfies their communal motives (Chen and Pajares, 2010; Dweck, 2006; Emerson and Murphy, 2015; Good et al., 2012; Yeager and Dweck, 2012). As one example, watching women scientists present on the altruistic aspects of their research increases adolescent girls' interest in science (Weisgram and Bigler, 2006). Learning about how a scientist's daily tasks involve working with and helping others (as opposed to working alone) also encourages women college students' attraction to STEMM fields (Diekman et al., 2011). Finally, women STEMM majors report being more interested in working with a faculty mentor who values communal goals compared to a mentor who values agentic goals (Fuesting and Diekman, 2017). Taken together, this research provides compelling evidence that presenting STEMM fields (including biomedical sciences and computer science) as communal enhances interest in STEMM and encourages recruitment of women in STEMM. It is noteworthy that many of these interventions enhanced interest in STEMM among both women and men (Brown, 2015; Steinberg and Diekman, 2018), suggesting that these strategies benefit any student who values helping others and do not inadvertently dissuade men from entering STEMM careers.

STEMM instructor characteristics and instructional features. Changing the structure of STEMM classes requires the involvement and commitment of STEMM instructors, and some may not feel comfortable or know how to incorporate techniques that can support active learning or growth mindset in their courses. To address this issue, STEMM education researchers have developed successful training and workshops that can teach instructors about these classroom techniques. For example, the National Academies Summer Institute for Undergraduate Education is a successful weeklong workshop, during which STEMM instructors learn how to develop and effectively incorporate active learning into their courses (Pfund et al., 2009). Moreover bias literacy interventions, which have the potential to reduce hostility towards women in STEMM by enhancing knowledge of sexism and discrimination toward women and changing individual level attitudes, have been successfully incorporated into these summer institutes (Moss-Racusin et al., 2016). The workshop involved the presentation of empirical evidence regarding gender bias, in an effort to resonate with these science faculty, and it communicated that increasing scientific diversity is part of everyone's responsibility. Two weeks after the intervention, faculty participants demonstrated not only increased awareness of gender bias and the importance of scientific diversity, but also a greater approach orientation toward diversity. In other words, they were more inclined to engage proactively in positive diversity behaviors and they were less likely to engage in avoidant behavior (Moss-Racusin et al., 2016). Multiple-day workshops for STEMM educators have the ability not only to increase active learning, but also to decrease harmful gender biases; thus, such trainings can help recruit and retain women in STEMM majors (Moss-Racusin et al., 2016; Pfund et al., 2009).

Instructor connections with students are also a critical predictor of whether women will feel welcome and will be successful in STEMM classes. Students generally are more engaged in active learning and earn higher grades in STEMM classes when they trust their instructor (i.e., believe their instructor cares about and accepts them) (Cavanagh et al., 2018). That said, even though encouraging trust and good relationships with students promotes engagement, it is important that STEMM faculty still work to challenge students. Compared to those with a growth mindset, math instructors with a fixed mindset are more likely to employ comfort strategies (e.g., assigning less work) for students with low math ability (Rattan et al., 2012). Comforting rather than challenging students leads students to believe that their instructors have low expectations for their success in math and harms their math motivation (Rattan et al., 2012).

A recent large-scale study further demonstrated the benefits of instructors with growth mindsets, and examined the performance of students across 634 STEMM courses (Canning et al., 2019). Relative to students who took classes with an instructor who had a fixed mindset, those who took classes with an instructor with a growth mindset were more likely to believe the instructor emphasized learning and development, were more motivated to do their best work, and, importantly, earned higher grades in the course. Moreover, the achievement gap between White and underrepresented minority students was twice as large in classes with fixed mindset instructors than in classes with growth mindset instructors (Canning et al., 2019).

Across another series of studies, Fuesting et al. (2019) found that when students believed their STEMM instructors have a growth mindset compared to a fixed mindset, they are more likely to believe that STEMM environments afford communal goals, which ultimately relates to higher interest in STEMM majors and careers. Finally, relative to those with a fixed mindset, instructors with a growth mindset also are more likely to adopt active learning exercises in their courses (Aragón et al., 2018), and growth mindset interventions are less effective in classes when teachers have a fixed rather than a growth mindset (Schmidt, 2015). Taken together, multiple studies suggest that training STEMM instructors to have a growth mindset will improve the performance of *all students* (not just women), and specifically will help recruit female students from STEMM classes into STEMM majors and careers.

A 2020 report by the National Task Force to Elevate African American Representation in Physics and Astronomy (TEAM-UP), which examined the reasons for the persistent underrepresentation of African Americans in these fields (AIP, 2020), also found that the characteristics of faculty influenced recruitment and retention. Specifically, the task force found that faculty behavior could influence the development of "physics identity," defined as "how one sees oneself with respect to physics as a profession." The task force noted that how students perceive themselves with respect to physics is predictive of achievement and retention in the field and identified faculty encouragement, recognition, and representation as key aspects of fostering physics identity among students. The task force recommended that to build physics identity, departments should be strategic in determining whether departmental activities are supportive of physics identity and assess the efficacy of activities and the diversity of faculty across race/ethnicity/gender and other social identities. The task force also found that African American student retention in physics improved when faculty “recognize and respond to students as unique individuals with a wide range of intersecting social identities and acknowledge their experiences of being minoritized in physics and astronomy department may impact their academic performance.” Other recommendations to address underrepresentation of African Americans in physics, included ensuring that teaching, mentoring, and advising include a focus on African American student success (AIP, 2020).

Instructors also play an important role in retention of post-traditional students, who make up the majority of students in this country (see Box 3-1 for more information). Packard and Jeffers (2013) demonstrated that women from community colleges are more likely to persist in STEMM fields if they are given

BOX 3-1
The Importance of Considering Post-Traditional Students

Historically, the conception of STEMM undergraduates has been that they are college ready, enroll in college or university full time, enroll the fall after high school graduation, live on campus, do not work while enrolled in school, and complete a bachelor’s degree in 4 years (Brown, 2017). However, these students, referred to as traditional students, make up only 26 percent of undergraduate students, according to the National Center for Education Statistics (NCES) (NCES, 2015). The remaining 74 percent of students fit a profile that is quite distinctive from the traditional student. These “post-traditional” students may need academic prep or remediation, enroll part time at community colleges, delay initial enrollment while entering the workforce, live off-campus with their parents or with their own dependents, take more than 4 years to complete a degree, and work more than 30 hours a week (Santiago, 2013). Post-traditional students are more likely to be women, particularly women of color (except Asian women) (Cruse et al., 2018). Therefore, as institutions work to broaden participation of women of color in STEMM, they may need to think beyond the traditional student to better meet the needs of post-traditional students.

There are many benefits to serving the needs of post-traditional students. For one thing, older students are less likely to change their major (Roelfs, 1975), which results in better student retention rates (Franklin, 1981). Additionally, post-traditional students, particularly women, are more likely to have higher GPAs and have greater decidedness. Additionally, a study on women post-traditional students found that they have lower levels of anxiety and depression and reported higher emotional quality than both their men nontraditional peers and traditional students (Carney-Crompton and Tan, 2002).

intentional and proactive academic advising from an individual who has knowledge of particular STEMM fields and STEMM transfer possibilities (Packard and Jeffers, 2013). This advising can help to alleviate confusion in signing up for coursework and in selecting a major (Packard et al., 2012). It may be helpful if faculty and transfer advisors work together to share this information, as many community college women do not have extended time to navigate campuses to receive transfer and career advice (Wang et al., 2017). In a study examining women's experiences in STEMM community college transfer pathways, Packard et al. (2011) identified several facilitators to women's success, including inspirational professors, effective transfer advising, and academic resources. Students reported that finding a helpful professor or advisor boosted student belongingness and contributed to their persistence in STEMM.

Group Composition

The group composition of classes or small activity groups in class (for female students), and working groups (for female scientists) may also play an important role in recruiting and retaining women in STEMM. For instance, female students perform worse on a math test when they are in a setting with majority male students as opposed to majority female students (Inzlicht and Ben-Zeev, 2000). Women students anticipate less belonging and are less interested in attending a conference that has majority male students versus gender parity (Murphy et al., 2010). Women established in STEMM also anticipate less belonging and are less interested in an academic conference when nearly all of the attendees are men (Richman et al., 2011), and women working in STEMM environments where they are outnumbered by men experience the highest level of gender identity threat[2] compared to men and to women who are not outnumbered by men (van Veelen et al., 2019).

Although women may benefit generally from active learning, being in women-majority activity groups may create the most welcoming and inspiring STEMM classroom environments (Springer et al., 1999). For example, Springer, Stanne, and Donnovan (1999) conducted a meta-analysis of the effects of small-group learning on undergraduates in STEMM courses and found that this is an effective approach for promoting greater academic achievement, improving attitudes, and increasing persistence for women (Springer et al., 1999). The authors noted that the positive effect of small-group learning on students' achievement was significantly greater for groups composed "primarily or exclusively of African Americans and Latinas/os (compared with predominantly White and relatively heterogeneous groups)." In a separate study, Dasgupta et al. (2015) found that students were more likely to participate and feel less anxious in women majority groups compared to male majority groups in an engineering class.

[2] Gender identity threat is the fear that their gender identity will be devalued (Steele et al., 2002).

The women students in the women majority groups also indicated higher STEMM career aspirations and confidence (Dasgupta et al., 2015). Beyond gender, related work has demonstrated that underrepresented minority students in STEMM also benefit from environments with other underrepresented minority students (Gates et al., 2011; Hurtado et al., 2007; Johnson et al., 2019). Hurtado et al. (2007), for example, found that among first year underrepresented minority college students in the sciences, several factors positively and significantly shaped their sense of belonging. These included interacting with a graduate student or teaching assistant, receiving advice from a junior or senior, receiving academic advice from a freshman, and interacting with peers of diverse racial backgrounds. Similarly, the authors noted that significant positive influence of cross-racial interactions on underrepresented minority students' sense of belonging further supports the benefits of diversity on college campuses.

When it is not possible to have women majority groups, it also may be helpful to address the biases of the male students in STEMM classes. Women and underrepresented minority STEMM majors report facing unwelcoming environments in their STEMM class from fellow students (Hurtado et al., 2007; Robnett and Thoman, 2017; Steele et al., 2002). Particularly relevant to group activities, Meadows and Sekaquaptewa (2013) found that when working in groups in engineering courses, male students tended to take on active roles (e.g., talk more, present group work), whereas women tended to be in technical roles (e.g., note takers). Thus, bias literacy interventions may not only be beneficial when implemented among STEMM faculty, but may also promote more inclusive STEMM classroom environments when targeted toward students in those classes (Becker and Swim, 2011, 2012; Kilmartin et al., 2015). As one example of the benefits of classroom bias literacy interventions, in an experiment by Bennett and Sekaquaptewa (2014), introduction to engineering courses were randomly assigned to receive presentation on the importance of egalitarian social norms (i.e., intervention classes) or receive no presentation (i.e., control classes). Relative to those in the control classes, White male students who underwent the intervention at the beginning of the course, reported valuing diversity more and higher intentions to speak out against discrimination (Bennett and Sekaquaptewa, 2014). In addition, regardless of receiving the intervention, racial/ethnic minority males did not differ on their attitudes toward diversity in engineering. The authors attributed this finding to the limited sample size or the fact that this population's attitudes may have already been more positive compared to White males.

Another successful intervention for students employed videos to demonstrate equitable classroom interactions (Lewis et al., 2019). Specifically, researchers assigned STEMM majors to watch a video of mixed gender groups conforming to gender stereotypes (i.e., male students speaking more than female students), or acting nonstereotypically (i.e., female students talking more than male students). The STEMM majors then completed a group task, modeled after typical STEMM classroom activities. In the interventions group, female and male students spoke equal amounts, whereas in the nonintervention teams, male students spoke more than female students (as revealed from both self-report data and video footage of group interactions) (Lewis et al., 2019).

THE IMPORTANCE OF ROLE MODELS

Researchers have found that exposure to a woman scientist role model (i.e., a scientist that women feel similar to and aspire to be like (Gibson, 2004); enhances female students' identification with and interest in STEMM (Ramsey et al., 2013; Stout et al., 2011), can change their personal beliefs about STEMM fields, and break stereotypical associations between men and STEMM (Young et al., 2013). Aside from changing perceptions of STEMM, however, when women interact with scientist role models, they also picture themselves becoming the scientists in the future (altering their possible future selves or their representations of who they could become in the future) (Lockwood and Kunda, 1997; Markus and Nurius, 1986; Markus and Kitayama, 2010). As a result, multiple theories have highlighted the benefits of role models for encouraging women's attraction to STEMM.

For example, the Motivational Theory of Role Modeling (Morgenroth et al., 2015) posits that, because individuals aspire to be like successful similar others, role models act as inspiration to encourage individuals to value certain domains and be attracted to those fields (Paice et al., 2002). This model further asserts that by identifying with role models, individuals view role models as evidence that it is possible to succeed in a given area, and feel self-efficacious (Lockwood and Kunda, 1997). Stereotype Inoculation Model further argues that when women feel similar to scientist role models, the role models inoculate against threatening stereotypes about women in STEMM and indicate that women will be valued and belong in STEMM environments (Dasgupta, 2011; Stout et al., 2011). For example, research has also shown that it is important for women at community colleges to identify role models from similar backgrounds who have successfully completed the transfer process and are currently enrolled in a STEMM baccalaureate degree (Wang et al., 2017). Having these role models helps to dismiss self-doubting notions that these students are not capable or will not receive support if they pursue a baccalaureate STEMM pathway. Critical to both theories is that women must identify with the role model for the role model to be inspirational. In general, women are more likely to identify with and feel more inspired by female than male role models (Lockwood and Kunda, 1997).

Consequently, even brief exposure to a woman scientist role model enhances female students' identification with and interest in STEMM (Ramsey et al., 2013; Stout et al., 2011). As one example, relevant to the early stages of recruitment, instructing middle school girls to reflect on and write about a role model they interacted with during a summer science program enhanced their sense of fit in STEMM relative to students who wrote about their best friends (O'Brien et al., 2017). In another experiment at the college level, researchers randomly assigned women engineering majors to learn about successful men engineers, women engineers, or innovative discoveries in engineering (i.e., control information). Relative to students who learned about male engineers or control information, those who read about female engineers indicated higher self-efficacy and career motivation in STEMM. This finding is pertinent to recruiting female engineering majors into the STEMM workforce, as well as retaining female engineers from college into STEMM careers. With regard to retaining female scientists after college, having supportive role models in their workplace also encourages belonging among women established in their STEMM careers (Richman et al., 2011).

However, requiring women scientists to act as role models may create extra service requirements (i.e., by having them serve on panels or give guest lectures) and harm their research productivity (Guarino and Borden, 2017). Consequently, another strategy to ensure women see relatable role models without burdening women working in STEMM is featuring women STEMM professionals in movies and television shows. The "Scully effect" is one demonstration of benefits associated with women scientists' representation in popular media. Specifically, researchers found that girls who consistently watched the *X-Files* television series in middle school and were exposed to the character, scientist agent Dana Scully, were more likely to express interest in STEMM, major in a STEMM field, and work in a STEMM profession compared to girls who did not watch the *X-Files* (Geena Davis Institute on Gender in Media, 2018). In a related study, researchers found that watching 10 short television clips featuring men and women scientists encouraged both male and female adolescents to picture themselves becoming scientists in the future (Steinke et al., 2009).

It is important to note that there are certain characteristics that result in role models being more or less effective for recruiting women into STEMM. For instance, researchers found that when female students who were not computer science majors interacted with a stereotypical female computer scientist (i.e., had masculine traits), these students reported lower self-efficacy and sense of belonging in computer science relative to students who interacted with a male or female counter-stereotypical scientist or who did not interact with a scientist (Cheryan, 2012; Cheryan et al., 2011a). Specifically, female students felt less similar to the stereotypical scientist than to the counter-stereotypical scientist, which feeling in turn, correlated with lower success beliefs and sense of belonging (Cheryan et al., 2011a; Cheryan et al., 2013). It is therefore unsurprising that female scientists who clearly value communal goals (as opposed to those who value agentic goals, such as being competitive, determined, and aggressive) are more likely to spark female students' interest in STEMM (Clark et al., 2016; Fuesting and Diekman, 2017). However, the role of counter-stereotypical feminine role models depends in part on students' perceptions of STEMM. Because of the masculine stereotypes associated with STEMM, being a feminine scientist may seem highly unattainable, particularly among female students with low STEMM identification[3] (Lockwood and Kunda, 1997). Supporting this possibility, Betz and Sekquaptewa (2012) found that feminine STEMM role models reduced middle school girls' current interest in math, self-rated abilities, and success expectations as compared with gender neutral scientist role models, particularly for girls who already disliked STEMM. Finally, women relate better to women scientists when they believe the scientists have had similar experiences and past challenges as themselves (Asgari et al., 2012; Pietri et al., 2018a).

It is also important to take into account that White women scientists may not be effective role models for women with multiple stereotyped identities because the identity of being a woman may not be the most salient of their intersecting identities with respect to STEMM (Pietri et al., 2018b). As one illustration of this possibility, because many Black women are more sensitive to the possibility of racism than sexism (Kirk and Olinger, 2003; Levin et al., 2002), they may identify more strongly with a Black male or female scientist than a White female scientist (Johnson et al., 2019; Pietri et al., 2018b). As a result, Black women anticipate more belonging in a STEMM company (Pietri et al., 2018b) or School of Science and Technology (Johnson et al., 2019) when they learn about a Black female or male scientist at the company or school compared to when they learn about a White female scientist. White female scientists, therefore, may not function as role models to recruit Black women in STEMM (Johnson et al., 2019; Pietri et al., 2018b).

With regard to retention, researchers found that among Black female college students majoring in STEMM, having Black women role models related to higher belonging in STEMM, whereas having White women role models did not predict belonging in STEMM (Johnson et al., 2019). Future research should continue to explore if White female scientists do or do not act as role models for women with multiple negatively stereotyped identities in STEMM. Nevertheless, these initial studies suggest that when presenting women with role models to broaden their future selves and spark self-efficacy, belonging, and interest in STEMM, it will be important that these interventions feature female scientists with multiple identities aside from gender.

CREATING INCLUSIVE RELATIONSHIPS THROUGH MENTORING

Scientists can act as role models and impact women's perceptions of STEMM fields, even when women lack direct contact with the scientists. In contrast, scientists only function as mentors when women have consistent interactions

[3] According to the 2018 National Academies' study *The Science of Effective Mentoring in STEMM,* science identity is defined as "an identity that is connected strongly to science, including three overlapping dimensions—competence in one's own mind and as judged by others, performance in terms of having the skills and opportunities to act like a scientist, and recognition by oneself and meaningful others."

with the scientists, during which the scientists provide guidance and support (Gibson, 2004). Consequently, creating positive relationships is more important for mentoring than the previous described interventions, and encouraging these meaningful connections is critical to retaining women in STEMM majors. Indeed, having mentors during college is one of the best predictors of women's reported involvement in their STEMM major (Downing et al., 2005; Hernandez et al., 2017), and, as discussed in Chapter 2, lacking mentors is a challenge for women in engineering, chemistry, and mathematics (Herzig, 2002, 2004a; Marra et al., 2009; Newsome, 2008). Once women graduate from college, continuing to build mentoring relationships is essential for the success of their career in STEMM (Allen et al., 2004; Eby et al., 2008). In light of the positive impacts of mentoring, there are a variety of professional organizations devoted to mentoring women in STEMM. Box 3-2 offers several examples.

Mentors help women in academic science grow and thrive in their careers by connecting women with potential collaborators and supporting both research and teaching (Misra et al., 2017). Thus, positive mentor relationships help women advance in their STEMM career (i.e., receive promotions, be successful in research and mentoring). Sponsor relationships also are useful interventions for advancing women in STEMM. Differing from mentorship, sponsorship does not involve emotionally supportive relationships, but rather is focused on providing opportunities to help women excel in their career by suggesting them for leadership positions and awards (Helms et al., 2016). Sponsorship is discussed further in Chapter 4.

Beyond providing support and career advice, mentors can also help enhance female students' interest in STEMM by providing valuable research opportunities in STEMM laboratories. Research experiences in general encourage students (particularly those from underrepresented groups) to both enter, persist, and advance in STEMM majors (Graham et al., 2013; Gregerman et al., 1998; Imafuku et al., 2015; Junge et al., 2010; Linn et al., 2015). For instance, Jones and colleagues explored how research experiences in biology impacted students who were interested in a biology major at University of California, Davis. Compared to those who did not take part in research, those who participated in research persisted for longer in the biology major, were more likely to graduate with a biology degree, and earned higher grades in their biology courses (Jones et al., 2010b). A qualitative study conducted at a primarily Hispanic serving institution additionally found that students who were a part of affinity research groups (ARGs) in computer science reported that these groups helped them grow as researchers and professionals, and promoted their integration into the larger computer science community (Villa et al., 2013). Importantly, these ARGs were strategically designed to create a sense of community in research labs via team-building activities, which suggests that labs should carefully construct inclusive and welcoming research opportunities to enhance interest in STEMM.

BOX 3-2
Mentoring as a Strategy for Improving Diversity and Inclusion in STEMM

A 2019 National Academies of Sciences, Engineering, and Medicine report recommended that academia take a more intentional, inclusive, and evidence-based approach to mentoring students in STEMM. The report indicated that "effective mentorship has an overall positive effect on academic achievement, retention, and degree attainment, as well as on career success, career satisfaction, and career commitment." Mentored students pursue graduate study more frequently than students without mentoring support and are more likely to stay in STEMM. In addition, "effective mentorship for students from underrepresented groups enhances their recruitment into and retention in research-related career paths" (NASEM, 2019b).

There are numerous examples mentoring programs that are working to improve the diversity of underrepresented groups in STEMM. A few select examples include:

Women in STEM (WiSTEM) Mentoring Program at the University of Connecticut (UConn). The WiSTEM program is designed to support underclasswomen pursuing STEMM degrees through the mentorship of their upper class women peers. The program includes monthly meetings designed to provide both the mentor and mentee with resources and support to ensure their growth in STEMM. Mentees are matched with a mentor who can provide personal support, academic advice, and knowledge about career development. Ultimately the goal of the program is to "enhance the role of women in STEMM at UConn through discussion and education about women's issues, gender equity and stereotypes, and female representation" (University of Connecticut, 2019).

University of Pittsburgh's Pitt EXCEL and Investing Now Programs. The University of Pittsburgh's Pitt EXCEL is a comprehensive undergraduate diversity program "committed to the recruitment, retention, and graduation of academically excellent engineering undergraduates, particularly individuals from groups historically under-represented in the field." Over 250 students participate in the program, which includes academic counseling, peer mentoring, tutoring, engineering research, graduate school preparation and career development workshops, as well as a 2-week intensive study skills, math and science review session for pre-freshmen (University of Pittsburgh, 2019b). The Investing Now program, also managed through the University of Pittsburgh's Swanson School of Engineering, is a college preparatory program created "to stimulate, support, and recognize the high academic performance of pre-college students from groups that are underrepresented in science, technology, engineering and mathematics majors and careers." Programming includes advising, tutoring, mentoring, workshops, summer enrichment programs, and parental involvement (University of Pittsburgh, 2019a).

Million Women Mentors (MWM) is a collaboration of partners across the United States with the mission of engaging 1 million STEMM mentors to increase interest and engagement of girls and women in STEMM programs and careers. MWM connects mentors to a network of over 1,000 volunteers across 40 states and multiple context-specific initiatives (Million Women Mentors, 2019).

Research laboratory environments can be structured to counteract masculine stereotypes and demonstrate how STEMM research can fulfill communal goals (Allen et al., 2018; Thoman et al., 2017). As one example relevant to recruitment, Thoman and colleagues (2017) surveyed a large sample of undergraduate research assistants across STEMM laboratories, and found that when lab culture values using science to helps others, underrepresented minority (URM) research assistants expressed more interest and motivation in STEMM. Mentors therefore may play a vital role in ensuring the success of women in STEMM; however, because of the pervasive masculine stereotypes in STEMM, both male and female STEMM faculty may be less interested in mentoring female students than male students (Moss-Racusin et al., 2012). Thus, it is important that interventions work to motivate scientists to act as mentors for women as well.

