# The Science of Effective Mentorship in STEMM

Mentoring serves an essential role in developing science, technology, engineering, mathematics, or medicine (STEMM) professionals. However, it rarely receives the focused attention, evaluation, and recognition of other aspects of professional development, such as teaching or research. While the nation's academic institutions have formalized the education and training of budding STEMM professionals, with few exceptions mentoring is largely left to happen organically.

A new report by National Academies of Sciences, Engineering, and Medicine lays out the scholarship on—or science of—mentorship and mentoring relationships and provides guidance on effective behaviors, frameworks, measures and assessment techniques, tools, possible relationship structures, and the role of institutional support. It highlights that mentorship is a skill that is learned, practiced, and improved upon with self-reflection and feedback. The report also explores the gap between what we know about effective mentoring and how it is practiced in higher education; identifies gaps and potential areas for future research on mentorship; and offers mentors, mentees, and mentoring program directors the evidence-based knowledge and skills necessary to ensure highly productive and sustainable mentoring relationships.
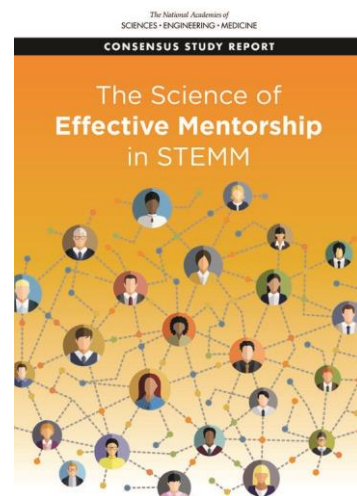
## WHY DOES MENTORSHIP MATTER?

Talent is equally distributed across all sociocultural groups; access and opportunity are not. Individual STEMM professionals identifying as African American, Latinx, American Indian, first-generation, or sexual or gender minority individuals, and individuals with disabilities continue to be less likely to be successfully integrated in STEMM environments. A variety of factors keep students from underrepresented (UR) groups from choosing and remaining in STEMM disciplines.

Given the economic benefits of well-trained STEMM professionals entering the workforce at a higher rate, effective mentoring can result in significant benefits to individuals, institutions, and society at large. But how can access and opportunity be facilitated within affirming environments in support of a STEMM talent development model for all?

Researchers have proposed many hypotheses to explain the underrepresentation of segments of the U.S. population in STEMM, yet the lack of effective mentorship for those students has only received attention recently. Addressing the underrepresentation of major segments of the nation's population requires a multipronged approach involving an ecosystem of participants, including institutional leadership, department chairs, program leaders, mentors, and mentees, and professional associations. Mentorship will likely constitute a significant component of the complex solutions required.

## WHAT DOES EFFECTIVE MENTORSHIP INVOLVE?

Mentoring relationships are interpersonal encounters and exchanges. Ongoing collaboration and discussions are key to sustaining an effective mentoring relationship that is responsive to the needs, goals, interests, and priorities of both mentors and mentees. Effective mentorship includes:

- **Support Functions**. Effective mentorship provides psychosocial and career support, as well as networking opportunities tailored to the needs, interests, and priorities of mentees.

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- **Trust**. Trust develops when mentors and mentees work together to identify and respond to their mutual goals, needs, and priorities, which can change over time and thus require adjustment.

- **Self-reflection**. Effective mentorship entails critical and honest self-reflection at multiple stages of the mentorship process.

- **Expectations**. Effective mentorship involves mentors stating expectations explicitly and the creation of a safe space for mentees to make their expectations explicit.

- **Education**. Mentorship is a learned skill, and mentorship education influences mentor and mentee attitudes, self-efficacy, and behaviors.

While dyads, or one-to-one relationships, continue to serve an important role for mentorship in STEMM, mentorship has expanded conceptually and operationally to include a broader range of structures to better support mentees' development. Effective mentorship structures also include triads, collective or group mentoring, mentoring networks, and emerging online and e-mentoring communities.

## HOW DO IDENTITIES AFFECT MENTORSHIP IN STEMM?

Social science research indicates that social relationships, such as those in mentorship, play a pivotal role in the formation