Mentorship for women of color is particularly important, as underrepresented students in STEMM are less likely than well-represented students to receive formal mentoring (Felder, 2010; Gayles and Ampaw, 2011; Johnson, 2015; King et al., 2018; Thomas, 2001). However, mentoring women of color requires attention to the identity-related challenges that their mentees may have, as well as skills to develop the talent of these mentees, while recognizing the racial and ethnic contexts they face (NASEM, 2019b). The majority of mentors in STEMM are likely to dismiss the idea that social identity shapes the experiences of mentees and approach mentoring with a color-blind approach (Brunsma et al., 2017; McCoy et al., 2015; Prunuske et al., 2013). However, in a study of primarily White mentors and undergraduate mentees from underrepresented groups, mentees were more likely than their mentors to want to discuss cultural diversity matters in the mentoring relationship. (Byars-Winston et al., 2019). In addition to mentees wants, research shows that culturally responsive mentoring helps validate students' experiences, reinforces their self-efficacy in their fields, and increases the likelihood of succeeding in STEMM fields (Byars-Winston et al., 2010; Thomas et al., 2007; Vaccaro and Camba-Kelsay, 2018). Therefore, all mentors, regardless of background, should be culturally responsive to their mentees.

As discussed earlier in this chapter with role models, many underrepresented students also prefer to have a mentor with a similar background to their own (i.e. race, gender, ethnicity, LGBTQIA status, and more) (Blake-Beard et al., 2011; Williams et al., 2016). However, due to the dearth of mentors from underrepresented backgrounds in STEMM fields, matching underrepresented students with mentors of the same background may not be possible, and, when it is possible, could lead to unequal service burdens for the mentors (Armstrong and Jovanovic, 2017; Xu, 2008). While prior research does support a race and gender mentoring match, Blake-Beard et al. (2011) demonstrated that having shared beliefs, values, and interests is a better predictor of mentoring relationship quality. Additionally, having a mentor from a well-represented background may provide access to resources that would otherwise be difficult for underrepresented students to access. Therefore, mentors of different identities who are culturally responsive and work to understand the experiences of underrepresented groups, may meet the needs of their mentees (Felder and Barker, 2013; O'Meara et al., 2013; Sanchez et al., 2014).

MALE ALLIES

To further alleviate the heavy service expectations for female scientists (Guarino and Borden, 2017), it is critical that male scientists play an active role in changing perceptions of STEMM (Akcinar et al., 2011). Indeed, by not conforming to agentic masculine stereotypes and by describing how their work fulfills communal goals, male scientists can inspire women's self-reported interest in STEMM and promote the recruitment of female students into STEMM (Cheryan et al., 2011a, 2013; Clark et al., 2016; Fuesting and Diekman, 2017). Women also may feel more welcome in STEMM environments that have supportive male allies. For instance, researchers found that when Black female STEMM majors perceive having multiple ally professors and care about helping Black women succeed in STEM, they report higher belonging in STEMM (Johnson et al., 2019). This study suggests that allies may help retain female students in STEM majors, by ensuring that students feel welcome in STEMM. Additional work has found that White female participants perform better on a spatial ability task, when they think that task was created by an expert from a similarly negatively stereotyped group (i.e., a Black male expert) than by a White male expert (Chaney et al., 2018). This enhanced performance is in part explained by participants' perceptions that the expert from a negatively stereotyped group is an ally who believes women have strong spatial abilities (Chaney et al., 2018). It is important to note that saying one is an ally and has a positive attitude toward a group may be beneficial, but not sufficient to elicit trust from members of that group (Dovidio et al., 2006; Hebl et al., 2009). Rather, one may need to perform a series of actions to signal commitment to helping that group (Ashburn-Nardo, 2018; Brown et al., 2015; Droogendyk et al., 2016), and hence researchers should continue testing how male scientists can effectively signal that they care about helping women in STEMM and are allies.

FINDINGS: CHAPTER 3

FINDING 3-1: To improve the representation of women in STEMM will require interventions to improve recruitment and retention of female students throughout their STEMM educational careers, including K-12. Women of color remain underrepresented among undergraduate degree earners in all STEMM fields, including those disciplines in which White women are well-represented (e.g. biology), and all women remain particularly underrepresented in math-intensive STEMM disciplines such as engineering, computer science, and physics.

FINDING 3-2: Reorganizing STEMM courses to incorporate *active learning exercises* generally improves learning among all students and is particularly beneficial for women in STEMM.

FINDING 3-3. Growth mindset interventions that impress upon students that skills and intelligence are not fixed, but, rather, are increased by learning, help all students, including those who have traditionally been underrepresented in STEMM, including women and underrepresented minorities.

FINDING 3-4. Encouraging individuals to introspect on *why* (e.g., improving society) as opposed to *how* (i.e., running experiments) scientists conduct research in STEMM increases beliefs that STEMM careers broadly satisfy communal ambitions and enhances both male and female students' positive attitudes toward those careers.

FINDING 3-5. Even brief exposure to a woman scientist role model enhances female students' identification with and interest in STEMM. However, requiring women scientists to act as role models may create extra service requirements for these STEMM professionals (i.e., by having them serve on panels or give guest lectures) and harm their research productivity. Consequently, another strategy to ensure women see relatable role models without burdening women working in STEMM, is ensuring women STEMM professionals are featured in movies and television shows.

FINDING 3-6. Having mentors during college is one of the best predictors of women's reported involvement in their STEMM major. Lack of mentorship is a particular challenge for women in engineering, chemistry, and mathematics. Mentorship for women of color is particularly important, as underrepresented students in STEMM are less likely than well-represented students to receive formal mentoring.

FINDING 3-7: Male allies can promote the recruitment of female students into STEMM, however, additional research should explore the characteristics of effective allies.

4

Effective Practices for Addressing Gender Disparity in Recruitment, Advancement, and Retention in STEMM

The analysis draws considerably from An Inclusive Academy: Achieving Diversity and Excellence *by Drs. Abigail J. Stewart and Virginia Valian. In addition, the chapter builds significantly on the contributions of the Committee on Understanding and Addressing the Underrepresentation of Women in Particular Science and Engineering Disciplines.*

A growing body of research literature and an increasing number of examples identify strategies and practices that institutions and organizations can adopt to diversify talent pools, mitigate biases in evaluation and promotion, and create and sustain a positive, inclusive organizational climate (Boxes 4-4 and 4-5). The sections below offer practical guidance on specific steps that institutions can implement to work to improve recruitment, retention, and advancement of women in science, technology, engineering, mathematics, and medicine (STEMM).

ACKNOWLEDGEMENT OF RESEARCH LIMITATIONS

There are certain limitations to the available research and practice that must be acknowledged up front. First and foremost, it is important to acknowledge that most research on promising and effective strategies for improving the recruitment, retention, and advancement of women in STEMM has failed to take into account how the intersection of gender with other marginalized identities (e.g. race, disability status, sexual orientation) may influence the efficacy of these interventions. Efforts supporting women in STEMM have tended to focus on middle-class White women at research intensive universities (Ong et al., 2011). As such, White women have tended to benefit predominantly from these efforts. That is not to say that the interventions outlined in this chapter may not, or cannot, support women of multiple marginalized identities in STEMM, but that we simply do not know.

Second, given that the focus of most of the research on promising practices in the STEMM workplace has been on research universities, information on the impact of these strategies and practices in a variety of institutional contexts is lacking. Given that most students in the U.S., and most students of color, are not studying at research intensive universities, much more research is needed on the impact of these interventions in a range of institutional contexts, including community college and minority serving institutions (MSIs).

Additionally, maintenance of an inclusive organization climate requires constant awareness of the impact of bias as well as intentional efforts to compensate for ingrained predispositions. As Regner et al. (2019) has shown, in the absence of monitoring, implicit biases continue to drive gender disparities even after evaluators participate in training designed to mitigate bias. Implementing the strategies and practices outlined in this chapter will not produce a process, or people, free from bias. Rather, if implemented intentionally, these strategies and practices can help mitigate biases.

Finally, the practices outlined in this chapter are likely broadly applicable across STEMM disciplines; however, there is certainly room for additional research on the ways these particular strategies and practices can impact recruitment, retention, and advancement of women within particular disciplines and sub-disciplines, as well as within the unique context of different schools and departments (see Chapter 5 for additional discussion). At a high level, the practices related to recruitment into academic computer science and engineering programs and further into industry jobs are particularly important, given the high attrition rates of women from these fields at the undergraduate level and the substantial underrepresentation of women in the technology industry. In the biological and biomedical sciences, particular attention should be paid to the postdoctoral stage and recruitment into the professoriate, as well as to biases that prevent retention and advancement of women into more senior ranks in academia, industry, and medicine.

Given the limitations of the existing research, successful implementation of the strategies and practices outlined in this chapter will be facilitated by the collection and monitoring of data on the recruitment, retention, and advancement of White women and women of other marginalized identities within institutional units (e.g., departments) before, during, and after implementation, as well as consideration of how these practices could work within the particular context of the institution (e.g. mission, size, resources, student needs, faculty expertise and competencies). There is no one size fits all approach that will work within all institutional contexts, and so an iterative pilot stage in which the practices and strategies outlined in this chapter may be "adapted" is likely to be a useful strategy. Chapter 5 offers an overview of a process through which an institutional unit may first "diagnose" its particular issues with recruitment, retention, and advancement of women, then makes use of the information presented in this chapter to take action to "treat" specific issues, and then evaluate whether the treatment worked and institutionalize effective practices. It is through such a process that many of the institutions highlighted throughout this report have identified the strategies that would work within the particular context of their particular institution.

WHAT WORKS TO IMPROVE RECRUITMENT

Institutions can improve their recruitment of women (and other underrepresented groups) by adopting or "adapting" strategies that enhance their appeal to a broader range of potential applicants and increase the likelihood of fair and effective evaluation of candidates. High levels of retention, a positive climate, and a good record of equitable advancement will support these strategies, but improving recruitment and hiring practices is an essential part of the overall institutional change needed to increase the presence of women scientists in an organization.

STRATEGY 1: Actively recruit year-round and expand networks of candidates.

An academic or other organization can attract a diverse set of candidates if it works continuously to diversify and grow its applicant pool for all positions and adopts proactive strategies to identify qualified candidates. Johnson et al. (2016) found that the odds of hiring a woman were 79 times greater if there were at least two women were in the finalist pool. The research indicates that organizations and institutions should hire new employees who have a documented record of serving as good mentors to women and other underrepresented groups as they will have access to a broader network (Johnson et al., 2016). This effort may include:

- Attending conferences to establish relationships with promising scholars and students from underrepresented groups and their mentors (Stewart and Valian, 2018).
- Requesting referrals from identified mentors of appropriate candidates from underrepresented groups (Stewart and Valian, 2018).
- Using searchable databases, such as PRISM or National Institutes of Health's Network of Minority Health Research Investigators (see Box 4-1).[1]
- Limiting referral hiring of current employee networks and friends, which will likely replicate a lack of diversity (Stewart and Valian, 2018).

STRATEGY 2: Represent the organization, program, and position in terms that make evident how it might appeal to a broad range of applicants.

[1] See, for example, the National Institutes of Health Network of Minority Health Research Investigators (NMRI), available at: https://www.niddk.nih.gov/research-funding/research-programs/diversity-programs/network-minority-health-research-investigators-nmri.

BOX 4-1
Resources for Expanding Networks of Candidates

Academic institutions and companies can seek a more diverse set of candidates by tapping into existing networks of underrepresented groups in STEMM and by establishing relationships with the following types of organizations and networks:

- National Medical Association
- National Association of Minority Medical Educators
- PRISM
- NIH Network of Minority Health Research Investigators
- Women of Color Research Network
- Latinas in Computing
- blackcomputeHER: Black Women in Computing and Technology
- Computing Alliance of Hispanic-Serving Institutions (CAHSI)
- Center for Minorities and People with Disabilities in IT (CMD-IT)
- The Institute for African-American Mentoring in Computing Sciences (iAAMCS)
- The Kapor Center
- Black Girls CODE
- Code 2040
- Black Data Processing Associates (BDPA)
- TechLatino: Latinos in Information Sciences and Technology Association
- National Society of Black Engineers (NSBE)
- Society of Hispanic Professional Engineering (SHPE)
- Society for Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS)
- American Indian Science and Engineering Society (AISES)
- Society of Asian Scientists and Engineers (SASE)
- Anita Borg Institute for Women and Technology
- Association for Women in Science (AWIS)
- Grace Hopper Celebration Conference
- theBoardlist
- National Center for Women & Information Technology (NCWIT)
- Gay, Lesbian, and Straight Education Network
- The Association on Higher Education and Disability

Use of language that signals to women that they belong and fit the job description (Smith et al., 2004) is a productive strategy for attracting a more diverse pool of applicants. Specific practices to construct these signals include:

- Writing job advertisements in a way that is appealing to a broad applicant pool, particularly by avoiding gendered wording in job descriptions (Gaucher et al., 2011).
- Placing a minimal number of constraints on the requirements of the job, so that women and men of color are less likely to self-select out of applying (Stewart and Valian, 2018).

- Using gender-neutral terms (e.g., "chair" versus "chairman").
- Avoiding descriptors that are stereotypically associated with men (e.g., "is a natural leader" or "can succeed in a competitive environment") (Stewart and Valian, 2018).

Institutions and organizations should signal to all candidates that they will be evaluated based on professional experience, not demographic characteristics, by ensuring that institutional publications, including websites, mention:

- Specific values that support diversity (Stewart and Valian, 2018).
- Fair and inclusive recruitment and hiring procedures.
- Family-friendly policies for faculty, students, post-docs, and staff.

Additionally, institutions and organizations can attract a more diverse pool of candidates by signaling their sensitivity to concerns about community diversity by providing information on the surrounding area, the history of the area, demographic data, and local activities that might be attractive to diverse candidates (Stewart and Valian, 2018).

STRATEGY 3: Examine job and admissions requirements to assess vulnerability to bias, adequacy as accurate indicators of talent, and relevance to success.

Making hiring and admissions decisions can be a time-consuming and complex process, especially when there are many qualified applicants. In many employment settings, hiring managers, admissions officials, and search committees use shortcuts to identify a subset of the most promising candidates. Such shortcuts can introduce bias into the process. For example, the prestige of the institution where the applicant received training is often erroneously used as an unbiased metric to evaluate candidates. In fact, using institutional prestige as an evaluation step is more likely to eliminate African Americans than Whites, Hispanics, or Asian Americans, and more likely to eliminate women than men (Stewart and Valian, 2018). Relying on institutional prestige favors White male applicants, and studies have shown that top students from lower-ranked schools are often as successful as their peers who attended more prestigious schools (Dale and Krueger, 2002, 2011).

Other metrics that are subject to bias are standardized test scores (e.g. GRE [Graduate Record Examinations], SAT), teaching evaluations, number of publications and journal impact factors, and letters of recommendation (Madera et al., 2009; Schmader, et al. 2007; Stewart and Valian, 2018; Trix and Psenka, 2003). Issues to consider in assessing an organization's evaluation practices include:

- Considering whether the characteristics of existing employees, students, or leaders at the institution are the *only* or *best* characteristics necessary for success in the job or educational program. Such criteria may be biased against certain groups. As stated by Stewart and Valian (2018) in their book *An Inclusive Academy*:

> *There might be many satisfactory ways to do a job only a subset of which are displayed by current job holders. For example, faculty can be surprised by how well a colleague performs as chair, noticing that his or her focus and style are very different from a previous admired chair's, but equally, if not more, beneficial to the department. (p. 203)*

- Considering the importance of research that has demonstrated that women who exhibit behaviors that are lauded (or at least tolerated) in men—such as ambition, self-promotion, competitiveness, or assertiveness—are evaluated negatively by both men and women. This phenomenon, known as the "backlash effect," occurs when women who are viewed as competent (i.e., they exhibit agency and authority) are, in turn, viewed negatively in terms of warmth and likeability (Rudman and Phelan, 2008). Such stereotypes can play out through race/ethnicity as well as gender (Fiske, 1999). For example, Asian Americans are often seen as competent, but not likeable, whereas African Americans and Latinx people are commonly viewed as likeable, but not competent (Fiske, 1999). This phenomenon unfairly disadvantages women and people of color, particularly in the context of leadership roles where perceptions of competence are especially important.

STRATEGY 4: Explicitly establish criteria for evaluation *before* assessing the pool of applicants.

Cognitive psychology research demonstrates that people share tendencies toward systematic errors in judgment that are amplified by implicit biases (Kahneman, 2011). Those making hiring or admissions decisions should be aware of how their biases can affect their judgments and should be required to adopt practices that will mitigate biases in evaluation. As a first step, hiring managers, admissions officers, and search committees can reduce bias by establishing explicit criteria before reviewing any application materials (Brewer, 1996; Norton et al., 2004; Tetlock and Mellers, 2011). This process will allow evaluators to develop relevant rationales for judging applicants that accurately reflect the desirable attributes identified as important by the organization, department, or school in a student, employee, or faculty member (see Strategy 3 above). If qualifications are waived for a specific candidate, the organizational or departmental leadership should require an explanation of why they are not important in that case—and keep track to see for whom requirements are waived.

STRATEGY 5: Hold those responsible for admissions and hiring decisions accountable for outcomes at every stage of the application and selection process.

Establishing clear criteria is only useful if evaluators adhere to them when reviewing application materials. To reinforce such adherence, evaluators should be required to complete an application review for each candidate, with the agreed-upon criteria listed (see Box 4-2). In this way, leaders can ask individual evaluators to justify their judgments with reference to the evidence in the file. To facilitate implementing clear hiring criteria, evaluators can, for example:

- Implement a "short-list review" (Billimoria, 2010), whereby the evaluators share their short list of candidates, their efforts to recruit a diverse applicant pool, and the demographic makeup of their list with an administrative office or leader. If their short list is less diverse than the applicant pool, then an admissions oversight body can weigh in and possibly demand a more diverse short list.
- Continue to monitor equity benchmarks throughout the hiring process to gauge whether they are achieving their goals or not by adhering to their clearly defined criteria (Sagaria, 2002).

STRATEGY 6: Educate evaluators to be sensitive when considering "gaps" in a resume.

Resume "gaps" can arise in many ways and immediately dismissing them as disqualifying can inappropriately limit the applicant pool. Women with children, for example, are 79 percent less likely to be hired than an identical candidate without children (Correll et al., 2007). Bias against parents is not only limited to women; according to Rudman and Mescher (2013), men who requested parental leave were viewed as "weaker" and poorer workers who were less deserving of economic rewards.

STRATEGY 7: When possible, evaluate a candidate's work directly.

In the case of faculty hires in academic settings, search committees should reduce reliance on biased proxies by evaluating a candidate's scholarship by reading their work directly. Although time-consuming, such direct evaluation of scholarship can increase the accuracy of scholarship assessment (Stewart and Valian, 2018).

- Limiting the number of publications applicants can submit to their top three (or fewer), which will allow candidates to submit the work that they think is most important. This practice also helps level academic capital awarded to those who publish with their advisor (Pinheiro et al., 2014), as men do more frequently than women, and counters biases related to prestige of publications and citation counts, which benefit men over women (Larivière et al., 2013; Maliniak et al., 2013).

BOX 4-2
Example: Application Review Sheet

The application review sheet that appears below is reproduced from the University of Michigan ADVANCE Program's Handbook for Faculty Searches and Hiring.

Candidate Evaluation Template

The following offers a method for department faculty to provide evaluations of job candidates. It is meant to be a template for departments that they can modify as necessary for their own uses. The proposed questions are designed for junior faculty candidates; however, alternate language is suggested in parentheses for senior faculty candidates.

Candidate's Name: ______

Please indicate which of the following are true for you (check all that apply):

- ☐ Read candidate's CV and statements (e.g. teaching diversity)
- ☐ Read candidate's scholarship
- ☐ Read candidate's letters of recommendation
- ☐ Attended candidate's job talk
- ☐ Met with candidate
- ☐ Attended lunch or dinner with candidate
- ☐ Other (please explain): ______

Please comment on the candidate's scholarship as reflected in the job talk: ______

Please comment on the candidate's teaching ability as reflected in the job talk: ______

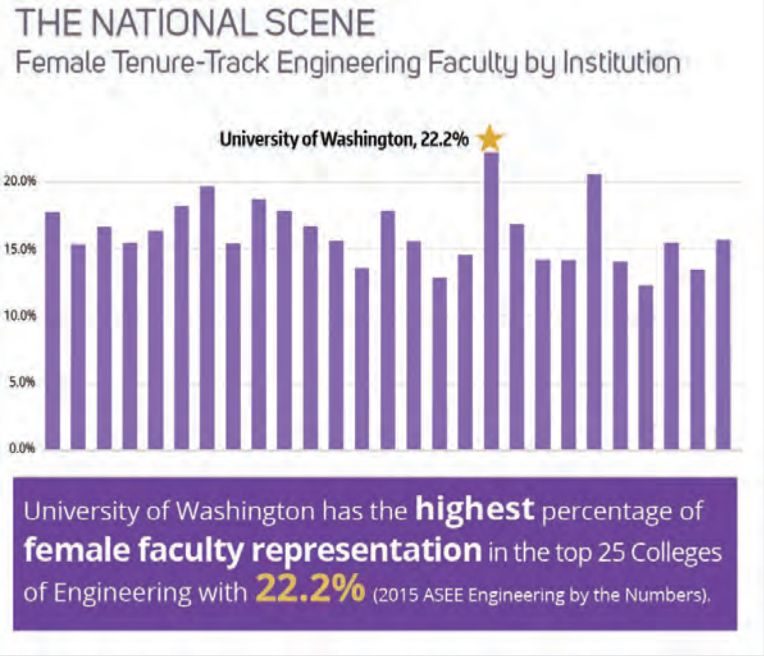
Please rate the candidate on each of the following:

	excellent	good	neutral	fair	poor	unable to judge
Potential for (evidence of) scholarly impact in the classroom	☐	☐	☐	☐	☐	☐
Potential for (evidence of) research productivity	☐	☐	☐	☐	☐	☐
Potential for (evidence of) research funding	☐	☐	☐	☐	☐	☐
Potential for (evidence of) collaboration	☐	☐	☐	☐	☐	☐
Potential for (evidence of) contribution to department's priorities	☐	☐	☐	☐	☐	☐
Ability to make positive contribution to department's climate	☐	☐	☐	☐	☐	☐
Potential (demonstrated ability) to attract and supervise diverse graduate students	☐	☐	☐	☐	☐	☐
Potential (demonstrated ability) to teach and supervise diverse undergraduates	☐	☐	☐	☐	☐	☐
Potential (demonstrated ability) to be a conscientious university community member	☐	☐	☐	☐	☐	☐

Other comments? ______

BOX 4-3
Example: The ADVANCE Center for Institutional Change at the University of Washington

The University of Washington (UW) was part of the first cohort of academic institutions to receive a National Science Foundation (NSF) ADVANCE Institutional Transformation award, which supported the implementation of many of the effective practices outlined in this chapter with the goal of increasing the representation and advancement of women in academic science and engineering careers. Through a range of activities, including the creation of handbooks of best practices to support equitable recruitment, retention, and promotion practices, UW has seen significant positive impacts. Over the course of the 5-year NSF grant, the university reported a 28.3 percent increase in the number of women tenure or tenure-track faculty, 17.8 percent increase in the number of women full professors, and 29 new women faculty hired into the departments that participated in the ADVANCE-supported effort. Since the end of the NSF ADVANCE funding, UW has sustained its efforts through support from additional grants and through internal support from the Office of the Provost, the College of Engineering, the College of Arts and Sciences, and the College of the Environment. This sustained support has contributed to steady improvement—in 2015 UW had the highest percentage of female faculty representation in the top 25 colleges of engineering.



- Ensuring that at least one publication per applicant is read by at least two members of the search committee (Stewart and Valian, 2018).
- Encouraging search committees to consider whether candidates achieved more than might be expected given the resources available at the institution(s) where they received their education and training, and avoid reliance on institutional prestige.

STRATEGY 8: Educate those who are assessing applicants about the best practices to mitigate biases in hiring and admissions.

Institutions and organizations should work to ensure that those who are assessing applicants be educated about best practices to mitigate biases in hiring and admissions. While research on one-off implicit bias training program shows that they can backfire, as they have the potential to normalize biases or create a sense of "moral license" among participants, Jackson et al. (2014) also suggest that approaches that emphasize particular practices to reduce bias can have positive effects.

Sekaquaptewa et al. (2019) showed that attending practice-oriented workshops increased positive attitudes toward equitable recruitment practices (such as those described in this chapter) and behavioral intentions to enact those strategies. Importantly, these effects were the result of attendees' increased belief in the social science evidence presented in the workshop (e.g., evidence of implicit bias in hiring and effects of stereotype threat on performance). Even faculty members who did not personally attend a workshop also showed these outcomes if they were in departments where a high percentage of department members had attended in the past. This finding suggests that the positive influence of the workshop can spread to others in the department, presumably through widespread knowledge and commitment to good practices (Sekaquaptewa et al., 2019).

Related research by Carnes et al. (2015) suggests that bias mitigation education that uses certain practices has the potential to move beyond simply raising awareness of bias to actually reducing gender disparities in hiring and improving organizational climate. Carnes et al. (2015) randomly assigned 46 science, medical, or engineering departments at the University of Wisconsin to receive a bias mitigation workshop intervention and 46 to serve as a waitlist control. Participants took the Implicit Association Test and answered questions indicating behavioral change before and after the intervention. The specific evidence-based strategies used in the workshop included:

- Strategy replacement, where a person recognizes they are stereotyping and challenges the stereotype with data.
- Counter-stereotypic imaging, where a person imagines exemplars of powerful women.
- Individuating, where a person avoids making generalizations about someone.

- Perspective-taking, where a person imagines living as a stereotyped individual.
- Increasing opportunities for contact with a stereotyped group.

These investigators found that stereotype suppression and too strong a belief in one's objectivity led to the greatest biases. The intervention improved participants' awareness of their personal biases, their motivation to change, and their self-reported behavior. A follow-up survey of faculty work-life showed that department climate improved and the departments that underwent the intervention had also hired more female and minority faculty than the controls at 2 years following the intervention.

STRATEGY 9: Use structured interviews and avoid asking inappropriate or illegal questions.

Once a short list has been established, organizations and institutions should ensure that interviews are fair, and recognize that the interview will influence a candidate's decision to accept an offer. Fair interviews adhere to the following guidelines:

- To verify that every candidate is treated equitably, employers should hold structured interviews with candidates, which are more resistant to biasing factors in evaluation than unstructured interviews (Levashina et al., 2014). For a thorough assessment of the elements of a good structured interview, see (McCarthy et al., 2010).
- Interviewers should be made aware that casual conversations over a meal at the end of an interview day count as part of the interview. Therefore, interviewers should not inquire about any personal information that candidates do not offer up themselves (e.g., "Are you currently pregnant or planning to have children?"), as these questions are illegal in interview settings, cannot be used in the discussion of candidates, and may be upsetting or off-putting to a candidate.
- Information on resources that may seem relevant to only some candidates, such as childcare policies, should be provided to all candidates.
- Interviewers should ask performance-based questions or behavioral interview questions (e.g., "Tell me about a time . . ."), because answers to such questions are strong predictors of future job performance and reduce reliance on perceived "potential," which tends to unduly advantage White men (Bock, 2015).
- If "culture fit" is viewed as important for success, organizations should provide a specific definition of what is meant by the culture of the specific organization or institution. Research has shown that evaluation of fit can disadvantage women and people of color if it is vague or inappropriately

defined (Rivera, 2015). As an example, organizations should not ask whether a candidate "likes playing golf" to determine fit.

STRATEGY 10: Offer students, trainees, and employees a living wage.

In academia, research indicates that many women leave at the transition from graduate school to the assistant professor stage (NRC, 2010). Although few studies have determined the specific underlying motivations and ultimate destinations of women who leave at this stage, among the testable hypotheses is that departures are due to economic constraints, particularly those arising from family needs. The low pay and long training periods for scientists, engineers, and medical professionals means they may face extreme financial hardship as they attempt to start a family while simultaneously continuing their training. The tradeoffs may be particularly challenging for those from disadvantaged backgrounds.

To address this issue:

- Offer salaries commensurate with the training STEMM professionals have received, combined with their value to the research endeavor. For example, paying a Ph.D. postdoc with 10 years of post-secondary education $50,000 for a 50-60-hour work-week—in some cases while they also raise children and pay for childcare—means only those with outside income sources can realistically pursue this career path.
- Do not defer contributions to retirement plans for early-career positions, such as postdoctoral positions. Deferring such contributions has major long-term financial implications and represents a further impediment to those from less advantaged backgrounds. This is especially true for some women who may also absent themselves from the formal workforce for an additional period for family reasons.

WHAT WORKS TO IMPROVE ADVANCEMENT

Background

Biases in evaluation for promotion are well documented and lead to different outcomes for women and men as they advance through their careers. In one recent study of performance evaluations in the technology sector, 75.5 percent of women's performance evaluations included language that was critical of their personality or behavior (e.g., "you come off as abrasive") compared with 1 percent of men's performance evaluations (Snyder, 2014). Several other studies have found that men are more likely to be granted tenure than women in the professoriate (Box-Steffensmeier et al., 2015; Di Fabio et al., 2008). Women spend longer within a particular rank than men (Ash et al., 2004; Geisler et al., 2007; Poor et al., 2009; Valian, 2000) (see Boxes 4-4, 4-5, and 4-6 for additional commentary on tenure). Women at 4-year colleges and universities are 10 percent less likely than men to attain full professor promotion, even after controlling for productivity, educational background, institution type, race, ethnicity, and nationality, suggesting that external factors may drive the differences in representation between men and women at the faculty level (Perna, 2001). Additionally, women tend to hold appointments at lower ranks, have positions with less prestigious affiliations, and receive less recognition than their male colleagues across academic science (Bailyn, 2003; Fox, 2001; Holton and Sonnert, 1995; Lincoln et al., 2012; NRC, 2001; Sonnert and Holton, 1995; Xie, 2003). There are particular issues with lack of advancement in the life sciences, where women are well represented at lower ranks but poorly represented at higher levels (NSF, 2019).

Many of the same kinds of practices that mitigate bias in evaluations for recruitment also mitigate biases in evaluations of performance that are associated with advancement. Here, the committee highlights a range of evidence-based practices that can mitigate bias in the advancement of women in STEMM.

STRATEGY 1: Sponsor women in senior leadership.

Sponsorship[2] is an important avenue to improve numbers of women in senior leadership. Neither formal mentoring programs nor executive coaching led to increases of women in top leadership, but sponsorship programs designed to accelerate the careers of women as leaders had a positive impact; in contrast with mentors, who work closely with faculty to enhance their research and education skills, sponsors have the position, power, and influence needed to advocate publicly for advancement of talented women to senior leadership positions (Helms et al., 2016; Travis et al., 2013). Both male and female employees are more likely to report that they are advancing in their careers, and feel more comfortable asking for raises, when they have sponsors in their company or institution compared with when they do not have sponsors (Hewlett et al., 2010). Connecting women to sponsors through formal programming is crucial for the advancement of women in STEMM (Huston et al., 2019; Sherbin, 2018).

Sponsorship also might help address another factor hindering women from reaching top leadership roles in technology companies—their lack of visibility within an organization and/or shortage of opportunities to showcase their skills and value to the organization (Correll and Mackensie, 2018; Simard et al., 2008). Specifically, sponsors can work to ensure that women have access to high-profile projects to propel them into more prestigious leadership positions.

[2] According to the National Academies report *The Science of Effective Mentorship in STEMM* (2019b), sponsorship is defined as "a potential career support function that involves a senior person publicly acknowledging the achievements of and advocating for a mentee."

STRATEGY 2: Establish clear, unbiased metrics for promotion and advancement.

To ensure a fair review, evaluations should be based on criteria that are clearly defined and consistently applied. This set of criteria should be consistent with the mission and goals of the company or university (Perna, 2001) and reward the types of behaviors that the employer or institution values (Stewart et al., 1996). Criteria should include the full range of activities that may be of interest to women in academia, including teaching, service, and research, and should provide incentives for working to achieve the company or institutional goals (Tierney and Bensimon, 1996).

- Evaluations should be conducted by more than one individual, as such evaluations are trusted and seen as fairer than those done by a single individual; this also builds in accountability, when evaluators know their opinion will be assessed alongside someone else's (Thorngate et al., 2009).
- Ensure that the review process is transparent and accountable by:
  - making sure administrators and tenure committee members are transparent about the procedure for evaluation, the steps in the process, and the timeline; and
  - reviewing the process periodically to determine if the process is fair or needs to be changed in any way.
- Collect data to answer questions such as:
  - Do your performance evaluations show consistently higher ratings for majority men than for women, people of color, or other underrepresented groups?
  - Do ratings decline after women employees have children, take parental leave, or adopt flexible work arrangements?
  - Do the same performance ratings result in different promotion or compensation rates for different groups?

The Center for WorkLife Law at the University of California at Hastings College of the Law offers a useful set of evidence-based tools and worksheets for employers. Among the practices recommended by the center are the following:

- **Appoint a bias interrupter.** Have team members or human resource business partners who have been trained to spot bias involved at every step of the evaluation process.
- **Begin with clear and specific performance criteria** directly related to job requirements.
- **Require evidence in the form of specific examples from the evaluation period that justifies the rating.**

- **For each candidate, consider their demonstrated performance and potential separately.** Performance and potential should be appraised separately, given the tendency for a majority of men to be judged on potential whereas others may be more often judged on performance (University of California at Hastings, 2019).
- **Separate personal styles from skill sets for each candidate.** Personal style should be appraised separately from skills, because a narrower range of behavior often is accepted from women and people of color. For example, women may be labeled "difficult" for actions that are accepted in majority men (University of California at Hastings, 2019).
- **Level the playing field** by ensuring all candidates for advancement possess skills for self-promotion and for articulation of expectations.
- **Offer alternatives to self-promotion.** Encourage or require managers to set up more formal systems for sharing successes, such as a monthly email that lists employees' accomplishments.
- **Provide a "bounceback."** Managers whose performance evaluations show persistent bias should have their evaluations returned to them for further analysis.
- **Have bias interrupters play an active role** in calibration meetings. In many organizations, managers meet to produce a target distribution of ratings or cross-calibrate rankings. Have managers read the Identifying Bias in Performance Evaluations Worksheet before they meet. Have a trained bias interrupter in the room.
- **Retain a formal performance appraisal system.** Eliminating formal performance evaoluation systems and replacing them with feedback-on-the-fly creates conditions for bias to flourish.

For more information and resources from the Center for WorkLife Law, see https://biasinterrupters.org/toolkits/orgtools/.

STRATEGY 3: Recognize and reward outstanding contributions to STEMM.

There are many ways to recognize and reward people for their outstanding contributions outside of formal promotion and evaluation processes. These include institutional awards for teaching, mentoring, service, and honorary degrees, as well as recognition by honorary societies, such as the American Academy of Arts and Sciences, the American Association for the Advancement of Science, and the National Academies of Sciences, Engineering, and Medicine. The fact that women have been historically underrepresented, marginalized, or overlooked in many scientific disciplines has contributed significantly to their underrepresentation in honorific societies. Differential failure to recognize and reward accomplishments by members of particular groups contributes not only to lack of advancement but also to attrition and to an overall negative climate for underrepresented groups.

STRATEGY 4: Encourage and Reward Contributions to Diversity, Equity, and Inclusion.

Chapter 2 presents research demonstrating that women in academia shoulder the burden of teaching, mentoring, and service (Armstrong and Jovanovic, 2015; Hermanowicz, 2012; Kulis et al., 2002; Madge and Bee, 1999; Urry, 2015), activities that can have a positive impact on diversity, equity, and inclusion (see Chapter 3). In fields where women are over- or well-represented at early career stages, but remain underrepresented at higher ranks, this gendered division of labor could contribute to this disparity by penalizing women for devoting time and energy to service efforts if they take time away from other activities the institution prioritizes and rewards, such as securing research grants and publishing peer-reviewed papers.

This issue was raised in the focus group research carried out by RTI International on behalf of the National Academies. Listening session participants suggested that once women achieve tenure, they encounter limited support for their ongoing advancement. They observed that many women's careers stall at associate professor, with little institutional support for achieving promotion to full professor. In the words of one participant:

> *Another slow-down area for women in particular is the post-tenure associate, getting stuck at the associate level. And we have a lot of data on this, and I don't think yet good programs address it.*

In addition to a lack of programs or policies aimed specifically at supporting or recognizing the intellectual contributions of mid-career women, participants noted that mid-career faculty often face the heaviest service burdens. When inequitably distributed by gender and race (as it is perceived to be at most institutions), the burden of service effectively curtails women's other contributions and hinders their advancement to full professorship. To quote one participant:

> *We had senior faculty who had opted completely out of service, and we were killing the associate professors because we were protecting the junior people . . . so, our mid-career [women faculty] weren't advancing.*

While some listening session participants felt that formal efforts to ensure equal distribution of service labor could help to address this challenge, others proposed that recognizing faculty contributions to diversity in their departments would better help to preserve these important contributions (for example, access to effective mentorship for underrepresented students) while still righting the imbalances they created. By formally assessing and valuing contributions to diversity in the context of performance review, merit increase, and promotion decisions, universities could avoid inadvertently penalizing those whose time was disproportionately devoted to it. Some institutions have also begun to take concrete steps in this direction. For example, several institutions have formally incorporated contributions to diversity, equity, and inclusion in tenure and promotion criteria. Box 4-4 provides several examples, and Box 4-5 offers an example rubric for how a department might consider the multiple ways a faculty member could work to promote diversity, equity, and inclusion.

WHAT WORKS TO IMPROVE RETENTION AND ORGANIZATIONAL CLIMATE

Background

Creating positive and collegial work environments is an essential element in retaining employees and thus is critical for achieving gender parity. STEMM professionals, regardless of gender or race, require similar conditions to thrive: inclusion, full participation, and community respect. These conditions are more available to majority demographic groups in university and business settings than to those that are from underrepresented groups, who often feel different from, or less comfortable with, colleagues (Ackelsberg et al., 2009; Gutierrez et al., 2012; Guzman et al., 2010; Harris, 2007; Thompson, 2008; Tokarczyk, 1993; Urry, 2008).

To improve retention and promote a positive organizational climate, employers and educators should provide a supportive working environment for a diverse group of students and employees by:

- Devoting resources to support research, teaching, advancement, and career development,
- Creating structures that promote fairness and transparency, and
- Treating employees with respect in both their personal and professional lives.

A positive organizational climate will also serve to prevent sexual harassment (Buchanan et al., 2014; Fitzgerald et al., 1997; Glomb et al., 1997; Wasti et al., 2000).

As stated in a National Academies report on this topic:

> *Organizational climate is the single most important factor in determining whether sexual harassment is likely to occur in a work setting . . . a positive climate decreases sexual harassment rates, reduces retaliation against those who confront and report harassment, and results in better psychological health and workplace experiences* (NASEM, 2018b, p. 50).

Preventing sexual harassment, rather than waiting to address it once it occurs, is critically important to retaining women in STEMM, not only because of the damaging effects of sexual harassment on women's personal and profes-

BOX 4-4
Recognizing and Rewarding Contributions to Equity, Diversity, and Inclusion in Tenure and Promotion

While it is true that most traditional tenure and promotion criteria do not engage faculty contributions to diversity, equity, and inclusion, there are examples of colleges and universities that have incorporated considerations of this type of work into their procedures and policies. These can include explicit statements about how diversity, equity, and inclusion fit into the values of the institution or suggestions of how a candidate might incorporate activities into their tenure and promotion package. Select examples of universities that have documented the importance of diversity, equity, and inclusion in their policies and procedures include:

Oregon State University: The university's stated goals include developing a collaborative and inclusive community that strives for equity and equal opportunity; faculty are expected to ensure that these goals are achieved. In fact, related to faculty positions, university policies note that "stipulated contributions to equity, inclusion, and diversity should be clearly identified in the position description so that they can be evaluated in promotion and tenure decisions. Such contributions can be part of teaching, advising, research, extension, and/or service. They can be, but do not have to be, part of scholarly work. Outputs and impacts of these faculty members' efforts to promote equity, inclusion, and diversity should be included in promotion and tenure dossiers" (Oregon State University., 2019).

University of Michigan, College of Engineering: The university has outlined general principles for promotion/tenure evaluation, including stating that "not all contributions fit neatly into one of the major categories of teaching, research, and service. In particular, mentoring plays an important role in all three, as does activity in support of diversity, equity, and inclusion (DEI)." As part of service, the university policies state that "outreach and other activities in support of diversity, equity, and inclusion are valued forms of service, both internal (e.g., for recruiting to Michigan or on behalf of a University activity) and external (e.g., for broadening participation in a field or serving societal need)" (University of Michigan, 2018).

Virginia Tech: The university includes the option of highlighting "inclusive practices and diversity initiatives" in the summary of a tenure and promotion package and in the candidate's statement. In addition, guidance to faculty notes that "service to the university and academic professional organizations constitutes an important faculty responsibility, as does advising of student organizations." This includes service that promotes diversity and inclusion (Virginia Tech., 2019).

Kenyon College: College guidance to faculty notes that one of the seven "essential" skills is "promotion of an inclusive classroom environment that values diversity, takes into consideration students from a broad variety of backgrounds and learning styles and challenges students to their best efforts" (Kenyon College., 2019).

BOX 4-5
Guidelines for How to Integrate Diversity, Equity, and Inclusion into Faculty Tenure and Promotion from University of Oregon

While there are few examples of institutions that have integrated diversity, equity, and inclusion into faculty tenure and promotion (see Box 4-4), the University of Oregon has fully embraced this approach. For example, the university requires “faculty to incorporate discussions of contributions to institutional equity and inclusion within their personal statements for review, tenure, and promotion” (University of Oregon, 2019b). Further, it has developed a rubric (see below, (University of Oregon, 2019b)) and a guidelines document (University of Oregon, 2019a) of examples for how to incorporate diversity, equity, and inclusion work in different aspects of faculty workloads and evaluations.

The rubric in the table below provides examples of faculty contributions to equity and promotion. The university states that these could be used to evaluate and situate a faculty member’s contributions.

	Individual impact: Equity work with individual students, faculty, community members, or organizations	**Programmatic impact:** Equity work establishing or providing significant leadership to a formalized program	**Institutional impact:** Contributing to efforts that strengthen institutional policy or practice
RESEARCH	*Research agenda incorporates equity and inclusion issues and/or diversity in objects of study (e.g., Psychology faculty incorporates diverse individuals within their subject pool)	*Leading or participating in a research group that addresses equity and inclusion (e.g., Law school faculty leads a research group on gender and labor)	*Establishing or supporting the creation of new academic initiatives (e.g., Education faculty establishes a disability studies research initiative)
TEACHING	*Efforts toward equity, diversity, and inclusion in undergraduate and graduate teaching and mentoring (e.g., Journalism faculty incorporates themes of equity and inclusion within introductory course assignments)	*Participating in a disciplinary mentorship or pipeline program (i.e., PPPM faculty attends mentorship conference for under-represented graduate students)	*Creating a new academic program, courses, or graduate specialization focused on equity (e.g., Ethnomusicologist leads development of a new MA program in music of the African diaspora)
SERVICE	*Work with diverse groups of individual students and/or organizations on and off campus (e.g., Business faculty advises undergraduate Women in Business group)	*Participating in program building efforts (e.g., Environmental studies faculty collaborates with indigenous groups to produce multiple environmental impact studies)	*Creation or leadership role in new UO program serving community constituencies (e.g., Economist establishes summer pipeline program for low-income high school students)

SOURCES: Univeristy of Oregon, 2019a, 2019b.

BOX 4-6
The Impact of Organizational Climate on Retaining Women in STEMM

One of the major factors in retaining women in STEMM fields is the climate of the institutions or organizations. *Organizational climate* is defined as the shared perceptions of an organization's atmosphere or environment. An organization's climate is reflected in the policies, practices, and procedures that it has in place and the attitudes and quality of the interpersonal interactions (Schneider, Ehrhart, and Macey, 2013). Work climates are tied to important metrics of success, such as employee satisfaction, productivity, retention, and emotional support (August and Waltman, 2004; Carr et al., 2003).

According to a 2007 National Academies report, *Beyond Bias and Barriers*: *Fulfilling the Potential of Women in Academic Science and Engineering,* many women cited negative workplace climates—hostility from colleagues, exclusion from the department community and its decision-making process, and slights and ridicule—as pervasive in university settings (NASEM, 2007). Further, organizational climate is the single most important factor in determining whether sexual harassment is likely to exist within an organization (NASEM, 2018b). Therefore, in order to successfully retain women in STEMM, organizations and institutions need to commit to changing organizational climates.

Most members of an organization can agree on what makes a good climate. However, not everyone within an organization or a department experiences the same climate. For example, women perceive conference climates with fewer women as being more sexist than men do. When low representation of women contributes to a sexist climate, men are generally unaware of it (Biggs, Hawley, and Biernat, 2017). Similarly, faculty of color reported discrimination, macroaggressions, and unwelcoming environments in their departments, while their White colleagues find their environments to be supportive (Zambrana et al., 2017). Therefore, it is important that institutions and organizations take into account the experiences of each individual in the department, even if those perceptions are not visible in aggregate measures of the climate.

sional health and well-being, but also because the research shows that women are unlikely to report sexual harassment because of an accurate perception that reporting sexual harassment will lead to a process that will re-victimize them (NASEM, 2018b). Scholars and focus group participants described a number of specific ways for organizations and institutions to improve the overall organizational climate, several of which are described below.

STRATEGY 1: Ensure fair and equitable access to resources for all employees and students.

To create fair and equitable access to resources for all employees and students, organizations should provide:

- Equal knowledge of institutional resources. Often, information about these resources is obtained through informal communications; however, these informal communication networks flow more smoothly among similar groups, which often leave underrepresented groups in the dark (Kanter, 1977; Rankin et al., 2007).
- Transparency about how resources are allocated. Institutions and organizations should repeatedly communicate information (Collins, 2001).
- A dedicated employee whose job is to disseminate necessary information, complete with relevant supplemental information and links.
- Direct assistance to employees including:
  - technology assistance, and
  - skill development
- Policies and resources for programs that recognize the diversity of families that exist and how family situations can evolve over time and throughout individuals' careers.
- Institutionalization of effective policies and practices so that they will survive a transition in leadership. One of the key messages from the focus group research carried out for this report (see Chapter 5 and www.nap.edu/catalog/25585) was that leadership transitions are a point of vulnerability for efforts to promote diversity and inclusion because new leaders may have different priorities. Standing policies make it less likely a change will be undone (see Chapter 5 for additional discussion).

STRATEGY 2: Create a respectful and equitable organizational climate.

Institutions and organizations should create respectful work climates that are perceived as equitable and fair by employees and students (see Box 4-5). When women feel that they are not receiving fair treatment or sufficient resources from institutional leaders, they tend to experience lower levels of job satisfaction and organizational commitment (Branscombe and Ellemers, 1998; Ensher et al., 2001; King et al., 2010). Organizations can create a fairer environment by being transparent about:

- The decisions that are likely to be made in the near and far future
- The rationale behind those decisions
- Who will participate in making these decisions
- What criteria will be used in the decision making (Stewart and Valian, 2018).

This level of transparency helps employees feel that organizations are operating according to some general principles and that, even if the decision is unfavorable, their preferences were heard.

Changing a workplace climate requires a coordinated, cooperative effort (Jordan and Bilimoria, 2007). In a case study of an academic science work environment conducive to the advancement of both men and women scientists, Jordan and Bilimoria (2007) identified several conditions and factors that supported a cooperative, inclusive, and productive work culture. The foundation of this culture was a set of values and beliefs about the goals of science (the pursuit of meaningful, significant advancements of knowledge) and qualities of successful scientists (the ability to learn rapidly, effective communication skills, an abundance of creativity, and a strong work ethic) reflected in the cooperative interactions within the department. Department chairs were helpful in creating and sponsoring activities, but support and ongoing leadership in maintaining these practices came from faculty within the department. Over time, these processes embedded values and beliefs held by a majority of department members as shared values and beliefs of the department, which ultimately shaped the department culture.

The focus groups also identified a number of facilitators of positive organizational climate, including:

Gender balance affects climate. Focus group participants perceived that, as changes in the gender composition took place in some departments over time, the culture changed accordingly and improved subsequent efforts at climate improvement (such as the success of mentoring programs).

Mentoring and social networks affect climate. Interpersonal connections built through mentoring and networking ameliorated negative organizational climates.

- Networks composed of women in their fields that provided both instrumental support (e.g., guidance on the university tenure process) and emotional support (e.g., an outlet for venting). Interdisciplinary collaborations offered an important avenue for intellectual work stifled by hostile departmental climates.
- Networking among National Science Foundation ADVANCE programs brought people together across institutions to exchange ideas. Cross-institution networking promoted both the sustainability and influence of efforts initiated with ADVANCE funding.

Individuals facilitated a positive climate. Participants identified several ways in which individuals' involvement acted to facilitate positive climates, including:

- Internalization of responsibility for contributing to positive climate.
- Bystander intervention and peer-to-peer learning (see Box 4-7).
- Availability of particular individuals for informal, confidential conversations about equity.

The specific disciplines can promote positive climates. The final set of facilitators pertained to the broad influence of disciplines as a whole. For example, as one focus group participant noted:

> *Electrical engineers really don't care what the biologists think because they say, "Biology, that's such a different field. There's nothing like us, nothing that they do could possibly relate to what we do." So, you have to have [someone from the discipline involved] who can say, "No, I'm an engineer, this works for engineering." And it's silly that you have to do that because so many of these things are cross cutting. They have nothing really to do with discipline. Faculty make it discipline-specific. But I think that you just have to do it.*

Climate assessments can drive positive change in disciplines. Some participants commented on the particular influence that external climate assessments or reviews conducted by various scientific or professional societies have within their disciplines. They emphasized the positive change within departments or institutions that can result from this external force.

STRATEGY 3: Policies and resources should work to address the family-related needs of students and employees.

Central to the challenges of retention are the family-related needs that an employee or student may have over the course of their career and education. Without a federal policy for paid family leave (Box 4-8), it is at the employers' discretion to determine fair family leave policies. However, these policies differ from institution to institution and even vary within a single institution (see Box 4-9).

Due to the funding structure supporting most researchers—that is, they are supported partially by their institutions and partially by federal grant money—the employer and the funding agency supporting the salary and work of an employee share responsibilities for family leave accommodations. A major finding of the focus group research conducted for this report was that family leave-related policies and practices within extramural funding agencies are a major barrier to gender equity among STEMM faculty, even when university-level policies are supportive. For example, participants explained that the fact that faculty with National Institutes of Health funding drain their grants during paid family leave forces individuals to choose between having their grant funds expended while work is paused or avoid taking leave altogether. Similarly, the failure to educate study sections on assessing timeline for researchers who have taken family leave can deter women from taking leave and potentially harm their career advancement if they do, due to perceived low productivity.

However, extramural funding agencies can also be a facilitator for supporting parents in STEMM. For example, the National Institutes of Health grants allow for reimbursement of childcare costs, parental leave, or additional technical support when such costs are incurred under formally-established institutional policies (National Institutes of Health, 2020). Grantee institutions can also request administrative supplements to cover these types of costs, if necessary. Additionally, the National Institutes of Health now provides up to 8 weeks of paid parental leave for intramural trainees and extramural trainees who have a Ruth L. Kirschstein National Research Service Award.

BOX 4-7
Bystander Intervention

Bystander intervention refers to the process by which a bystander (someone who observes a situation and has an opportunity to intervene) identifies and acknowledges a problematic situation and then chooses how to respond. Bystander intervention training has focused on helping people (1) notice the event, (2) interpret it as problematic, (3) assume personal responsibility for intervening in some way, (4) decide how to intervene, and (5) act on that decision (Darley and Latane, 1968; Holland et al., 2016). In short, this training is designed to transform people into active bystanders that can help people who are experiencing harm. The training generally equips people with the skills to intervene in four possible ways, known as the four D's of intervention: Direct (directly intervene), Distract (distract either party), Delegate (get help from others), and Delay (check in later).[a] The broad goal of bystander intervention training is to create a culture of support, rather than one of silence and looking to others to act or help (Banyard, 2015).

This training can apply to a wide range of problematic situations, including harassment (i.e. sexual and racial), bullying, bias, incivility, sexual violence and other forms of violence, abusive alcohol consumption, suicide, and depression. There are also many different programs or approaches for conducting bystander intervention training. Two examples that have been used to intervene when bias and discrimination occur are Confronting Prejudiced Responses (CPR) and Behavior Modeling Training (BMT). The first, CPR helps participants understand the factors that promote and inhibit them from intervening, and provides them with a series of steps to go through before deciding whether and how to intervene (Ashburn-Nardo et al., 2008). BMT is focused on developing and practicing skills to intervene. In BMT, participants view model behaviors, practice or rehearse the model behaviors in a safe setting, and then transfer these skills to their work environments (Decker and Nathan, 1985; Goldstein and Sorcher, 1973; Taylor et al., 2005).

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[a] See: https://sapac.umich.edu/article/bystander-intervention.

As discussed in Chapter 2, it is important to acknowledge that the "ideal worker norm" 24/7 work culture of certain STEMM disciplines disadvantages women because they tend to bear a greater share of parenting and domestic responsibilities relative to men. In one study, married or partnered female physician researchers with children reported spending 8.5 hours more per week on parenting and/or domestic activities than male physician researchers (Villablanca et al., 2011). Thus, women are more likely to view work-life balance as a key priority (DeCastro et al., 2014). Nevertheless, real and perceived barriers to the utilization of family-supportive policies are evident; even when career flexibility policies are available, cognitive dissonance can arise over their use due to concern for negative personal or professional repercussions, Several factors contribute to the likelihood of whether a bystanding individual will choose to intervene; if they are in a position of power or perceive a status challenge, for example, they are more likely to intervene (Hershcovis et al., 2017). Even if bystanders may be well positioned to intervene in situations of workplace incivility, it may not always be beneficial that they do (Jones et al., 2015b). Bystanders subject themselves to risk when they choose to intervene: as perpetrators are often powerful, central players that control access to resources and have ties to powerful people. Choosing to intervene can harm the intervener's social positioning and increase their likelihood of experiencing retaliation (Cortina and Magley, 2003; Hershcovis et al., 2017); silence, therefore, may be considered the safest option. Additional research is needed to understand the outcomes of when bystanders choose to intervene; effectiveness of specific mechanisms of intervention; the timing and conditions under which bystander intervention effectively stops harassment; and how to mitigate the risks that bystanders face when intervening (Feldblum and Lipnic, 2016).

Bystander intervention training has increasingly been used in higher education environments to address sexual violence among students, and efforts have recently been developed for addressing sexual harassment in workplace and education environments within higher education for undergraduate and graduate students, and faculty, and staff. Additionally, higher education institutions are beginning to develop scenarios for use in bystander intervention training that are specific to the environments and experiences of those in science, engineering, and medicine (NASEM, 2019c). Preliminary evidence suggests that programs to promote bystander intervention may be effective in combating problematic situations faced by women in STEMM. In the context of sexual harassment and sexual violence, for example, bystander intervention education can increase awareness of sexual violence, help dispel myths, encourage intervening behavior (Banyard et al., 2004, 2007), and may even reduce sexual violence altogether (Coker et al., 2016). Although additional research is needed, training bystanders to intervene may be a promising method for disrupting problematic situations and facilitating a positive culture and climate.

including being perceived as being less committed to one's career (Carr et al., 2017; Villablanca et al., 2011).

The remedy for this situation is well-articulated, broadly communicated, and consistent policies related to family caregiving and childbearing, accompanied by culture change efforts aimed at normalizing the use of such benefits and resources. Institutions and organizations should create policies, and set aside resources, to support employees during times when family and personal life demands are heightened. Practices should include:

- Making stop-the-tenure-clock and modified duty policies (which should be available to as wide a group as possible) a genuine time-out from work

BOX 4-8
The United States is One of Only Six Countries that Does Not Offer Paid Leave for Mothers

The United States is one of very few countries that does not offer guaranteed paid leave for mothers. In a study of 173 countries by the WORLD Policy Forum (Human Rights Watch, 2011) 168 countries offered guaranteed leave for mothers related to childbirth. The United States, along with Lesotho, Liberia, Papua New Guinea, and Swaziland, guarantees no paid leave for mothers in any segment of the workforce. The absence of guaranteed paid leave has serious health consequences for parents and children. Parents with short or unpaid leaves are more likely to experience physical and mental health problems, delayed health-care visits for babies, shortened duration of breastfeeding, financial hardship, and denial of raises or promotions compared with parents with generous family leave policies (Human Rights Watch, 2011). The committee has been struck by the fact that in many sectors of the U.S. work force the decision to be a parent (whether through adoption or birth) is treated as a lifestyle choice instead of as a fundamental human right. Until this perception changes, the committee believes that women in the U.S. STEMM workforce will continue to face major barriers in their professional careers, as men who are more active and engaged parents.

BOX 4-9
Lack of Both Inclusivity and Institutionalization in Family Leave Policies

The Gender Values project, which helps institutions evaluate their work-life policies and practices, used a rubric to assess the language and coverage of family-friendly policies at 51 institutions (all received National Science Foundation ADVANCE Institutional Transformation Awards). Preliminary findings from this project show that most institutions lack both inclusivity and institutionalization in their family leave policies (77 percent). The details of their policies were hidden within their handbook and few or no policies that were offered went beyond what is required by law. Additionally, most institutions did not place any emphasis on the leave options for women and men nor did they provide incentives for taking advantage of the policies (Mack et al., 2016).

for caregiving and medical recovery (not as an opportunity to publish),[4] and should not penalize those who take advantage of the policies.

- Providing private spaces with appropriate equipment for parents to feed infants and (if needed) to express and store milk,

[4] Research on the impact of "stop-the-clock policies" has been mixed, with one study showing such policies benefiting men who used the time out of the office to publish papers and book chapters (Antecol et al., 2018).

- Limiting department meetings and functions to specified working hours that are consistent with family-friendly workplace expectations.

In general, policies and practices that address workers' need to balance work and family roles, and that recognize that these policies increase productivity and enhance work performance, will serve to support the creation of a positive, inclusive organizational climate.

The committee acknowledges that the issue of supporting working parents is a complex multi-stakeholder issue, but without a national policy, institutions and organizations must work to support working families using whatever resources are available. In the private sector, many companies have begun offering generous, paid maternity and paternity leave for birth and adoption (Greenfield, 2018).

FINDINGS: CHAPTER 4

FINDING 4-1. Although many educational institutions and employers have adopted programs and policies aimed at improving equity and diversity in STEMM, such interventions typically fail to consider the complex, cumulative ways in which the effects of multiple forms of discrimination (e.g., racism, sexism) intersect in the experiences of women of multiple marginalized identities (e.g., women of color, women with disabilities, sexual minorities, etc.). Programs aimed at improving the representation of women in STEMM have largely benefited White women and have not paid enough attention to the experiences of women with multiple intersecting identities.

FINDING 4-2: There are a number of recruitment strategies identified by institutions and companies that have been proven effective in increasing the number of women entering academic programs and STEMM jobs. Some of these strategies include:

a. Working continuously to identify promising candidates from underrepresented groups and expanding the networks from which candidates are drawn.
b. Writing job advertisements in ways that would be appealing to a broad applicant pool.
c. Interrogating the requirements and metrics against which applicants will be judged to make sure they are not biased and are not poor predictors of success.
d. Deciding on the relative weight and priority of different admissions or employment criteria *before* interviewing candidates or applicants.
e. Holding those responsible for admissions and hiring decisions accountable for outcomes at every stage of the application and selection process.
f. Educating evaluators, including reviewers, to be thoughtful when considering "gaps" in a resume.

g. When possible, evaluating a candidate's work directly.
h. Using structured interviews.
i. Educating hiring and admissions officials about bias and strategies to mitigate biases.
j. Increasing stipends and salaries for graduate students, postdocs, non-tenure track faculty, and others to ensure all STEMM trainees and employees are paid a living wage.

It is important to acknowledge that most of the research on these strategies has not disaggregated data by gender and intersectional identity (e.g., race, disability status, sexual orientation) and has tended to focus on improvements for White women at research universities. Thus, it is difficult to know the extent to which such strategies and practices can benefit women of multiple marginalized identities studying and working in a range of institutional contexts (see Chapter 5 for a discussion of how local, disaggregated data collection and evaluation can offer a process through which a unit (e.g., department, school) can work to develop targeted, data-driven strategies and practices to support all women).

FINDING 4-3: There are several approaches that have been proven effective in mitigating biases that serve to hinder the advancement of women in STEMM along their educational and career trajectory. Such approaches include:

a. Establishing clear metrics for success and advancement and avoid reliance on metrics that are known to be biased (e.g. teaching evaluations, impact factor of publications, external letters of support, or appraisal of "potential").
b. Mitigating bias in performance evaluations, promotion decisions, and in selections for awards and special recognitions. For example:

    i. having someone who has been trained to spot bias involved at every step of the evaluation process.
    ii. beginning with clear and specific performance criteria directly related to job requirements.
    iii. considering performance and potential separately for each candidate.
    iv. separating personality issues from skill sets for each candidate.
    v. leveling the playing field by ensuring everyone knows how to promote themselves effectively and sending the message they are expected to do so.
    vi. offering alternatives to self-promotion to communicate accomplishments.
    vii. ensuring that performance reviews are conducted by more than one individual so decisions are based on more than one perspective.

viii. nominating women for rewards and recognition outside of formal promotions.

Again, it is important to acknowledge that most of the research on these strategies has not disaggregated data by gender and intersectional identity (e.g., race, disability status, sexual orientation) and has tended to focus on improvements for White women at research universities.

FINDING 4-4: There are a range of strategies and practices that institutions and organizations can adopt or "adapt" to improve the retention of women within STEMM educational programs and careers, including:

a. Ensuring that there is fair and equitable access to resources for all employees and students, including equal knowledge of institutional resources and transparency of how resources are allocated.
b. Revising policies and resources to reflect the diverse personal life needs of employees and students at different stages of their careers and education and advertise these policies and resources so that all are aware of and can readily access them.
c. Monitoring use of policies and revising them when necessary to meet the needs and access for all groups.
d. Creating programs and educational opportunities that encourage an inclusive and respectful environment free of harassment.
e. Setting and widely sharing standards of behavior, including sanctions for disrespect, incivility, and harassment. These standards should include a range of disciplinary actions that correspond to the severity and frequency for perpetrators who have violated these standards.
f. Creating policies that support employees during times when family and personal life demands are heightened. For example, stop-the-clock and modified duty policies, which should be available to as wide a group as possible, should be a genuine time-out from work, and should not penalize those who take advantage of the policies.
g. Providing private space with appropriate equipment for parents to feed infants and (if needed) to express and store milk.
h. Creating policies and practices that address workers' need to balance work and family roles, recognizing that these policies increase productivity and enhance work performance.
i. Limiting department meetings and functions to specified working hours that are consistent with family-friendly workplace expectations.

It is important to acknowledge that most of the research on these strategies has not disaggregated data by gender and intersectional identity (e.g., race, disability status, sexual orientation) and has tended to focus on improvements for White women at research universities.

5

Overcoming Barriers to Implementation

The analysis draws substantially from the focus group report, by Tasseli McKay and Dr. Christine Lindquist of RTI International, which was commissioned for this study. The full research paper appears at: www.nap.edu/catalog/25585.

As Chapters 3 and 4 demonstrate, there are a variety of evidence-based and promising practices and strategies to advance the participation and advancement of women in science, technology, engineering, mathematics, and medicine (STEMM). Some institutions have adopted such policies and practices and have seen improvements in the representation and experiences of women in STEMM education and careers. However, in *most* institutions and organizations there are particular entrenched patterns of underrepresentation across disciplines that still exist; namely, that women remain underrepresented at all levels of education and career in disciplines like computer science, physics, and engineering—and are underrepresented among more senior leadership roles in disciplines like medicine, biology, and chemistry (see Chapter 2). The fact that some institutions, departments, or schools are doing better than others in improving the recruitment, retention, and advancement of women in STEMM raises questions about why this is the case. Which factors serve as barriers or facilitators to institutional adoption and sustainability of effective policies and practices? To quote the statement of task for this report, why is it that "effective interventions have not been scaled up or adopted by more institutions?"

In this chapter, the committee provides an overview of the characteristics of successful programs and describes the common institutional barriers to sustainably implementing these practices. This analysis is supported by the research literature, as well as by the findings from a series of focus groups with faculty and administrators carried out by RTI International on behalf of the National Academies of Sciences, Engineering, and Medicine (see www.nap.edu/catalog/25585 for the full results from the focus group research). At a high level, both the research literature and the focus group findings point to a common set of conditions that support positive institutional change, including:

- Committed leadership at all levels
- Dedicated financial and human resources
- An understanding of institutional context
- Accountability and data collection
- Adoption of an intersectional approach

The sections below elaborate on these five key points.

COMMITTED, SUSTAINED LEADERSHIP

Organizational transformation requires changing institutional culture (Bilimoria, 2008; Eckel and Kezar, 2003), which in turn requires leadership. Research demonstrates that leadership is a major factor in organizational transformation and is critical to successful equity and diversity efforts (Bilimoria, 2006; Eckel and Kezar, 2003; Garvin, 2000; Plummer, 2006). Eckel and Kezar (2003) describe four core strategies common to institutions undergoing transformation, including senior administrative support, collaborative leadership, flexible vision, and visible action. In particular, senior administrative involvement is a prerequisite for successful organizational change (Bilimoria, 2008; Eckel and Kezar, 2003; Garvin, 2000). Collaborative leadership is also critical in institutional transformation because it shapes organizational vision, sends institutional messages and signals, and has authority to implement change (Bilimoria and Liang, 2011; Eckel and Kezar, 2003).

Bilimoria and Liang (2011) note that universities can increase women's representation in science by creating and supporting a transformation team composed of senior faculty leaders and administrators to comprehensively address the issues of women's underrepresentation. Similarly, Plummer (2006) notes that communication and leadership strategies are key to the successful implementation of policies, processes, and programs designed to achieve institutional transformation. In addition to being a strategy for implementing lasting change, senior administrative and faculty leadership can serve as a preliminary indicator of lasting institutional change (Plummer, 2006).

In order for transformative change to be sustainable, leaders should be alert to institutionalizing successful features promoting cultural and structural change, and mobilize adequate resources to support change in the long term (Bilimoria and Liang, 2011). Also, direct or indirect access to and support from the highest levels in university administration are cited as being critical in bringing about changes in institutional policies, infrastructure, and climate to address the recruitment, advancement, and retention of women and minority faculty, as well as to create new positions and offices for the implementation of future changes (Bilimoria, 2006; Plummer, 2006).

Based on an evaluation of National Science Foundation (NSF) ADVANCE programs, Plummer (2006) found that:

> *Presidents, chancellors, provosts, vice presidents, and deans created an environment that supported the goals of ADVANCE by communicating frequently about the educational value of diversity and the productivity possible in supportive college and department climates and by expressing support for the goals of ADVANCE. Senior administrators communicated and modeled institutional values and norms by articulating their commitment verbally in formal and informal settings and by underscoring the importance of ADVANCE endeavors.*

A co-principal investigator from one NSF ADVANCE program summarized what several other focus group participants expressed about the important role university leaders, namely: "The leadership of the administration matters. Central leadership from the top is crucial. It's amazing how much difference this makes—what the president says and does" (Plummer, 2006).

The results of the focus group research carried out for this report also highlighted the important role of leadership. In particular, a lack of strong leadership support from university presidents, provosts, deans, and others is a major barrier to equity and diversity efforts. Even if academic leaders are personally supportive of gender-equity practices, the lack of willingness to risk controversy on equity-related initiatives can be an additional barrier. Some leaders fear backlash from vocal opponents and may see little incentive to implement changes, given the risks to them personally. In the words of one participant:

> *I think a lot of times people know what the best practices are, and would personally be supportive of them, but they feel like they're going to incur too much backlash . . . if they're not secure in their base of power, they feel like rocking the boat too much isn't something that they want to push for . . . 'Why am I going to go out on a limb to do this? There's no real incentive for me to do it, for me personally as the leader.' And so, they're just unwilling to go up against the very strong faculty members who are loud, and don't want to make the changes.*

To be successful, equity work needs to actively involve those who have power within their institutions. Yet such work is frequently delegated to university diversity and inclusion officers, who are often marginalized within their institutions, are women and minority faculty tapped by virtue of their service on relevant committees, and who have limited power to bring real change (in addition to risking being overburdened and harming their individual careers). Delegation of equity work to nonacademic staff, such as human resources personnel, was also reported to be a concern, given the perception that human resources is focused foremost on protecting the institution from legal liability. As one participant noted:

> *Human resources. . . . they're so bogged down in following the letter of the law that they lose track of what the spirit of the law often is. And so, they're not willing to be flexible about a lot of things.*

Leadership transitions are also a point of vulnerability for equity and diversity efforts. Inadequate planning to implement new procedures and the failure to identify a new "champion" when turnover occurs can undermine any progress that has been made under prior leadership. Although new leaders may be committed to change, they often bring new agendas to advance and may give less attention to existing policies or practices. Even when such policies have been formalized, the extent to which they are communicated and encouraged to the campus depends on implementation by new and existing leaders alike, which makes them vulnerable when administrative transitions take place. To quote one participant:

> *There used to be a feminist statement to married women, 'Most women are only one man away from welfare' . . . I feel like a lot of these programs are only one man away from existing . . . I hope every day [that the provost] is not out looking for jobs, because I don't know what will happen to a lot of these programs. Even if you think it's institutionalized, it's really not institutionalized . . . it's all very vulnerable, it's still peripheral.*

The focus groups also discussed the role of leaders in facilitating the implementation of research-based policies and practices. First, they cited as a facilitator equity-related initiatives from boards of trustees, with some participants noting that this push from the top could be particularly effective, given trustees' roles in allocating resources and concern for public relations. Equity-related initiatives are also part of the governing boards' responsibilities. The Association of Governing Boards (AGB) notes the following responsibilities as part of a Board's duty:

> *Accordingly, higher education governing bodies must ensure institutional compliance with applicable federal, state, and local laws, including those that prohibit discrimination based on age, race, gender, sexual orientation, religion, disability, and other characteristics, and those that protect freedom of speech and academic freedom (Association of Governing Boards, 2016).*

The role of governing boards with respect to campus climate was addressed in 2016 in the *AGB Board of Directors' Statement on Governing Board Accountability for Campus Climate, Inclusion, and Civility* (Association of Governing Boards, 2016). The statement defines diversity across a number of demographic characteristics, including gender, and notes the importance of campus climate, culture, and norms in terms of building diversity. Building from diversity, the statement recognizes the role of inclusion: "Inclusion recognizes and embraces the need for all members of the institutional community to have a sense of ownership in the institution and a place of belonging. It requires sustained and intentional institutional commitment and action." Further into the statement, the AGB lists recommendations to boards to develop a safe and inclusive campus climate, with significant mentions between the board and the campus leader. As part of their governing function, boards select campus leaders, delegate the management of the institution to those leaders, and provide oversight to the leader's performance (Eckel and Kezar, 2016). For supporting a diverse, equitable, and inclusive campus climate, the AGB recommends the following actions between the board and campus leader: collaboration and transparency, periodic updates to review policies and ensure compliance, ensuring appropriate allocation of resources to address needs, and a communication plan with regular updates on the implementation of campus climate activities. While board members may not spend the majority of time on campus, they have the right to hold leadership accountable to the school's mission, to determine the progress of institutional change, and to adopt new policies to address issues.

Second, the focus groups discussed strong alignment among academic leaders and academic staff at all levels as another enabler of research-based policies. Participants emphasized the benefits of equity work receiving simultaneous effort and priority among both leadership and faculty. As one participant suggested, "senior-level support coupled with policies and coupled with leadership development at all levels of the institution" produces the largest impact on "institutional traction and progress."

Alignment between the formal and informal emphasis placed by deans and chairs on equity efforts was also identified as a facilitator. The formal actions of a dean or chair, such as allocating hiring resources and enforcing policies, are necessary for successful implementation. Their informal actions, particularly the communication of motives behind the formal policies or requirements, are equally important for motivating faculty who are involved in carrying them out. One participant noted:

> *It's up to a chair to energize a [search committee] and not just hear it from the office of advancement or equal opportunity . . . why we're doing this, why it's important. Just kind of that motivation of why these policies came into being in the first place, and [that] it's not a check box.*

In industry settings, research points to a need to intentionally connect the diversity and inclusion strategy with the business strategy. Although most business leaders voice support for diversity and inclusion initiatives, the show of support tends to be insincere. For example, one study noted that when private sector leaders rated a number of potential business priorities, nearly all of them ranked diversity and inclusion initiatives in last place. Chief diversity officers intimated that business strategy was accordingly the weakest driver of diversity and inclusion. Recommendations from this study noted that successful diversity and inclusion programs should—similarly to academia—focus on defining the problem, provide funding support, and require data, accountability, and buy-in from leaders to gauge effectiveness and drive progress (Paikday et al., 2019).

Leaders must also work to ensure that they effectively communicate and enforce policies (see Chapter 4 for additional discussion). Focus group participants reported that a lack of standardization and communication at the university level often results in individual departments implementing policies on their own, despite inadequate department-level familiarity with and communication about equity-related policies. It was noted that some department chairs and search committee members who are in a position to implement the university's equity-related policies (e.g., family leave entitlements, search committee processes) are simply not familiar enough with them to ensure they are uniformly available and implemented. Relatedly, the "soft adoption" of equity-related policies, where implementation is left to department judgment, was perceived to be a barrier to successful implementation. For example, some universities may automatically implement tenure clock stoppage when family leave is taken, whereas at others, this stoppage is recommended to departmental leadership as a "best practice" but essentially left up to them to implement. The latter approach has much greater potential for uneven application. Similarly, the lack of department-level accountability for university-wide efforts was identified as a related barrier, with several participants noting that it is necessary to move from department-idiosyncratic policies toward more standard practices at the university level.

Finally, both the research and the focus group participants noted that leaders in all sectors should work to embody the respectful, inclusive behavior they expect from members of their organization since the behavior of leaders sends powerful cues about organizational expectations. Individuals in an organization take notice of the behaviors of leaders and model this behavior—and sometimes attitudes—accordingly (NASEM, 2018b).

DEDICATED FINANCIAL AND HUMAN RESOURCES

Both the literature and the focus group research emphasize the need for institutional leaders to set aside adequate resources to support equity and diversity efforts. As described above, the vast majority of equity work is assumed, in an uncompensated manner, by existing women faculty and faculty of color. The predominant model for accomplishing such work was perceived to rely on those who are passionate about equity to assume it voluntarily—on top of their regular workload—and with no teaching release or other compensation.

> *It's perceived as an extra workload kind of thing . . . you're willing to do the extra work if it's your passion . . . if you have one person with the passion to do it they figure out a way to do it, but then it's extra work for them. They don't get any kind of release . . . and then it goes away [if they leave].*

In addition to the burden imposed on the individuals carrying out the work (described by one participant as "putting a burden on the oppressed"), this approach can be ineffective, making equity issues easier to sideline or compartmentalize. Participants suggested the need for greater involvement from male and/or majority culture faculty:

> *All too often, the ethnic minority or the gender minority population that is most affected is being asked to solve these kinds of issues. But women can't solve the fact that they are paid less than men. They need men on board to solve that problem. And ethnic minorities can't solve their pay inequalities either. They need people from the majority culture to also say, 'hey, let's solve these kinds of issues.' So, I think will is absolutely one of those things where if the university doesn't have that, everything else is just going to be lip service. And a lot of extra service work to hide the fact that it's just lip service.*

The research literature points to similar findings regarding general lack of resources to support equity and diversity work. A recent study of 234 chief diversity officers at Standard & Poor's 500 companies found that many in this position were in fact business leaders selected to lead internal diversity and inclusion efforts in addition to their other job responsibilities. The multiple layers of responsibilities unrelated to diversity and inclusion frequently hindered their ability to perform their jobs fully. The study also indicated that chief diversity officers often lacked data and analytics, such as employee demographic data, requisite to their positions (see below for a discussion of the importance of data collection for accountability and targeted intervention).

Similar findings have been reported in the field of pediatrics (where White women and women of color are underrepresented among senior leadership roles). In a recent publication, Spector et al. (2019) used the example of hospital safety as a comparison to illustrate the point:

> *Institutional hospital safety leaders, not patients (those most affected), are held responsible for identifying and prioritizing inadequacies, eliciting solutions, assigning institutional funds and resources, and collecting, analyzing, and compiling outcome data into reports distributed both internally and to regulatory agencies. In contrast, gender-equity initiatives have been largely driven from a grassroots level (with little or variable institutional recognition or support) by those most affected (women who are underpaid and underrecognized) with few resources (volunteering their spare time and often underwriting the initiatives themselves)* (Spector et al., 2019).

After conducting a comprehensive evaluation of the state of White women and women with intersecting identities in pediatrics, Spector et al. concluded that achieving gender equity in medicine needs to include a number of specific scientific principles, namely: leadership accountability; dedicated financial and human resources; and an evidence-based, data-backed, and transparent approach to evaluation and reporting (see discussion below) (Spector et al., 2019). These conclusions are consistent with the research presented throughout this chapter.

Beyond compensating those individuals in an organization that take on responsibility for equity and diversity efforts, it is important to ensure that such support is sustained over time. Focus group participants noted that even when money is allocated to equity work, its vulnerability to budget cuts or re-appropriation is a barrier to sustained implementation. True institutionalization of policies and practices was reported to be expensive and labor intensive, and the vulnerability of efforts is particularly pronounced when resources are dispersed across budgets in different departments and offices within the university. One participant offered an example illustrating the potential for funds to be misused in such arrangements:

> *We had funds that were put aside for opportunity hires for underrepresented women and underrepresented minority men and women. And over time they were used for all kinds of things. Whoever the provost was who came in or whatever the president wanted, the funds got used, and they eventually disappeared.*

Focus group participants additionally observed that the most effective approaches for addressing issues with equity and diversity are also often very resource- and labor-intensive to implement and sustain (e.g., in-person instead of online trainings). Other resource-related barriers identified in the focus groups included the lack of investment in equity-related initiatives from major donors and/or alumni, who wield strong influence in the institution, and the unwillingness or inability of departments to allocate the additional resources that may be required to successfully recruit an under-represented candidate (e.g., associated with many women faculty needing jobs for partners).

Participants viewed grant-funded efforts as playing an especially important role in facilitating the implementation and sustainability of gender-equity efforts. They emphasized the receipt of NSF ADVANCE institutional transformation grants as a major facilitator of implementation success within their institutions (and others).

> *I really think NSF, between the ADVANCE program and broader impacts, made it sort of important for institutions to pay attention to this. You know, there's probably some effects from the changing environment at large. But, I think the first big push at my institution came from more ADVANCE institutional transformation grants.*

Participants viewed the NSF ADVANCE program as drawing initial attention to gender-equity issues as well as serving as a catalyst for sustained equity efforts. Stakeholders at some institutions were able to secure ongoing, university-level funding to continue initiatives that were implemented with the grants, which was identified as a facilitator of sustained implementation. One participant commented that institutionalizing efforts initiated with NSF ADVANCE grant funding enabled the institution to continue to innovate and be a continued leader in the field, and that "institutional resources have to undergird that initial external funding."

Participants also identified school- or department-level funding support was also identified as a facilitator of implementing and sustaining research-based policies and practices. For example, some STEMM departments or schools allocated funding for search committee training that was formerly covered by outside grants.

UNDERSTANDING INSTITUTIONAL CONTEXT

While there are shared characteristics of successful programs and common institutional barriers and facilitators to sustainably implementing these practices, the committee recognizes that institutions have different goals and missions, values, cultures, and resources and this institutional context can impact the efficacy of any program, regardless of that program's designation as "successful" and "evidence-based." There is no one-size-fits-all solution, policy, or practice that will perfectly fit the needs of all institutions. As Hardcastle et al. (2019) state: "Greater participation of women and faculty of color in STEMM fields is complicated and dependent on complex and multi-layered interactions between activities and actors." In addition, because researcher and institutional goals vary as a function of target population and context, "generalizable models can struggle in the face of larger broadening participation efforts."

To further explore these issues, Hardcastle et al. (2019) conducted a social network analysis, an exit survey of departed faculty, longitudinal analysis of career trajectories and research productivity, and a survey on the interaction between values and climate to assess the barriers for women in STEMM across institutions. The authors found that a "dynamic, multi-scaled and organizational level approach is required to reflect the reciprocal dialogue among research questions, best practices, tailored applications and quantifiable goals" (Hardcastle et al., 2019).

The authors identified three strategies to better retain women in STEMM across institutional contexts, including (1) improving women's professional networks; (2) re-aligning policy documents and departmental practices to better reflect faculty values; and (3) improving departmental climate. Regarding the need to improve women's professional networks, the authors found that helping women proactively develop professionally-oriented connections, while also working with department heads to assist with this process, should help improve a sense of fit and belongingness, which should in turn decrease attrition (Hardcastle et al., 2019).

Hardcastle et al. (2019) noted that changing explicit policies has a much greater and immediate impact than trying to change hearts and minds. "Claiming institutionally that we value diversity and diverse forms of scholarship is one thing, but formally recognizing diverse scholarship and having policy to point to in promotion and tenure cases are more convincing. Moreover, policy can outlast any set of 'hearts and minds,' since they stay when people leave" (Hardcastle et al., 2019).

Regarding improving departmental climate, the authors state that a strong and continuous organization can promote sustained change by holding the institution accountable for achieving diversity and inclusion (see discussion of accountability in the section below). "True institutional transformation will not come from the work of select individuals across campus; instead, it must be driven by organized groups over a significant period of time who connect both with leadership and faculty, who also can leverage each other's successes, and who can ensure that institutional leaders enforce policies, standards, and expectations" (Hardcastle et al., 2019).

Similarly, the results of the focus group research carried out for this report highlighted the issue of institutional context and how it can impact whether a policy will have a positive impact. For example, focus group participants noted that there is a need to recognize and engage the specific strengths and challenges of different institutional contexts. Participants noted that cross-context adaptation is challenging and can be poorly guided. Another theme from the focus groups included that adapting research-driven policies and practices to different institutional contexts is critical to achieving large-scale equity across STEMM disciplines, since most such initiatives had been developed and tested in a single type of university only. To quote one participant:

> *We know a reasonable amount about these kinds of initiatives; what we don't know is how to do them in all the different contexts. And so, I think that's an enormously hard and important problem . . . there's not a magic bullet process or procedure to use. It has to be adapted, and how do we analyze the examples that exist and say, 'This would work here, but it would have to change in this way'?*

Also, focus group participants highlighted gaps in cross-contextual and translational research that could inform such adaptation efforts, noting that the lack of research constrained efforts to scale or adapt "evidence based" policies and practices to their own institutional contexts. In the words of a focus group participant:

> *'What about this program works that can then be applied at other institutions?' A lot of times [what is] presented as research is actually a single institution implemented a practice and it worked really well for them.*

DATA COLLECTION FOR ACCOUNTABILITY AND TARGETED INTERVENTION

As it can be difficult to predict the interventions that will be most successful within particular institutional contexts, it is necessary for individual institutions and organizations to collect data and monitor trends in the recruitment, retention, and advancement of women in STEMM to better adopt or adapt targeted interventions and to monitor their efficacy. By collecting and monitoring data and evaluating it over time, employers and admissions officers can better understand whether recruitment, retention, or advancement—or some combination—is the major issue affecting the representation of women (see Figure 5-1 for an example of an online dashboard at Stanford University). If recruitment is an apparent issue, institutions can evaluate and monitor the diversity of applicant pools at every stage of the recruitment process and keep track of who decides to enroll or accept the job once an offer is made. By tracking trends in the recruitment process, employers or admissions officers will be better able to determine whether the underrepresentation of women is related to particular stages in the recruitment process (e.g., a limited pool of candidates, shortlist, interview group, or final choice). Data on who is completing a given program or leaving an organization is useful in diagnosing whether retention of women is an issue, and examining data on the representation and rate at which White women and women of color are advancing, as compared with other groups, is helpful in identifying problems of advancement. In addition, examining patterns of advancement longitudinally, rather than only at key transition points, will provide a better evaluation of issues related to advancement. It is only by tracking attrition and delay (e.g., of promotions) at each stage, that organizations can gain a greater understanding of how apparent parity at the beginning of a process (e.g., admissions or hiring) can result in large disparities at the end (graduation or degree completion, and advancement to the highest positions). Several organizations and higher education institutions already make use of publicly available dashboards that include data on gender representation. For example, Google,[1] Stanford,[2] and the University of Michigan[3] have such interactive dashboards (see Figure 5-1 for an example).

The importance of data collection to "diagnose" and "treat" equity issues was also discussed extensively during the focus group sessions. Participants noted that when data *were* available or data collection systems were in place, they made implementation of equity-related policies and practices more likely, and they could get university stakeholders and professional associations representing specific disciplines interested in solving equity-related problems, tracking progress toward solutions, and establishing organizational priorities.

Beyond the numbers, it is also important for institutions and organizations to understand the experiences of White women and women of color through periodic climate research carried out by an evaluator outside the relevant unit. Enlisting the services of an evaluator external to the unit is important in that it will permit assessment of the climate in a school, company, or department in a manner that is methodologically sound, independent, objective, and free from bias and conflict of interest. Such climate research can take the form of surveys, focus groups, and/or interviews. That being said, given the extremely low representation of women of

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[1] See https://diversity.google/annual-report/.

[2] See https://ourvision.stanford.edu/design-teams/ideal-homepage/ideal-dashboard.

[3] See https://advance.umich.edu/dashboards.

FIGURE 5-1 Screenshot of Stanford University's IDEAL dashboard. The dashboard shows the composition of undergraduate students, graduate students, post docs, professoriate faculty, and staff, disaggregated by sex and race/ethnicity. While this dashboard is meant to be interactive this screen shot of their data is a pertinent example of the type of data this report calls for.
SOURCE: See: https://ourvision.stanford.edu/design-teams/ideal-homepage/ideal-dashboard.

color in most STEMM fields, it is important to adopt a methodological approach that can protect the anonymity of such individuals and accurately capture their experiences. In some instances, interviews may serve as the most appropriate means to gather this information; in others, conducting such research within a single institution may be deemed unsafe for the women of color who make up an extreme minority in certain fields. In instances where there is a small sample size, specifically in the case of women of color in most STEMM fields, qualitative research may be extremely valuable, particularly as it can provide richly-textured information, relevant to the phenomenon under investigation. For example, focus group methods may be uniquely well suited to exploring issues with existing processes or strategies and gaining insight into the functioning of institutions (Stewart et al., 2009), as is the case in for many of the issues addressed in this report.

Additionally, data collection, monitoring, and evaluation, if done transparently, can increase accountability, which can, in turn, serve as a driver of positive change. The social science and business literature offers many examples of the positive impact of greater accountability on equity and diversity efforts in education and business (Dobbin and Kalev, 2016). Take, for example, Emilio Castilla's field study of the Massachusetts Institute of Technology's Sloan School of Management, where African Americans were consistently given smaller raises than White employees, despite identical job titles and performance ratings (Castilla, 2015). To address this pervasive issue, Sloan began posting the average performance reviews and associated raises for each unit by demographic characteristics (i.e., race and gender). As soon as managers realized that bias in compensation by race and gender would become public knowledge within the school, they developed an increased sense of accountability and the discrepancies in compensation disappeared.

Deloitte offers another compelling example. In 1992, chief executive officer (CEO) Mike Cook realized that despite gender parity in hiring, the company was struggling to retain and advance talented women (Gaventa and McGee, 2013). He assembled a high-profile task force to address the issues with retention. Adopting a strategy that relied on accountability, the task force got each office within the company to monitor the career progress of its women and set goals to address the problem within the context of the specific unit. To quote a *Harvard Business Review* article on this case:

> *When it became clear that the CEO and other managing partners were closely watching . . . "Women started getting their share of premier client assignments and informal mentoring." And unit heads all over the country began getting questions from partners and associates about why things weren't changing faster. An external advisory council issued annual progress reports, and individual managers chose change metrics to add to their own performance ratings. In eight years turnover among women dropped to the same level as turnover among men, and the proportion of female partners increased from 5 percent to 14 percent—the highest percentage among the big accounting firms. By 2015, 21 percent of Deloitte's global partners were women, and in March of that year, Deloitte LLP appointed Cathy Engelbert as its CEO—making her the first woman to head a major accountancy.*

Similar examples are found in educational settings. When teachers realize that they will have to explain their evaluations, they rely less on their biases. For instance, studies have shown that when teachers are told that they will have to discuss and justify the grades they give students on papers, racial bias in grading disappears (Kruglanski and Freund, 1983). Equally, when departments are expected to present short lists of potential candidates to the dean's office for review, those lists include more diverse candidates (Bilimoria and Buch, 2010).

In addition to improved accountability, data collection allows an organization to gain a more complete understanding of its specific issues with recruitment, retention, and advancement and develop targeted strategies to address these issues. In the example offered above, it would have made little sense for Deloitte to invest additional resources in the recruitment of women candidates since women were being hired at the same rate as men—the specific issue they were facing was one of poor retention. To address a problem and make best use of the (often) limited resources available to address the issue, we must first understand the nature of the specific problem.

Institutions and organizations that have collected, monitored, and reported data over time to assess the recruitment, retention, and advancement of White women and women of color have been able to implement targeted interventions and seen marked improvements in equity and diversity. For example, within some schools and colleges at the University of Michigan, every department is provided annual data about the rate of Ph.D. attainment by women and minorities in the

BOX 5-2
The SEA Change Effort at the American Association for the Advancement of Science (AAAS): Supporting Institutional Transformation in Support of Diversity, Equity, and Inclusion, Especially in Colleges and Universities

Modeled after the Athena SWAN (Scientific Women's Academic Network) Charter in the United Kingdom, the STEMM Equity Achievement (SEA) Change effort, which was launched by the American Association for the Advancement of Science in 2018, provides institutions with a community of practice, a range of educational resources, and opportunities on best and promising practices for promoting equity, diversity, and inclusion, and positive incentives to work toward systemic change through an award program that recognizes institutions that undergo self-assessment, take action, and then reassess in both a top-down and bottom-up manner.

The Three Pillars of the SEA Change Effort

Community: SEA Change provides a "safe space where partnerships and collaborations can be established to nurture the talent pool for STEMM" among member institutions, organizations, and individuals committed to advancing diversity, equity, and inclusion.

Institute: The SEA Change Institute offers participating institutions with a repository of research, access to issue-based convenings, courses, trainings, and recordings of past SEA Change events, and information on how to apply for a SEA Change award (see next page).

relevant field at Ph.D.-granting institutions, at institutions that the University of Michigan considers "peers," and within the department at Michigan itself. This practice allows for departments and deans to notice when the Ph.D. production in a department is not meeting that of the national production and when this needs to be addressed. Additionally, it helps remedy the often incorrect assumptions about the potential availability of applicants so that realistic goals can be developed (Stewart and Valian, 2018). When these data were first distributed, many were surprised by how few women and minority Ph.D.s they had graduated and that the pool of applicants was larger than they expected. These data are now expected among the departments to achieve the diverse applicant pool they desire to fill their faculty positions. Other efforts that place a significant emphasis on data collection in support of driving greater accountability and the adoption of evidence-based, targeted practices by institutions include the Athena SWAN (Scientific Women's Academic Network) Charter in the United Kingdom and the STEMM Equity Achievement (SEA) Change effort in the United States (see Box 5-2).

Awards: Participating institutions can apply for recognition by the SEA Change program for a bronze, silver, or gold award that recognizes "commitment to and creation of sustainable systemic change through self-assessment."

SEA Change resembles Athena SWAN in its emphasis on establishing a community committed to principles of equity, diversity, and inclusion and the focus on a cycle of self-assessment followed by the adoption of evidence-based practices and the establishment of an action plan that includes reassessing and monitoring progress toward ambitious, but attainable, goals. Athena SWAN reports that over 100 institutions and 700 departments in the United Kingdom are engaged with the charter. SEA Change, while similar, differs in several important ways. Chief among them is that SEA Change places a much greater emphasis on race and ethnicity and the intersectional experiences of women of color, while Athena SWAN is focused primarily on gender. Further, the different educational and research landscapes in the United States and the United Kingdom necessitate slightly different approaches. For instance, in 2011, the chief medical officer of the United Kingdom announced that academic departments applying for funding from the National Institute for Health Research must hold an Athena SWAN silver award. In contrast, the United States does not couple public funding for research with efforts to promote and address equity, diversity, and inclusion through SEA Change. To do so would require changes in U.S. law. Another difference is that, in 2015, the Athena SWAN Charter was expanded to include "work undertaken in arts, humanities, social sciences, business and law (AHSSBL), and in professional and support roles, and for transgender staff and students," while the SEA Change effort is currently focused on STEMM.

SOURCES: SEA Change: https://seachange.aaas.org/what-is-sea-change; Athena SWAN: https://www.ecu.ac.uk/equality-charters/athena-swan/.

One challenge, however, is that the extremely small numbers of women of intersectional identities in a department or field can serve to hinder organizational accountability and quality improvement with regard to their representation. Focus group participants noted that, within a given discipline or university, tracking how women of color and women with other intersectional identities benefited (or not) from policies and practices intended to increase women's representation or advancement is difficult.

> *We are necessarily going to overlook those individuals with intersecting identities . . . because the sample sizes are so small they often get collapsed into broader categories . . . The data systems don't allow for really looking at [this].*

Without the ability to rigorously assess the status of women of intersectional identities or examine whether the representation of particular groups of women expanded with the introduction of a certain initiative or policy, institutions lack accountability for promoting the inclusion and advancement of all women. As one participant put it: "The lack of data . . . has tended to perpetuate the underrepresentation." This suggests the need for careful consideration of how to balance the importance of collecting and monitoring data on the experiences and participation of women of color and women with other intersecting identities, while also ensuring sufficient protections and anonymity for such a small group of people.

ENSURING THAT ALL WOMEN BENEFIT FROM EQUITY AND DIVERSITY EFFORTS BY ACCOUNTING FOR INTERSECTIONALITY[4]

The literature and the focus group research indicate that not all women in STEMM benefit equally from policies and practices designed to support their representation, advancement, and academic contributions. Instead, such efforts tend to be unevenly successful depending on women's life experiences (particularly racialized life experiences), their career stages, and the institutional contexts in which they work (such as distinctions between public and private universities, historically minority- and majority-serving institutions, and academia and industry). As discussed in Chapter 2, most research on women in STEMM has focused almost exclusively on middle-class White women and very little empirical attention has been paid to the intersection of ethnicity, race, gender, and the scientific culture. Further, well-intentioned efforts to support women in STEMM have historically failed to account for the intersectional experiences of

[4] The concept of intersectionality considers the complex, cumulative ways in which the effects of multiple forms of discrimination (e.g. racism, sexism, homophobia, classism, etc.) intersect in the experiences of women of multiple marginalized identities (e.g. women of color, women with disabilities, sexual minorities, etc.). For a discussion of intersectionality, see Chapter 2.

women of color and women of other intersecting identities, such that "programs intended to serve women disproportionately benefit White women, and programs intended to serve minorities mainly benefit minority males (Ong et al., 2011)." This was further emphasized in a recent paper by Corneille et al. (2019), which synthesized the available literature barriers to the advancement of women of color faculty in STEMM, and found that "there is limited research that examines STEM women of color faculty experiences at minority-serving institutions and in leadership roles. Further research is needed to examine the long-term efficacy of mentoring strategies and institutional transformation efforts for women of color" (Corneille et al., 2019).

The results of the focus group research are consistent with the findings in the published literature. Focus group participants agreed that existing policies and practices have been inadequate or ineffective for supporting the representation, advancement, and contributions of women of color. They noted that active institutional recognition of distinct challenges relevant to women of color in STEMM lagged considerably behind rhetoric and policies regarding gender or the needs of academic "women" as an undifferentiated group.

Despite some positive change in gender composition in many institutions and fields represented in the focus groups, participants observed that efforts to address the inclusion of women and their representation in academic leadership roles have not brought corresponding shifts in the presence of women of color in their fields.

> *There's definitely a sense of full inclusion based on gender in my department, but that doesn't carry forward or I don't think the same can be said when we consider race and ethnicity and women of color, as we have very low representation . . . there's not a sense of that we're really achieving all that we could achieve on that.*

Participants suggested that this persistent underrepresentation of women of color in many STEMM fields, even those in which gender composition had shifted in recent decades, is symptomatic of greater discomfort or intolerance regarding efforts at inclusion and advancement for women of color.

> *Most colleagues, I think, are reluctant to engage it . . . the indifference or resistance to hiring underrepresented minorities. It's quite astonishing that in some schools they've just hired their first African American. In fact, if you look at African American or Latino women, in some cases there are whole segments of higher education, STEMM fields, that haven't hired any.*

The failure to address issues of underlying racial bias or the specific needs of women of color with regard to representation and advancement meant that White women had tended to benefit more heavily from efforts to address gender composition than their colleagues of color.

The one exception noted by focus group participants was the inclusion of non-native-born women, whom a few participants observed tended to benefit disproportionately from university initiatives to increase the representation of women and faculty of color. Participants felt very positively about the presence of immigrant scholars in STEMM fields and about efforts to encourage their full contributions. However, they noted that immigrant faculty might not have the same capacity to relate to, and steward the contributions of, women students of color from racialized and marginalized American communities. For this reason, it is critical that their presence is not seen as replacing ongoing efforts to recruit and promote native-born faculty of color who shared those experiences of racialization and marginalization.

> *Many of the people who are being promoted are not ethnic minority Americans, but instead recent immigrant ethnic minorities . . . Somebody who just got here from Nigeria has a very interesting and worthwhile perspective [but] it doesn't advance the civil rights movement in this country because they're not tied to it at all . . . [and] what we've always asked people as any underrepresented group, whether that's women or African Americans or Latinx populations, is that, as they attain positions of responsibility and authority, they reach back and help people who are like them, who are similarly disadvantaged. But that kind of system breaks down if they don't have any relationship with the natural communities that [faculty of color] should be helping to bring up.*

Participants noted that the introduction of requirements to address intersectionality in applications for the NSF ADVANCE grants helped to bring attention to intersectionality generally and issues faced by women of color at their institutions. Still, this nascent attention was perceived as "barely scratching the surface," unaccompanied by a well-developed understanding of issues faced by women of color or how to address them.

That being said, those institutions that have taken an intersectional approach in their efforts to improve the representation of women in STEMM offer some important lessons learned. For example, a 2014 study of NSF ADVANCE[5] institutional transformation (IT) grants evaluated the programs' approaches to, and strategies for, addressing issues faced by women of color in STEMM fields (Armstrong and Jovanovic, 2017).

The study identified five "intersectional facilitators" for institutional leaders that can help drive new strategies for supporting and improving the diversity of women of color in STEMM. These included:

> (1) Creating accountable leadership that participates actively and cooperatively in efforts aimed at supporting women of color in STEM. This includes proactive institutional leaders who are supportive in more than word and share responsibility for outcomes. An example includes "senior level administrators who

[5] See https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5383.

understand significance of issues and proactively create consequences for actors who do (not) attend to those issues."

(2) Recognizing and engaging with multiple "institutional climates" and adopting strategies for intervention and change in a locally intersectional context. The authors cited the example of developing an array of programming that reflects an understanding that faculty work within multiple structural climates within an institution.

(3) Understanding the implications of the "small N" problem and leveraging it as an opportunity to name and intervene in the dynamics of majority privilege while learning how to be effective allies to women of color. An example includes majority faculty consistently listening to underrepresented minority women and becoming responsive to their needs.

(4) Becoming knowledgeable about common obstacles and solutions, as well as key scholarship and research findings, on issues commonly affecting women of color in STEMM, in order to close the knowledge gap between current research and the agents of change at any given institution and among change agent team members themselves.

(5) Promoting "counterspaces," or community structures that provide women of color opportunities to find others with whom they share a particular identity, allowing for collaboration or mentorship. Specifically, underrepresented minority women in STEMM should benefit directly from structures that "bring them together, increase their investment in organizational change, and allow them to define their own needs" (Armstrong and Jovanovic, 2017) (see Box 5-3).

Universal Design

While approaches that incorporate intersectionality in their design may have promise in addressing representation of women of color, programs that address the needs of the most marginalized populations may similarly prove to have a positive impact on all groups. The concept of universal design may be applicable in these cases.

Mace et al. (1988) coined the term *universal design* as "the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design." The initial conception of universal design was focused on the design of buildings and roadways to ensure accessibility to the entire public, including those with disabilities. A familiar example of universal design is the sidewalk "curb cut," which allows individuals with mobility disabilities to more easily transition from a sidewalk in to the roadway. While designed to meet the needs of individuals with disabilities, these curb cuts also improve the experience of individuals pushing strollers, bicyclers, and many others (Schreffler et al., 2019).

BOX 5-3
Counterspaces and Women of Color in STEMM

Counterspaces in STEMM contexts are often considered "safe spaces" that offer support and enhance feelings of belonging for groups traditionally underrepresented in these fields (Solorzano et al., 2000). These spaces allow for students to share their experiences and have them validated, vent frustrations, and challenge negative perceptions of people of color (Ong et al., 2018). Qualitative research has shown that five types of counterspaces have been particularly helpful for women of color in STEMM: (1) peer to peer relationships that provide academic, social, and/or emotional support; (2) mentoring relationships that helped women of color navigate how to succeed in STEMM; (3) STEMM and non-STEMM campus groups to advance professional skills and develop leadership opportunities; (4) diversity conferences to gather large groups of women of color going through similar experiences; and (5) STEMM departments that hosted inclusive events that facilitated women of color students' access to opportunities and relationships to bring them into the department as a whole (Ong et al., 2018). These intersectional facilitators can offer innovative ways of thinking about change that can drive new strategies for practical interventions that foster diversity and support women of color in STEMM. The National Institutes of Health's Women of Color Research Network (WoCRn) is a good example of a counterspace on a national scale. The WoCRn is an online community of women of color helping other women of color succeed in biomedical research. This resource provides its members with resources, such as networking and mentoring opportunities, as well as tools to successfully navigate the National Institutes of Health's grant process. When organizations undertake these deliberate, strategic actions in a sustainable way, they are approaching this issue with the intentionality required to ensure measurable, high-impact solutions.

There is evidence that applying a universal design approach may address equity for marginalized populations. The goal of universal design extends beyond eliminating discrimination toward people with disabilities. "A universal design benefits everyone or, at least, a large majority . . . Universal design demands creative thinking and a change in perspective. It is not sufficient merely to apply design criteria in accessibility regulations in a mechanistic way. Often a change in perspective is needed" (Steinfeld and Maisel, 2012).

Pliner and Johnson (2004) note that universal design "not only serves students with disabilities, it also serves the increasingly diverse student population at large (diversity in terms of race, class, gender identification, religion)." Newman et al., 2011 add that "universal design for learning is one way to make every lesson accessible to every student. By making STEMM content accessible to all students, colleges and universities may see an increase in STEMM enrollment by underrepresented populations. Universal design is "a goal that puts a high value on both diversity and inclusiveness. It is also a process" (Burgstahler, 2013).

By incorporating the concept of intersectionality and universal design as key components in programs, strategies, and policies to address the underrepresentation of women of color in STEMM, particularly ensuring that the most marginalized groups are at the forefront of the design, the impact will likely be felt more broadly across the STEMM enterprise.

Nevertheless, there is a clear need for additional research on the experiences of women of color in STEMM and on the impact of specific strategies and practices intended to support the improved recruitment, retention, and advancement of women in STEMM (such as those reviewed in Chapter 4), and on women of color, specifically. We should be cautious about assuming that an intervention that has benefited middle-class White women will benefit all women. The only way to determine whether this is in fact true is to carry out rigorous comparative studies. This committee urges additional research on whether and how the strategies and practices outlined in this report benefit women of color and women of other intersecting identities.

FINDINGS: CHAPTER 5

FINDING 5-1: Organizational transformation requires changing institutional culture, which in turn requires committed leadership. A lack of strong leadership support from university presidents, provosts, deans, and others is a major barrier to equity and diversity efforts. Leadership transitions are a point of vulnerability for equity and diversity efforts. Inadequate planning to implement new procedures and the failure to identify a new "champion" when turnover occurs can undermine any progress that has been made under prior leadership.

FINDING 5-2: Governing boards are an effective way to hold institutional leadership accountable for creating diverse and inclusive environments, given trustees' roles in allocating resources and concern for public relations.

FINDING 5-3: Strong alignment among academic leaders and academic staff at all levels facilitates the implementation of research-based policies and practices.

FINDING 5-3: For equity efforts to succeed, leaders in all sectors should work to embody the respectful behavior, including meaningful communication, and equity-related policies, and ensure that institutional departments and diversity and inclusion officers receive adequate resources.

FINDING 5-4: Women faculty and male faculty of color assume, in an uncompensated manner, the vast majority of equity work. In addition, a general lack of resource allocation exists in gender-equity work, including:

a. Lack of funding or teaching relief for equity work,
b. Vulnerability to budget cuts or re-appropriation of funds allocated for equity work, and
c. Lack of investment in equity-related initiatives from major donors and/or alumni.

Thus, there is a need for institutional leaders to set aside adequate resources to support equity and diversity efforts. School- or department-level funding support, as well as support from the federal government, can facilitate implementing and sustaining research-based policies and practices.

FINDING 5-5: To be successful, equity work needs to actively involve those who have power within their institutions. Such work is frequently delegated to university diversity and inclusion officers, who are often marginalized within their institutions, are women and minority faculty tapped by virtue of their service on relevant committees, and have limited power to bring real change.

FINDING 5-6: While there are shared characteristics of successful programs, and common institutional barriers and facilitators to sustainably implementing these practices, institutions have different goals and missions, values, culture, and resources and this institutional context can impact the efficacy of any program, regardless of that program's designation as "successful" and "evidence-based." There is no one-size-fits-all solution, policy, or practice that will perfectly fit the needs of all institutions.

FINDING 5-7: Given that it can be difficult to predict which interventions will be successful in which institutional contexts, it is necessary for individual institutions and organizations to collect data and monitor trends in the recruitment, retention, and advancement of women in STEMM to better adopt targeted interventions and monitor their efficacy. Collecting and monitoring data and evaluating it over time, employers and admissions officers can increase utility in ascertaining whether recruitment, retention, or advancement (or some combination) is the major issue affecting low representation of women.

FINDING 5-8: Not all women in STEMM benefit equally from policies and practices designed to support their representation, advancement, and academic contributions. Participants suggested that such efforts tended to be unevenly successful depending on women's identitites (particularly race and ethnicity), their career stages, and the institutional contexts in which they worked.

FINDING 5-9: By incorporating the concept of intersectionality and universal design as key components in programs, strategies, and policies to address the underrepresentation of women of color in STEMM, particularly

ensuring that the most marginalized groups are at the forefront of the design, the positive impact will likely be felt more broadly across the STEMM enterprise.

FINDING 5-10: A clear need for additional research exists, specifically on the experiences of women of color in STEMM and on the impact of specific strategies and practices intended to support the improved recruitment, retention, and advancement of women in STEMM on women of color and women with other intersecting identities.

6

Recommendations

This report is not the first report of its kind. There have been many past reports published by the National Academies of Sciences, Engineering, and Medicine and other groups that have described the factors that drive the underrepresentation of women in science, technology, engineering, mathematics, and medicine (STEMM) and have laid out the evidence-based steps that organizations and institutions can take to improve the recruitment, retention, and advancement of women in these fields (see Appendix B). Some institutions and organizations have intentionally implemented such policies and practices and seen great improvements in the participation of women in science, engineering, and medical education and careers. For example, following the release of the 2007 National Academies report *Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering,* the National Institutes of Health formed the Working Group on Women in Biomedical Careers and created a grant program, Research on Causal Factors and Interventions that Promote and Support the Careers of Women in Biomedical and Behavioral Science and Engineering, which funded 14 institutions to directly address the recommendations in the report (Plank-Bazinet et al., 2016). Nevertheless, the issue persists at a national level.

This report concludes that entrenched patterns of underrepresentation in STEMM disciplines persist due to a range of factors, including: lack of broad awareness of the evidence-based practices reviewed in this report, a need for greater prioritization and resource allocation by institutions toward targeted, data-driven equity and diversity efforts, and because real progress on this issue will require culture change driven by systemic, coordinated efforts from a range of stakeholders—Congress, the White House, federal agencies, faculty, employees, academic administrators, professional societies, and others.

Below we offer a set of recommendations aimed at providing the appropriate incentive structures, grounded in the need for transparency and accountability, to allow these many stakeholders to work in concert to implement promising and effective practices to improve the recruitment, retention, and advancement of women in STEMM.

RECOMMENDATIONS

The committee's recommendations are grouped into four broad categories, which are targeted at incentivizing and informing the broad adoption of evidence-based promising practices for improving the recruitment, retention, and advancement of women in science, engineering, and medicine:

I. **Driving transparency and accountability.** Institutions must articulate and deliver on measurable goals and benchmarks that are regularly monitored for progress and publicly reported. Multiple studies have demonstrated that transparency and accountability are powerful drivers of behavior change.

II. **Targeted, data-driven approaches to addressing the underrepresentation of women in science, engineering, and medicine.** Rather than guessing at the interventions that work best for all women of all intersectionalities across all disciplines, the committee recommends a targeted, focused, data-driven approach to closing the gender disparities in science, engineering, and medicine. Such an approach includes, for example, dissecting the challenges and barriers by discipline and career stage, acknowledging the fact that interventions and strategies that work well for White women may not work well for women of color, and using disaggregated data collection, analysis, and monitoring as the basis for constructing specific interventions within the unique context of a given institution.

III. **Rewarding, recognizing, and resourcing equity, diversity, and inclusion efforts.** 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. The committee 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.

IV. Filling knowledge gaps. Although scholarly research on gender disparities in science, engineering, and medicine has yielded an abundance of information that can be applied toward reaching gender equity, there are critical knowledge gaps that require closer attention.

The rationale for the recommendations the committee offers within each category is rooted in the notion that there are certain levers of change that, if pulled, can drive greater, more widespread, systemic action. However, it is important to acknowledge that the four broad categories into which the committee's recommendations are grouped are not, in fact, distinct, but instead are fundamentally interconnected components of a complex system of actors, incentives, and information (see Figure 6-1). For example, drivers of transparency and accountability yield new information that can inform targeted, data-driven interventions, while also acting as an incentive that can drive greater resource allocation for equity, diversity, and inclusion efforts. The committee contends that the interconnectedness of these recommendations underlies their strength. This is not to say that individual recommendations, if implemented by stakeholders, cannot have a tangible impact, but the systemic change that is needed to drive swift change on this issue is suited to a systemic approach.

In addition to high-level recommendations, the committee offers a series of implementation actions for each recommendation that are designed to provide stakeholders with specific, practical advice. In many instances, the committee intentionally developed these implementation actions such that they take advantage of existing infrastructure and activities, and sometimes modify them in specific ways, to facilitate the implementation of the recommendations.

I. DRIVING TRANSPARENCY AND ACCOUNTABILITY

The legislative and executive branches of the federal government have the power to serve as drivers of transparency and accountability in the scientific, engineering, and medical enterprise. In Chapter 5, the committee found that transparency and accountability are critical levers for driving positive change in equity and diversity efforts. Therefore, the committee recommends several actions that can increase public transparency and accountability so that the nature, extent, and impact of federal agency and university efforts will ensure equity, diversity, inclusion, and equal opportunity in the scientific, engineering, and medical workforce. As explained, these recommendations, while focused primarily on driving transparency and accountability, also serve other functions. For example, if implemented with fidelity, these recommendations can serve to highlight the extent to which each federal agency is making equity, diversity, and inclusion efforts a priority, and shine a light on whether such programs are properly resourced. Further, the implementation of these recommendations may provide the government and universities with information on the impact of the

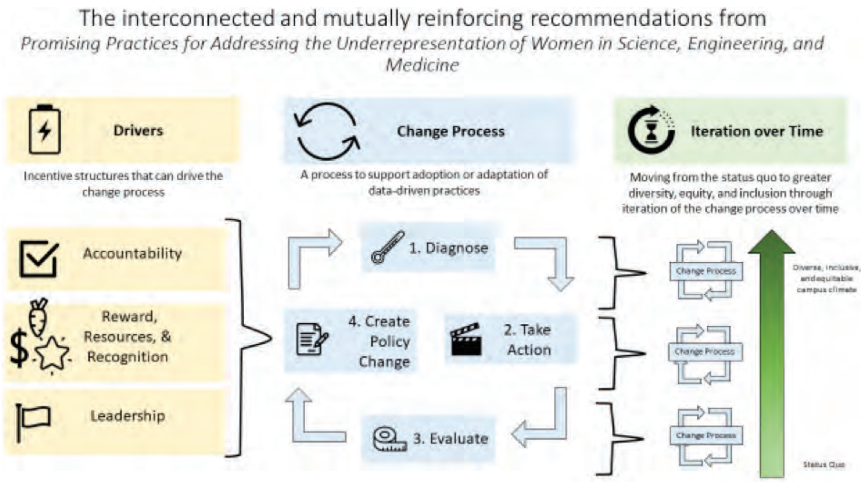

FIGURE 6-1 Improving the recruitment, retention, and advancement of women in STEMM will require systemic change driven through the actions of a range of stakeholders. The committee's recommendations are intended to support such systemic change through an interconnected process with three main components:

Drivers: Transparency and accountability; rewards, resources, and recognition; and committed leadership can provide positive and negative incentives that increase the likelihood that institutions will take action and adopt a change process. **Recommendations 1, 2, 6, 7, and 8** and their associated implementation actions are aimed at establishing such drivers.

Change Process: The process consists of four stages: (1) an institution, school, or department collects, analyzes, and monitors quantitative and qualitative data to first diagnose the particular issues they are having with recruitment, retention, and advancement of White women and women of color; (2) institutional leaders take action to address their shortcomings at the program, school, or department level by drawing upon the existing research and practice to adopt or adapt targeted, evidence-based approaches; (3) the institution, school, or department repeats the data collection and monitoring to determine whether the treatment has been effective or whether it is time to try a new approach; (4) leaders formally institutionalize effective practices through policy changes so they can sustain transitions in leadership, budget fluctuations, and other potential disruptors that could undermine the sustainability of the effort. **Recommendations 3, 4, and 5** and their associated implementation actions are intended to support this change process. **Recommendation 9**, which calls for future research to fill knowledge gaps, will also support this process by providing additional information on the efficacy of certain strategies and practices.

Iteration over Time: The goal of the change process outlined above is to move from the status quo, in which women, and particularly women of color, are underrepresented in STEMM, to a more diverse, equitable, and inclusive STEMM enterprise. To achieve this outcome will require institutions to invest in an iterative cycle of action and evaluation that supports the development and, ultimately, institutionalization of strategies and practices that will work within the particular context of the institution. All of the recommendations offered by the committee are intended to support iteration over time to reach the ultimate goal of greater equity, diversity, and inclusion in STEMM.

various efforts by the federal agencies and universities to support greater equity, diversity, and inclusion in science, engineering, and medicine such that more successful programs could be scaled and amplified, while less successful programs could be improved or replaced.

There is considerable debate as to whether new public policies have their intended positive impacts. The answer, of course, is that it depends. Some government policies help some people they intend to serve, but might hurt others. For example, there is evidence that minimum wage laws do, in fact, increase the average incomes of current low-wage workers in communities where the laws are enacted. But there is still considerable uncertainty as to whether minimum wage laws have a negative effect on the employment rate (Allegretto et al., 2018; Jardim et al., 2017). Based on its extensive experience in observing the consequences of government policies over the past half-century, the committee recognizes both the potential for good and the very real limitations of government policy to drive and sustain change. In that context, we see government policies as one vital part of a systemic strategy to catalyze and incentivize the kinds of changes needed to open the doors to more women in STEMM disciplines and STEMM careers. Even if government policies only remove a few barriers, rather than mandate actions and impact that may be sufficient to create pathways for change that conscientious leaders can use to implement effective strategies and practices. It is in that spirit that the following recommendations are offered.

Recommendation 1.
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.

Implementation Actions

Action 1-A. National Institutes of Health (NIH) and National Science Foundation (NSF) co-chairs of the Subcommittee on Safe and Inclusive Research Environments of the Joint Committee on the Research Environment should annually catalog, evaluate, and compare the various efforts by the federal science agencies to broadly support the recruitment, retention, and advancement of women in science, engineering, and medicine. The director should task the subcommittee with publishing an annual, open-access report, modeled after NSF's summary table on programs to broaden participation in their annual budget request to Congress, that documents existing programs at each agency, with a particular emphasis on those programs that take an intersectional approach, accounting for the experiences of women of color and women of other intersecting identities (e.g., women with disabilities, LGBTQIA), and the qualitative and quantitative impact of these programs, using program evaluation metrics and data, when collected.[1]

Action 1-B. Congress should commission a study by an independent entity, such as the Government Accountability Office, to offer an external evaluation and review of the existing federal programs focused on supporting greater equity, diversity, and inclusion in science, engineering, and medicine. Such a study should result in a publication that documents the nature, impact across various groups, and prioritization of these programs, as described above, across federal agencies.

Recommendation 2.
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.

Implementation Actions

Action 2-A. Federal funding agencies should carry out an "equity audit" for grantee institutions that have received a substantial amount of funding over a long period of time to ensure that the institution is working in good faith to address gender and racial disparities in recruitment, retention, and advancement. Institutions could be electronically flagged by the funding agency for an equity audit after a certain length of funding period is reached. An evaluation of the representation of women among leadership should be included in such an audit. Equity audits should include a statement from institutions to account for the particular institutional context, geography, resource limitations, and mission and hold that institution accountable within this context. It should also account for progress over time in improving the representation and experiences of underrepresented groups in science, engineering, and medicine and should indicate remedial or other planned actions to improve the findings of the audit. The equity audit should result in a public facing report that will be available on the agency's website.

Action 2-B. Federal agencies should consider institutional and individual researchers' efforts to support greater equity, diversity, and inclusion as part of the proposal compliance, review, and award process. To reduce additional administrative burdens, agencies should work within the existing proposal requirements to accomplish this goal. For example, NSF should revise the guidance to grantees on NSF's "Broader Impact" statements, and NIH should revise the guidance to grantees on the "Significance" section in the research plan to include an explicit

[1] The committee recognizes that programs will have different metrics of success, depending on what the goals of the program are and that direct comparison of programs across agencies will not be possible. However, the evaluation will examine the data collected on the outcomes of the programs included and the extent to which the program met its goals.

statement on efforts by the prospective grantee and/or institution to promote greater equity, diversity, and inclusion in science, engineering, and medicine. While many grantees currently describe equity, diversity, and inclusion efforts as part of these sections of NSF and NIH proposals, historically, these sections of the proposals have served, first and foremost, to document the societal impact of the research (e.g. addressing climate change, curing cancer). The latter function of these sections of the proposal is critical and should not be replaced by the description of equity, diversity, and inclusion efforts. Rather this section of the proposal should be expanded to include commentary on *both* of these critical components of federally funded research. Moreover, these sections of proposals should be assessed and taken seriously in funding recommendations by review panels and funding decisions by agency personnel. If such sections of proposals are given different consideration by different institutes, departments, and directorates, effort should be made to standardize the weight rating given to these sections of the proposal across the agency. For example, the National Science Board could carry out a review of past NSF awards to determine how the NSF Directorates have accounted for gender equity, diversity, and inclusion among the metrics evaluated in proposals submitted to NSF.

II. TARGETED, DATA-DRIVEN INTERVENTIONS BY COLLEGES AND UNIVERSITIES[2]

In many ways, the recommendations in this section (particularly the many sub-recommendations under Recommendation (4) represent the most direct action items of this report. These recommendations are based on the committee's analysis of years of research, data, and evidence on specific strategies and best practices that can improve the participation and advancement of women in science, engineering, and medicine.

The recommendations offered by the committee in this section also outline a change process. The process starts with an institution, school, or department collecting, analyzing, and monitoring quantitative and qualitative data to first diagnose the particular issues they are having with recruitment, retention, and advancement and then to take action to address their shortcomings by drawing upon the existing research and practice to adopt targeted, evidence-based solutions. The next step in the process is to repeat the data collection and monitoring to determine whether the treatment has been effective or whether it is time to try a new approach. The final step in the process is to formally institutionalize effective practices through policy changes so they can sustain transitions in leadership,

[2] Because there is a significant academic orientation to this report—with college and university administrators being a primary audience—the committee has configured recommendations targeted directly to higher education leaders. Many of the ideas and recommendations here, however, can be easily adopted or adapted by private sector employers and government agency employers that also aim to close the gender gap in science, engineering, and medical fields.

budget fluctuations, and other potential disruptors that could undermine the sustainability of the effort.

The committee recommends a change process, rather than a single blueprint for change since there is no one-size-fits-all approach that will work in every institutional context. Institutions vary in mission, student demographics, student needs, and resource constraints and a particular strategy may work well at one institution and not well at another. For this reason, the committee recommends that institutions work to adopt or adapt the strategies and practice outlined in this report (see implementation actions 5 A-C) and iterate over time to develop an approach that will work well for their particular institution and the people it serves.

Recommendation 3.
College and university deans and department chairs should annually collect, examine, and publish[3] 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 (see Recommendations 5 and 7 for guidance on specific strategies and practices leaders can adopt or adapt to address issues with recruitment, retention, and advancement, piloting and modifying them as appropriate, such that they are effective within the particular context of the institution).

Implementation Actions

Action 3-A. College and university deans and department chairs should collect and monitor department level demographic data, leveraging data already being collected by their institution in compliance with data reported to the Integrated Postsecondary Education Data System (IPEDS) annually to determine whether there are patterns of underrepresentation among students, trainees, residents, clinical fellows, faculty, and staff, including in leadership roles. Specifically, deans and department chairs should request the following types of data and track these data over time:

a. The demographic composition of the students currently enrolled and recently graduated in a given department or college. These data should be disaggregated by gender and race/ethnicity and should be tracked over time.
b. The longitudinal demographic composition of the faculty disaggregated by faculty rank, department, gender, and race/ethnicity.

[3] Except in cases for which reporting such data would publicly identify individuals and breach anonymity. For such data, the report should indicate that the numbers are "too low to report."

c. The longitudinal demographic composition of postdoctoral researchers, residents, clinical fellows, and staff scientists disaggregated by department, gender, and race/ethnicity.

This information should be used to adopt or adapt evidence-based promising and effective practices, taking into account the particular context of the institution (see Recommendation 5).

Recommendation 4.
College and university administrators should dedicate resources to carry out qualitative research on the climate in the school or department and the experiences of underrepresented groups and use this information to shape policies and practices aimed at promoting an inclusive climate and supporting underrepresented groups enrolled or employed at the institution.

Implementation Actions

Action 4-A. College and university administrators should work with an evaluator outside the relevant unit to support periodic climate research to assess the climate in the school or department in a manner that is methodologically sound, independent, objective, and free from bias and conflict of interest. Climate research can take the form of surveys, focus groups, and/or interviews.

Action 4-B. Given the extremely low representation of women of color in most science, engineering, and medical fields, administrators and external evaluators should work together to adopt a methodological approach that can protect the anonymity of such individuals and accurately capture their experiences. In some instances, interviews may serve as the most appropriate means to gather this information. It should be noted that, in some settings, researchers from a single institution may not be able to sufficiently protect the anonymity of women of color, who make up an extreme minority in certain fields, and so it may be best to conduct such research across an institutional system. Protecting sensitive, personal information will also be aided by the use of an external consultant that can hold the raw data and report only aggregated findings to the departmental leadership.

Recommendation 5.
Taking into account the institutional context, college and university presidents, deans, department chairs, and other administrators should adopt or adapt the actionable, evidence-based strategies and practices (see implementation actions 5 A-C) that directly address particular gender gaps in recruitment, retention, and advancement of women in science, engineering, and medicine within their institution, as observed by quantitative and qualitative data analysis and monitoring (see Recommendations 3 and 4 above).

Implementation Actions

Action 5-A. To work to improve the recruitment and retention of women in STEMM education, faculty and administrators in higher education and K-12 education should adopt the following approaches:

a. Reorganize STEMM courses to incorporate *active learning exercises* (e.g., having students work in groups, use clickers) and integrated peer-led team learning.
b. Promote a growth mindset by communicating to students that ability in STEMM fields can be improved by learning.
c. Challenge stereotypical assumptions about the nature of STEMM careers by communicating to students that scientists often work in teams, conduct research focused on helping others, and have lives outside of work.
d. Take steps to expose students to a diverse set of role models in STEMM that challenge the persistent societal stereotype that STEMM professionals are heterosexual, cis-gendered, White, men. For example, faculty and administrators should give assignments that require students to learn about the work of women who have made significant contributions to the field; work to ensure that the faculty in the department are diverse, such that students take courses and conduct research with people from a range of different demographic groups; and invest in educational materials (e.g., textbooks and other instructional media) that highlight the diverse range of people who have contributed to science, engineering, and medicine.
e. Strive for gender-balanced classroom and group composition and take steps to promote equitable classroom interactions.

Action 5-B.[4] To address issues with the recruitment of women into academic programs and science, engineering, and medical careers, admissions officers, human resources offices, and hiring committees should:

a. Work continuously to identify promising candidates from underrepresented groups and expand the networks from which candidates are drawn.
b. Write job advertisements and program descriptions in ways that appeal to a broad applicant pool and use a range of media outlets and forms to advertise these opportunities broadly.
c. Interrogate the requirements and metrics against which applicants will be judged to identify and either eliminate or lessen the emphasis given to those that are particularly subject to bias and may also be poor predictors of success (e.g., certain standardized test scores).

[4] See Chapter 4.

d. Decide on the relative weight and priority of different admissions or employment criteria *before* interviewing candidates or applicants.
e. Hold those responsible for admissions and hiring decisions accountable for outcomes at every stage of the application and selection process.
f. Educate evaluators to be mindful of the childcare and family leave responsibilities often faced by women, especially when considering “gaps” in a resume.
g. When possible, use structured interviews in admission and hiring decisions.
h. Educate hiring and admissions officials about biases and strategies to mitigate them.
i. Increase stipends and salaries for graduate students, postdocs, nontenure track faculty, and others to ensure all trainees and employees are paid a living wage.

Action 5-C.[5] To address issues with retention of women in academic programs and within science, engineering, and medical careers, university and college administrators should:

a. Ensure that there is fair and equitable access to resources for all employees and students.
b. Take action to broadly and clearly communicate about the institutional resources that are available to students and employees and be transparent about how these resources are allocated.
c. Revise policies and resources to reflect the diverse personal life needs of employees and students at different stages of their education and careers and advertise these policies and resources so that all are aware of and can readily access them.
d. Create programs and educational opportunities that encourage an inclusive and respectful environment free of sexual harassment, including gender harassment.
e. Set and widely share standards of behavior, including sanctions for disrespect, incivility, and harassment. These standards should include a range of disciplinary actions that correspond to the severity and frequency for perpetrators who have violated these standards.
f. Create policies that support employees during times when family and personal life demands are heightened—especially for raising young children and caring for elderly parents. For example, stop-the-clock and modified duty policies, which should be available to as wide a group as possible, should be a genuine time-out from work and should not penalize those who take advantage of the policies.

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[5] See Chapter 4.

g. Provide private space with appropriate equipment for parents to feed infants and (if needed) to express and store milk.
h. Create policies and practices that address workers' need to balance work and family roles (including not only child and family care but also responsibilities for attending to children's school and extracurricular activities).
i. Limit department meetings and functions to specified working hours that are consistent with family-friendly workplace expectations.

Action 5-D. In order to be effective mentors and to create more effective mentorship relationships, faculty and staff should recognize that identities influence academic and career development and thus are relevant for effective mentorship. As such:

a. Institutional leadership should intentionally support mentorship initiatives that recognize, respond to, value, and build on the power of diversity. Leaders should intentionally create cultures of inclusive excellence to improve the quality and relevance of the STEMM enterprise.
b. 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 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.
c. Mentees should reflect on and acknowledge the influence of their identities on their academic and career trajectory and should seek mentorship that is intentional in considering their individual lived experiences.

Action 5-E. Institutional leaders, as well as individual faculty and staff, should support policies, procedures, and other infrastructure that allow mentees to engage in mentoring relationships with multiple individuals within and outside of their home department, program, or institution, such as professional societies, external conferences, learning communities, and online networks, with the ultimate goal of providing more comprehensive mentorship support.

Action 5-F. Colleges and universities should provide direct and visible support for targets of sexual harassment. Presidents, provosts, deans, and department chairs should convey that reporting sexual harassment is an honorable and courageous action. Regardless of a target filing a formal report, academic institutions should provide means of accessing support services (social services, health care, legal, career/professional). They should provide alternative and less formal means of recording information about the experience and reporting the experience if the target is not comfortable filing a formal report. Academic institutions should develop approaches to prevent the target from experiencing or fearing retaliation in academic settings.

Action 5-G. Colleges and universities should create "counterspaces"[6] on their campuses that provide a sense of belonging and support for women of color and serve as havens from isolation and microaggressions. Such counterspaces can operate within the context of peer-to-peer relationships; mentoring relationships; national STEMM diversity conferences; campus student groups; and science, engineering, and medical departments. Counterspaces can be physical spaces, as well as conceptual and ideological spaces.

Recommendation 6.
Federal agencies should support efforts and research targeted at addressing different profiles of underrepresentation in particular scientific, engineering, and medical disciplines throughout the educational and career life course.

Implementation Actions

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 (ENG), Computer and Information Science and Engineering (CISE), and Mathematical and Physical Sciences (MPS) to set aside funding and work collaboratively with the Education and Human Resources Directorate to support education grants that address the following:

a. 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:
    i. those that incorporate growth mindset interventions that impress upon students that skills and intelligence are not fixed, but, rather, are increased by learning;
    ii. those that highlight that scientists and engineers are well positioned and equipped to do work that has a positive societal impact; and
    iii. those that highlight the contributions of a diverse array of people to the scientific, engineering, and medical enterprise today and throughout history.

[6] Researchers have defined counterspaces to be: "academic and social safe spaces that allow underrepresented students to: promote their own learning wherein their experiences are validated and viewed as critical knowledge; vent frustrations by sharing stories of isolation, microaggressions, and/or overt discrimination; and challenge deficit notions of people of color (and other marginalized groups) and establish and maintain a positive collegiate racial climate for themselves" (Solórzano et al., 2000; Solórzano and Villalpando, 1998).

b. 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, Dartmouth, Carnegie Mellon).
c. 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.

Action 6-B. Across all science, engineering, and medical disciplines, federal agencies should:

a. Address funding disparities for women researchers, particularly for women of color. For example, NIH should address disparities in success rates of Type 1 R01 awards for African American women compared to White women;
b. Directly (e.g., through supplements) and indirectly (e.g., through specific programs) support the work-life integration needs of women (and men) in science, engineering, and medicine; and
c. In addition to programs designed to support mentorship, support investigation into the impact of sponsorship on the advancement of both White women and women of color into leadership roles in science, engineering, and medicine.

III. PRIORITIZE, RECOGNIZE, REWARD, AND RESOURCE

The recommendations the committee offers here advise institutions, both academic and governmental, to sustainably allocating resources and authority to the leaders of equity, diversity, and inclusion efforts, while providing positive incentives for faculty—in the context of promotions and rewards and recognition by honorific and professional societies—that could pave the way toward culture change yielding broader recognition 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.

Implementation Actions

Action 7-A. University administrators should institutionalize effective policies and practices so that they can sustain transitions in leadership by, for example, writing them into the standing budget and creating permanent diversity, equity, and inclusion-related positions.

Action 7-B. University and college administrators should appropriately compensate and recognize individuals responsible for equity and diversity oversight and equip them with sufficient resources and authority.

Action 7-C. Academic senates of universities should adopt amendments to faculty-review committee criteria that formally recognize, support, and reward efforts toward increasing diversity and creating safe and inclusive research environments. Adopting this criteria sets the expectation that promoting inclusivity is everyone's responsibility and encourages faculty involvement in university diversity initiatives. Formal recognition of efforts to promote equity, diversity, and inclusion should include consideration of effective mentoring, teaching, and service during hiring decisions, in determining faculty time allocations, and in decisions on advancement in rank, including tenure decisions.

Action 7-D. Professional and honorific societies should:

a. Create special awards and honors that recognize individuals who have been leaders in driving positive change toward a more diverse, equitable, and inclusive scientific, engineering, and/or medical workforce;
b. Monitor the diversity of nominees and elected members in the society over time; and
c. Adopt policies that discourage panels of speakers composed entirely of a single demographic group (e.g., all White men) at meetings.

Recommendation 8.
Federal agencies and private foundations should work collaboratively to recognize and celebrate colleges and universities that are working to improve gender equity.

Implementation Actions

Action 8-A. NIH and NSF should collaborate to develop a recognition program that provides positive incentives to STEMM departments and programs on campuses to make diversity, equity, and inclusion efforts a high priority. Departments and programs would compete to be recognized for their successes in closing the gender gaps in STEMM. Such a program would include multiple rounds: the first to allow departments and programs to develop plans to self-assess their progress and plans toward the goal; the second to create and implement new programs and practices; and the third to show improvement from the original evaluation. In order for institutions to compete equitably for this recognition, departments and programs that apply should compete against similar institutions. For instance, departments and programs that apply could compete only against others within institutions with the same Carnegie Classification as their own. After the initial exploration of this model by NIH and NSF, other federal agencies could be encouraged to adopt a similar model.

Action 8-B. Federal agencies should provide financial assistance to institutions that would like to be recognized for their efforts to improve diversity, equity, and inclusion. These grants would support the resource-intensive data collection that is required to compete for these awards, which, for example, in the UK often falls to women, and would be granted on a needs-based justification, with priority given to under-resourced universities.

Action 8-C. Private foundations should require that awardee institutions complete a self-evaluation of themselves, specific to the departmental policies, similar to the New York Stem Cell Foundation's Initiative on Women in Science and Engineering, which required institutions to complete a gender equity report card before receiving funding. In order to continue receiving funding from these private foundations, departments must show improvements, or plans to make improvements, in improving gender equity in their departments.

IV. FILLING KNOWLEDGE GAPS

Although the recommendations offered by the committee speak to the fact that there is much that leaders and employees at academic institutions and in the government can do immediately to promote positive change that is more broadly experienced by women in science, engineering, and medicine, there are critical knowledge gaps that must be filled, with deliberate speed, to support most effectively the improved recruitment, retention, and advancement of all women in science, engineering, and medicine.

Recommendation 9.
Although scholarly research on gender disparities in science, engineering, and medicine has yielded an abundance of information that can be applied toward reaching gender equity, there are critical knowledge gaps remain and require very close attention. These include:

a. **Intersectional experiences of women of color, women with disabilities, LGBTQIA women, and women of other intersecting identities (e.g., age).**
b. **Strategies and practices that can support the improved recruitment, retention, and advancement of women of color and women of other intersecting identities.**

c. **Factors contributing to the disproportionate benefit accruing to White women of practices adopted to achieve gender equity.**
d. **Specific factors contributing to successes and failures of institutions that have adopted policies and/or implemented programs aimed at diversifying the science, engineering, and medical workforce.**
e. **Long-term evaluation of the promising practices listed in the report, specifically, how their sustained implementation impacts the recruitment, retention, and advancement of women over time.**
f. **Strategies and practices that have proven most effective in supporting STEMM women faculty and students in nonresearch intensive institutions, such as community colleges.**
g. **Characteristics of effective male allies and approaches to training allies.**

BOX 6-1
Addressing the Need for Systemic Change in Higher Education and Academic Research: Themes from Three Recent National Academies Reports

Since 2018, the National Academies of Sciences, Engineering, and Medicine released four consensus reports that have taken a systemic approach in addressing key issues in higher education and academic research: *Graduate STEM Education for the 21st Century* (NASEM, 2018a); *Sexual Harassment of Women: Climate, Culture, and Consequences in Academic Sciences, Engineering, and Medicine* (NASEM, 2018b); *The Science of Effective Mentorship in STEMM* (NASEM, 2019b); and *Minority Serving Institutions: America's Underutilized Resource for Strengthening the STEM Workforce* (NASEM, 2019a). Each of the committees created reports that situated the issue of interest (graduate education, sexual harassment of women, mentoring, and minority-serving institutions) within the broader culture of higher education, as the committees saw campus environments and incentive and reward systems in academic research as critical drivers of behavior.[a]

While the four reports have varied in the degree to which they focus on gender, each of these reports has included findings or recommendations to key stakeholders in the higher education system that affect women. Below are summaries of four themes shared across the previous reports, as well as additional recommendations or findings related to the work of the Committee on Increasing the Number of Women in STEMM. Each theme provides a high-level summary of the findings and recommendations, and the full text of each report is available for download at NAP.edu.

Theme I: Provide Diverse, Equitable, Inclusive, and Respectful Environments

Research, training, and education environments affect their participants. When individuals operate in diverse, equitable, inclusive, and respectful environments, all individuals stand to benefit from the effects. Additionally, environments that are respectful and civil are associated with lower rates of sexual harassment. For many disciplines and programs where women have been historically underrepresented in STEMM, recruiting women to universities as students, faculty, or in other leadership roles is an important part of the strategy. From there, developing environments that support women can help increase persistence rates and eliminate male dominated environments, which the report *The Sexual Harassment of Women* states can reduce the likelihood that sexual harassment will occur. Leaders play a significant role in creating these diverse, equitable, inclusive, and respectful environments and *The Sexual Harassment of Women* report calls on leaders to take explicit steps to achieve greater gender and racial equity in hiring and promotion, and to foster greater cooperation, respectful work behavior, and professionalism. It also states that there is a role for all individuals to play

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[a] The reports *Graduate STEM Education for the 21st Century,* and *Minority Serving Institutions: America's Underutilized Resource for Strengthening the STEM Workforce* did not include academic medicine in its charge. *The Sexual Harassment of Women* and *The Science of Effective Mentorship in STEMM* included medical training in addition to science, technology, engineering, and mathematics.

in creating inclusive, civil, and respectful environments that prevent and address sexual harassment.

In *The Sexual Harassment of Women*, the report states that the experiences of sexual harassment undermine the professional and education attainment of those who experience it as well as their physical and mental health. These negative effects cause harm not only to those who experience the harassment but also to bystanders and the report states that the cumulative effects of such hostile environments and sexual harassment damages the integrity of research and reduces the talent pool within the STEMM fields.

In part of providing a sound environment for women, *The Sexual Harassment of Women* and *The Science of Effective Mentoring in STEMM* identify the importance of recognizing and providing support for women of color. From the report *The Sexual Harassment of Women*, one finding stated: “For women of color, preliminary research shows that when the sexual harassment occurs simultaneously with other types of harassment (i.e., racial harassment), the experiences can have more severe consequences for them.” Recognizing the impact of intersecting marginalized identities appeared in relationship to mentoring as well—a recommendation from *The Science of Effective Mentorship in STEMM* calls for the recognition of and response to identities in mentorship. Here, the use of identities as a plural can be applied to the challenges faced by women of color in STEMM, who hold layered experiences based on their gender, race or ethnicity, and other experiences.

The *Minority Serving Institutions* report states that while true of all higher education institutions organizational cultures play an especially significant role in promoting student success at minority serving institutions. Many highly academically qualified minority students who could attend more selective institutions report that they attend MSIs for their supportive and inclusive environments. The report notes that a crucial aspect of establishing and maintaining a supportive climate is building an equity-oriented culture that promotes equitable educational engagement, participation, and success. The report tasks institutional leadership with laying the foundation for this culture and promoting communication among students, faculty, staff, and administration that can create and support a sense of belonging for students on campus.

Related Findings and Recommendations

- *Graduate STEM Education for the 21st Century:* Recommendation 3.5
- *The Sexual Harassment of Women:* Findings 4.1, 4.4, 4.6, 4.11, 6.2, and 6.3 and Recommendations 1, 4, 7, and 15
- *The Science of Effective Mentorship in STEMM***:** Recommendation 4
- *Minority Serving Institutions: America’s Underutilized Resource for Strengthening the STEM Workforce***:** Finding 5.2, Recommendation 1

Theme II: Provide Transparent Incentive, Reward, and Accountability Structures

In addition to promoting values, three reports note that the system of higher education and individual institutions should ensure that incentive, reward, and accountability structures align and support those values. These structures are key components to driving behavioral change at the individual level, which can have strong effects on the relationships that women have as students, faculty, administrators, mentors, and leaders. In the university structure, the report *The Science of Effective Mentoring in STEMM*, which has a focus on inclusive and diverse mentoring, recommends the documentation and inclusion of effective mentoring as part of the reward structure for recruitment, hiring, promotion, advancement, and incentivized through awards.

The report *Graduate STEM Education for the 21st Century* notes the need for the stakeholders that hold power through funding and professional prestige (e.g. federal and state agencies, private funders, professional societies, and other nongovernmental organizations) to include diversity and inclusion metrics in their criteria. In terms of funding specifically, the report calls for creating both incentive and accountability measures through adapted policies and reporting mechanisms that take diversity, equity, and inclusion into account.

In addition to these broad mandates, the report on *The Sexual Harassment of Women* notes that environments that are perceived to tolerate sexual harassment can have significant, negative effects. In *The Sexual Harassment of Women*, the report states that environments where people (1) perceive reporting as risky, (2) believe they will not be taken seriously if they report, and (3) perceive that perpetrators escape sanctions will have a greater likelihood of sexual harassment behaviors occurring. As a result, the report finds that transparency and accountability are crucial elements to addressing and preventing sexual harassment and recommends institutions set expectations of behaviors up front and have clear policies that include a range of escalating disciplinary consequences if it is violated. Additionally, balancing transparency and confidentiality, academic institutions should demonstrate that an institution is taking people seriously when they come forward and holding people accountable.

Related Findings and Recommendations

- *Graduate STEM Education for the 21st Century:* Recommendations 3.1 and 3.5
- *The Sexual Harassment of Women:* Finding 2.8, 2.9, 6.5, 6.7, Recommendations 4, 13, and 14
- *The Science of Effective Mentorship in STEMM***:** Recommendation 6

Theme III: Support Additional Data Collection and Research

Related to accountability structures, each of the reports recommend systems of collecting data at the national level and the institutional level to understand the state of the problem. 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 used as 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. The reports also call for the support of research to deepen the evidence base for programs, policies, and practices to improve graduate education, mentorship, ways to address and prevent sexual harassment, and the measurement of social and economic returns on investment of higher education.

Related Findings and Recommendations

- *Graduate STEM Education for the 21st Century:* Recommendations 3.1, 3.2, and 3.7
- *The Sexual Harassment of Women:* Recommendations 4, 8, 11, and 14
- *The Science of Effective Mentorship in STEMM:* Recommendations 8 and 9
- *Minority Serving Institutions: America's Underutilized Resource for Strengthening the STEM Workforce:* Finding 4.4

Theme IV: Address Hierarchical Structures that Create Strong Power Differentials

The system of higher education operates in a hierarchical power structure. Administrators and leadership can make decisions that affect faculty, faculty can make decisions that affect post-doctoral researchers and students. In a hierarchical system, many relationships will have an imbalance of power where the individual with higher status can directly and/or indirectly affect the educational and professional trajectory of another individual. But in situations with particularly strong power differentials – like between advisors and trainees and postdoctoral researchers and their supervisors - the individual of lower status feels undue pressure to, for instance, work longer hours, not speak up when they feel harmed or insulted, to agree to do something they do not want to do, or otherwise behave in a way to ensure that she does not lose status with the higher status individual. While there might be situations in which an individual of lower status experiences direct coercive behavior from the higher status individual, the mere presence of the strong power imbalance can pressure individuals to cooperate or act in fear of retaliation.

For mentoring, all four reports make recommendations encourage multiple mentors. Notably in the relationship between a graduate student or trainees with a research advisor, the broader network of mentors, advisors, and other forms of support provides the graduate student with other channels for information, support, and professional development. The *Minority Serving Institutions* report highlights that mentoring is particularly effective for students of color. Many students from these institutions reported that faculty mentors were considered "sponsors" who not only advised students, but actively advocated on their behalf in ways that advanced their careers. The *Minority Serving Institutions* report recommends that institutional leadership develop strategies to establish or improve effective mentorship and sponsorship of students.

The Sexual Harassment of Women provides an additional recommendation around providing alternative funding options directly to the student or trainee and departmental funding to avoid situations in which a student or trainee depends on a single principal investigator for funding.

Related Findings and Recommendations

- *Graduate STEM Education for the 21st Century:* Recommendation 3.2
- *The Sexual Harassment of Women:* Finding 6.4 and Recommendation 5
- *The Science of Effective Mentorship in STEMM:* Recommendation 5
- *Minority Serving Institutions: America's Underutilized Resource for Strengthening the STEM Workforce:* Finding 5.2, Recommendation 1, and Recommendation 2

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APPENDIX A

Intervention	Level	Goal	Outcome (s)	Tested in STEMM field?	Citation
Bias literacy (Video Interventions for Diversity in STEM; VIDS)	Individual level (behavioral intentions)	Recruitment	Reported behavioral intentions to recruit and mentor female students	Yes – Faculty across science departments	(Moss-Racusin et al., 2018)
Bias literacy workshop (faculty recruitment workshop; FRW)	Individual level (attitudes and behavioral intentions)	Recruitment	Positive attitudes toward equitable search strategies from workshop attendees, intentions to use equitable strategies during search	Not specifically, faculty across all departments	(Sekaquaptewa et al., 2019)
Changing STEM classroom environments	Individual level (changing students' individual level beliefs about computer science	Recruitment	Reported interest in computer	Yes – Computer science	(Cheryan et al., 2009; Cheryan et al., 2011b)
Description of STEM male or female potential mentor (using communal words in ads)	Individual level (interest in working with a STEM mentor)	Recruitment	Reported interest in working with STEM mentor	Yes – Across STEM majors	(Fuesting and Diekman, 2017)
Describing STEM jobs with communal of feminine words	Individual level (interest in working at job)	Recruitment	Reported interest at working at jobs	No – Female students generally (not specifically STEM majors)	(Gaucher et al., 2011)
Describing biomedical research as fulfilling communal/helping goals	Individual level (career motivation)	Recruitment	Reported motivation to pursue a career in biomedical sciences	No – Male and female students generally (not specifically STEM majors)	(Brown et al., 2015)
Having a female scientist describe career as fulfilling communal goals (helping others working with others)	Individual level (interest in STEM)	Recruitment	Reported interest in STEM careers	No – Female students generally (both college students and adolescent girls)	(Diekman et al., 2011; Weisgram and Bigler, 2006)

Presenting students with female scientist role models	Individual level (career motivation)	Recruitment/ retention	Reported intentions to pursue a career in engineering	Yes – Female college engineering majors	(Stout et al., 2011)
Writing about favorite role models	Individual level (sense of fit in STEM)	Recruitment	Reported sense of fit in the sciences	No – Female middle school students attending a science summer camp	(O'Brien et al., 2017)
Having Black female or male scientist in recruitment materials (i.e., on a school or company's website)	Individual level (anticipated belonging)	Recruitment	Anticipated belonging at company/or school	Yes – Black women across STEM majors	(Johnson et al., 2019; Pietri, 2018a)
Watching women scientists in television shows	Individual level	Recruitment	Majoring in STEM, and entering a STEM career (participants respectively reported whether they watched the *X-files* with Agent Scully)	Yes – Women currently working in STEM fields	(Geena Davis Institute on Gender in Media, 2018; Steinke et al., 2009)
Having a STEM graduate program emphasis that men and women work hard for success in the program	Individual level (reported interest)	Recruitment	Reported interest in graduate program	Yes – Female students generally, and female STEM graduate students	(Smith et al., 2012)
Teaching female students that intelligence is malleable and can improve	Individual level (career motivation, grades in Math)	Recruitment	Higher career motivations in math, higher grades in math	No – Female middle school students	(Blackwell et al., 2007; Good et al., 2003)
Bias literacy workshop (WISELI)	Individual level behavior	Retention	Self-reported actions to promote equity in department (when > 25% of department attended)	Yes – Departments in medicine, science, and engineering	(Carnes et al., 2015)
Ensuring Black female students have Black woman role models	Individual level (reported belonging)	Retention	Reported belonging in STEM	Yes – Black female students across STEM majors	(Johnson et al., 2019)

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Intervention	Level	Goal	Outcome (s)	Tested in STEMM field?	Citation
Having multiple allies in a STEM environment	Individual level (reported belonging)	Retention	Reported belonging in STEM	Yes – Black female STEM majors	(Johnson et al., 2019)
Values affirmation–having women write about a valued aspect of their identity	Individual level (grades and attitudes toward major)	Retention	Higher grades and positive attitudes toward engineering major/grades in a physics class	Yes – Female engineering majors/female students enrolled in a physics class	(Miyake et al., 2010; Walton et al., 2015)
Exposure to counter-stereotypical exemplars (female leaders)	Individual level beliefs	Advancement	Women-leadership IAT	No (student samples)	(Dasgupta and Asgari, 2004)
Imagine contact (imagining a strong capable leader)	Individual level beliefs	Advancement	Women-strength IAT	No (student samples)	(Blair et al., 2001)
Bias literacy workshop	Individual level beliefs	Advancement	Women-leadership IAT	Yes – Medicine faculty	(Girod et al., 2016)
Bias literacy training (incorporated into week long workshop on improving STEM education)	Relational/groups levels (STEM instructors' beliefs about STEM courses)	Recruitment	Reported valuing of diversity in STEM classes	Yes – STEM instructors across fields	(Moss-Racusin et al., 2016)
Bias literacy workshop (interactive theater GEAR UP workshop)	Group level behavior (search committees)	Recruitment	Search committees engaged in positive behavior	Yes – Across all departments, with a focus on STEM	(Shea, 2019)
Lab environments that promote perceptions that STEM is communal	Relational/groups level (research mentors and lab environments)	Recruitment	Reported interest and career motivation in STEM	Yes – Male and female research assistants across STEM laboratories	(Allen et al., 2018; Thoman et al., 2017)

STEM instructors with a growth mindset	Relational/groups level (STEM instructors and STEM classes)	Recruitment	Interest in STEM career, motivation in classes, and grades in STEM courses	Yes – Male and female students in STEM classes	(Canning et al., 2019; Fuesting et al., 2019; Rattan et al., 2012)
Incorporating service learning projects into STEM courses	Groups level (structuring STEM classes)	Recruitment	Interest in taking a STEM course	No – Male and female college students' interest in taking an engineering class	(Belanger et al., 2017)
Peer Led Team Learning in introductory to computer science courses	Relationship/groups level (structuring STEM classes)	Recruitment/ retention	Entering and persisting in computer science major, higher grades in computer science	Yes – female students in computer science	(Horwitz et al., 2009)
Having a female mentor	Relational (having female peer mentors)	Recruitment/ retention	Reported belonging and self-efficacy, and interest in engineering career	Yes – female engineering majors	(Dennehy and Dasgupta, 2017)
Egalitarian norms intervention	Groups level (STEM classes)	Recruitment/ retention	Higher valuing of diversity and intentions to confront bias	Yes – White male students in introductory engineering course	(Bennett and Sekaquaptewa, 2014)
Having positive mentor relationships (or fostering positive mentor relationships) for female college students	Relational level (the importance of mentor relationships)	Retention	Remaining in engineering majors/reported interest in major	Yes – Female engineering majors/female STEM majors generally	(Downing et al., 2005; Marra et al., 2009)
Culturally aware mentor training	Relational (improving mentoring relationships)	Retention	Reported improved mentoring behaviors	Yes – clinical and translational researchers	(Pfund et al., 2013; Pfund et al., 2015)
Integrating active learning in STEM courses	Relationship/groups level (structuring STEM classes)	Retention	Persisting in computer science major		(Latulipe et al., 2018)

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Intervention	Level	Goal	Outcome (s)	Tested in STEMM field?	Citation
Having female majority activity groups in STEM classes	Relationship/ groups level (group composition)	Retention	Higher reported interest in STEM careers	Yes – Female engineering majors	(Dasgupta et al., 2015)
Having students watch a video of students behaving counter-stereotypically in project teams	Relationship/groups level (student group intervention	Retention	Resulted in women and men contributing equal amounts in group work (rather than men speaking more than women)	Yes – Students in STEM project teams	(Lewis et al., 2019)
Research experiences in college	Relationship/groups level (research mentors)	Retention/ advancement	Persisting in biology major, graduating with biology degree, and earn higher grades in biology major.	Yes – Male and female students who reported an interest in majoring in biology	(Jones et al., 2010a)
Mentor relationships for STEM female faculty	Relational level (positive mentor relationships)	Advancement	Helping build connections with regard to research and teaching (i.e., aspects of the job that help with promotion)	Yes – Female faculty across the sciences	(Misra et al., 2017)
Having a sponsor to promote women for leadership positions and prestigious awards	Relationship/groups (sponsor relationships)	Advancement	More advancement opportunities	No – Multiple review papers suggest sponsorship should be utilized in STEM	(Hewlett et al., 2010; Huston et al., 2019; Serbin, 2018)
Bias literacy workshop (WISELI)	Organizational level hiring	Recruitment	Increased hiring of women in STEMM departments by 18%	Yes – Departments in medicine, science, and engineering	(Devine et al., 2017)
Bias literacy workshop (faculty recruitment workshop; FRW)	Organizational level norms	Recruitment	Positive attitudes toward equitable search strategies among department mentors who did not attend workshop (when a higher % of departmental faculty attended)	No – Faculty across all departments	(Sekaquaptewa et al., 2019)

Bias literacy workshop (interactive theater GEAR UP workshop)	Organizational Level (hiring))	Recruitment	% women hired in STEM departments went from 40% to 63.6%	Yes – Across all departments, with a focus on STEM	(Shea, 2019)
TRACS training for faculty search committees (relied on self-determination theory)	Organizational Level (hiring)	Recruitment	Compared to control searches, searches in intervention were 6.3 times more likely to make an offer to a woman, and women were 5.8 times more likely to accept	Yes – Across STEM departments	(Smith et al., 2015)
Bias literacy workshop (WISELI)	Organizational level (climate)	Retention	Fit perceptions in department, comfort in raising personal/professional conflict in department	Yes – Departments in medicine, science, and engineering	(Carnes et al., 2015)
Presence of gender-inclusive policies	Organizational level (climate)	Retention	More positive cross-gender conversations and lower social identity threat	Yes – Working engineers	(Hall et al., 2018)
Project TRACS dedicated grant support staff, family advocate, equity advocates	Organizational level (climate)	Retention	Increased autonomy, competence, relatedness, and job satisfaction	Yes – STEM and non-STEM faculty	(Smith et al., 2018)
TRACS grant-writing boot camp	Organizational level (climate)	Retention/ Advancement	Higher likelihood of submitting and receiving a grant	Yes – Female STEM faculty	(Smith et al., 2018)

APPENDIX B

Relevant Findings and Recommendations from National Academies of Sciences, Engineering, and Medicine Reports

Numerous National Academies reports and workshops have addressed the topic of the underrepresentation of women in STEMM over the last 20 years. The findings, recommendations, and suggestions raised in many of these consensus reports and workshop summaries align closely with findings and recommendations in this report. Although the primary audience for most of the recommendations is academia, a good number are also directed to federal agencies, Congress, and foundations.

From Scarcity to Visibility: Gender Differences in the Careers of Doctoral Scientists and Engineers (NRC, 2001)

Issue	Select Relevant Finding or Recommendation
Family-Friendly Policies	**Finding:** Marriage and family are the most important factors differentiating the labor force participation of male and female scientists and engineers. Single men and single women participate equally in the workforce. Marriage and children are associated with increased rates of full-time employment for men, but declining rates for women.
Hiring, Promotion, and Tenure	**Finding:** Career interruptions matter to the chance that a person will achieve tenure track status. Women with interruptions before receiving the Ph.D. are more likely to become faculty, while this variable has the opposite effect for men
Gaps in Resources	**Finding:** Differences remain in the ways that men and women fund their education making it more likely that men are launched into research careers. Men are more likely to receive funding through research assistantships. Women are more likely than men to fund their graduate work by holding teaching assistantships in the physical sciences, mathematical sciences, and engineering—fields in which they are least well represented.

To Recruit and Advance: Women Students and Faculty in Science and Engineering (NRC, 2006)

Issue	Select Relevant Finding or Recommendation
Changing Culture	**Recommendation:** Create and institutionalize a pervasive inclusiveness mandate on campus, with buy-in from the highest levels of the administration, and then dedicate resources to that mandate.
Data Needs	**Recommendation:** Conduct periodic university studies of various issues affecting women, such as tenure process, salary equity, or climate.
Family-Friendly Policies	**Recommendation:** Improve institutional policies and practices such as the tenure clock, child care, leave, spousal hiring, and training to combat harassment.
Hiring, Promotion, and Tenure	**Recommendation:** Modify and expand faculty recruiting programs by creating special faculty lines, diversifying search committees, encouraging intervention by deans, and assessing past hiring efforts
Mentoring	**Recommendation:** Create mentoring programs for students and female faculty
Education	**Recommendation:** Extend outreach to potential students at both the K-12 and undergraduate levels. Such outreach might take the form of summer science and engineering camps, lecture series, career days, collaborative research projects, and support for K-12 teachers.

Biological, Social, and Organizational Components of Success for Women in Academic Science and Engineering: Report of a Workshop (NAS, NAE, and IOM, 2006)

Issue	Comments or Suggestions from Workshop Participants
Addressing Bias	**Participant Suggestion:** Using new metaphors and descriptions to discuss bias, in particular calling bias or stereotyping unexamined places the responsibility on the person who holds or acts on the bias or stereotype.
Family-Friendly Policies	**Participant Suggestion:** Establishing flexible-time policies such as family leave, flex time, part-time tenure, and temporary stoppage of the tenure-clock; and, just as importantly, an atmosphere that allows faculty members to take advantage of these policies without fearing damage to their careers.
Hiring, Promotion, and Tenure	**Participant Suggestion:** Restructuring hiring and promotion procedures to reduce bias and encourage diversity, particularly the training of search committees, deans, and department chairs to recognize and reduce bias in hiring, evaluation and promotion.
Mentoring	**Participant Suggestion:** Establishing programs to provide mentoring and support to women and other underrepresented groups.

Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering (NAS, NAE, and IOM, 2007)

Issue	Select Relevant Finding or Recommendation
Addressing Bias	**Finding:** A substantial body of evidence establishes that most people—men and women—hold implicit biases. **Recommendation:** University leaders should incorporate into campus strategic plans goals of counteracting bias against women in hiring, promotion, and treatment. **Recommendation:** University leaders should as part of their mandatory overall management efforts hold leadership workshops for deans, department heads, search committee chairs, and other faculty with personnel management responsibilities that include an integrated component on diversity and strategies to overcome bias and gender schemas and strategies for encouraging fair treatment of all people. **Recommendation:** Deans, department chairs, and their tenured faculty should develop and implement programs that educate all faculty members and students in their departments on unexamined bias and effective evaluation. **Recommendation:** Federal funding agencies and foundations should ensure that their practices—including rules and regulations—support the full participation of women and do not reinforce a culture that fundamentally discriminates against women. All research funding agencies should provide workshops to minimize gender bias.

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Issue	Select Relevant Finding or Recommendation
Family Friendly Policies	**Recommendation:** University leaders should develop and implement hiring, tenure, and promotion policies that take into account the flexibility that faculty need across the life course, allowing integration of family, work, and community responsibilities. **Recommendation:** Establish policies for extending grant support for researchers who take a leave of absence due to caregiving responsibilities.
Institutional Barriers	**Finding:** Academic organizational structures and rules contribute significantly to the underuse of women in academic science and engineering.
Data Needs	**Recommendation:** Expand support for research on the efficacy of organizational programs designed to reduce gender bias, and for research on bias, prejudice, and stereotype threat, and the role of leadership in achieving gender equity.
Oversight	**Recommendation:** Congress should take steps necessary to encourage adequate enforcement of anti-discrimination laws, including regular oversight hearings to investigate the enforcement activities of the Department of Education, the Equal Employment Opportunity Commission, the Department of Labor, and the science granting agencies—including the National Institutes of Health, the National Science Foundation, the Department of Defense, the Department of Agriculture, the Department of Energy, the National Institute of Standards and Technology, and the National Aeronautics and Space Administration. **Recommendation:** Federal enforcement efforts should evaluate whether universities have engaged in any of the types of discrimination banned under the anti-discrimination laws, including: intentional discrimination, sexual harassment, retaliation, disparate impact discrimination, and failure to maintain required policies and procedures.
Hiring, Promotion, and Tenure	**Recommendation:** University leaders should take action immediately to remedy inequities in hiring, promotion, and treatment. **Recommendation:** University leaders should require evidence of a fair, broad, and aggressive search before approving appointments and hold departments accountable for the equity of their search process and outcomes even if it means canceling a search or withholding a faculty position **Recommendation:** Deans, department chairs and their tenured faculty should expand their faculty recruitment efforts to ensure that they reach adequately and proactively into the existing and ever-increasing pool of women candidates

Gender Differences at Critical Transitions in the Careers of Science, Engineering, and Mathematics Faculty (NRC, 2010)

Issue	Select Relevant Finding or Recommendation
Data Needs	**Recommendation:** Investigate why female faculty, compared to their male counterparts, appear to continue to experience some sense of isolation in subtle and intangible ways
Family-Friendly Policies	**Recommendation:** Explore gender differences in the obligations outside of professional responsibilities (particularly family-related obligations) and how these differences may affect the professional outcomes of their faculty **Recommendation:** Monitor and evaluate stop-the-tenure-clock policies and their impact on faculty retention and advancement. Where such policies are not already in place, adopt them and ensure effective dissemination to faculty members.
Mentoring	**Recommendation:** Initiate mentoring programs for all newly hired faculty, especially at the assistant professor level.
Hiring, Promotion, and Tenure	**Finding:** In every field, women were underrepresented among candidates for tenure relative to the number of female assistant professors. Most strikingly, women were most likely to be underrepresented in the fields in which they accounted for the largest share of the faculty—biology and chemistry **Finding:** Most institutional and departmental strategies for increasing the percentage of women in the applicant pool were not effective as they were not strong predictors of the percentage of women applying. The percentage of women on the search committee and whether a woman chaired the search, however, did have a significant effect on recruiting women. **Recommendation:** Make tenure and promotion procedures as transparent as possible and ensure that policies are routinely and effectively communicated to all faculty **Recommendation:** Design and implement new programs and policies to increase the number of women applying for tenure-track or tenured positions and evaluate existing programs for effectiveness

Seeking Solutions: Maximizing American Talent by Advancing Women of Color in Academia: Summary of a Conference (NRC, 2013)

Issue	Comments or Suggestions from Workshop Participants
Addressing Bias	**Participant Suggestion:** One of the most striking realizations was the recognition that a major issue is the innate biases that all humans carry (see, for example, Thinking, Fast and Slow by Daniel Kahneman). This innate bias leads us all—men, women, people of color—to make snap judgments that, unrecognized and unchecked, will contribute to perpetuating the status quo. In many ways, this recognition frees institutions and individuals from blame and may make it easier for all to join forces in an attempt to fully marshal the talent of the nation in STEM endeavors. **Participant Suggestion:** Include bias awareness training at key points in university processes. Important points at which to provide bias awareness training include: searches for new faculty and postdocs (for search committees), regular occasions for faculty evaluation—annual reviews, third year reviews, tenure and promotion reviews (for all faculty), reviews of research grants (for reviewers), the hiring of a "solo" —the department's only [anything], a woman, woman of color, etc. (for departmental chairs, faculty members, staff) **Participant Suggestion:** Incorporate bias awareness training in universities into training programs that already exist
Changing Workplace Culture	**Participant Suggestion:** When a department hires a "solo" (and thus comes to include a sole individual of any group), it must deliberately work to ensure that its climate and policies do not inadvertently discriminate against the new faculty member or hinder her or his ability to thrive in that community. It is beneficial if university leadership is available to provide this guidance.
Representation	**Participant Comment:** The largest difference in academic promotion between women of color and White women occurs at the beginning of a faculty career, with the obtaining of a tenure-track job at a non-minority-serving, non-research-I institution. Therefore, although from that point forward women of color and White women are promoted at similar rates, their relative numbers have been distanced by the nonequivalent starting conditions, and the representation of women of color in faculty positions persists at low levels. **Participant Comment:** Women of color (in this case, not including Asian women) were more likely to be in nontenure-track positions and less likely to be in full professorships, meaning that women of color are disproportionately occupying positions that have the least power and authority in the academic context.

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Issue	Comments or Suggestions from Workshop Participants
Data Needs	**Participant Suggestion:** We should collect and publish data such as a diversity index. A diversity index would contain institutions' and departments' track records in training and supporting doctoral students as well as notes on students' progress as they move forward in their careers. **Participant Suggestion:** In order for undergraduate students to make informed decisions about where to pursue graduate degrees, they need information about an institution's commitment to creating and maintaining a culture of inclusion. Information needs to be available for all levels: faculty, department, college/school, and university overall.
Family-Friendly Policies	**Participant Suggestion:** An important factor in the slow integration of women of color into academia is the structural impediments built into current institutions, particularly in the United States. There cannot be full participation by women of color in academia until policies and expectations for work-family balance are addressed.
Hiring, Promotion, and Tenure	**Participant Suggestion:** Institutions should increase the number of women and underrepresented minorities in candidate pools **Participant Suggestion:** Search committees, particularly for leadership positions, should include women and underrepresented minorities. **Participant Suggestion:** Institutions should make the policies on promotion and tenure public and clear. **Participant Suggestion:** To increase the diversity of the faculty at U.S. institutions of higher education, a top priority should be policies designed to increase college graduation rates among women of color. **Participant Suggestion:** There is a great need to capture institutional and departmental contexts and climates, quantitatively and—the more acute need—qualitatively. It would be beneficial to put institutions' successful strategies in context so that institutions and departments can judge which interventions are most likely to be successful in their particular contexts.
Mentoring	**Participant Suggestion:** Faculty, specifically graduate advisers, should maximize the types of projects and career paths that undergraduates and graduate students are exposed to, so that they can make optimal choices about where to invest their creativity with full information about where the opportunities are in the world of STEM careers. **Participant Suggestion:** Offer training to people whose actions have an impact on the careers of talented women of color in STEM, including people in leadership positions in federal agencies, academia, and the scientific community overall **Participant Suggestion:** Since sponsorship does not lend itself to encouragement through policies, individuals must take the lead. Some participants encouraged senior women of color to continue to be or to become more aware of opportunities to sponsor talented junior faculty who are women of color as these faculty advance their careers.

Sexual Harassment of Women: Climate, Culture, and Consequences in Academic Sciences, Engineering, and Medicine (NASEM, 2018)

Issue	Select Relevant Finding or Recommendation
Changing Workplace Climate	**Finding:** The two characteristics of environments most associated with higher rates of sexual harassment are (a) male-dominated gender ratios and leadership and (b) an organizational climate that communicates tolerance of sexual harassment **Finding:** A systemwide change to the culture and climate in higher education is required to prevent and effectively address all three forms of sexual harassment. **Finding:** Organizational climate is, by far, the greatest predictor of the occurrence of sexual harassment, and ameliorating it can prevent people from sexually harassing others. **Recommendation:** Move beyond legal compliance to address culture and climate. Academic institutions, research and training sites, and federal agencies should move beyond interventions of policies that represent basic legal compliance and that rely solely on formal reports made by targets. Sexual harassment needs to be addressed as a significant culutre and climate issue that requires institutional leaders to engage with and listen to students and other campus community members.
Data Needs	**Recommendation:** 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.
Representation	**Finding:** For women of color, preliminary research shows that when the sexual harassment occurs simultaneously with other types of harassment (i.e., racial harassment), the experiences can have more severe consequences for them.

The Science of Effective Mentorship in STEMM (NASEM, 2019)

Issue	Select Relevant Finding or Recommendation
Mentoring	**Finding:** Mentorship across a broad range of professional domains has an overall positive effect on academic achievement, retention, and degree attainment as well as on career success, career satisfaction, and career commitment. **Finding:** Engaging in culturally responsive mentoring, whereby mentors show interest in and value students' cultural backgrounds and their non-STEMM social identities, is one strategy mentors can implement to validate their mentees' multiple identities, especially in cross-racial relationships. **Finding**: Changes in institutional rewards systems can enhance mentoring provision and quality A commitment from institutional leadership to support mentorship could have a profound effect on the quality of mentorship and ultimately the development of undergraduate and graduate students **Finding:** Funding agencies can further encourage culture change in mentorship by requiring evidence-based mentorship plans, mentor and mentee education, and reports of mentorship quality and outcomes for grantees. **Recommendation**: Institutional and departmental leadership should regularly and systematically review formal mentorship activities and programs to support development of mentorship skills and student success and well-being. **Recommendation**: 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 such as 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. **Recommendation**: 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 award for mentorship, and process measures that assess mentoring relationship quality from the perspective of the mentee and the mentor. **Recommendation**: Funding agencies should encourage the integration of evidence-based mentorship education for mentors and mentees and assessments of mentorship into grant activities that involve undergraduate and graduate student research, education, and professional development to support the development of the next generation of talent in STEMM.

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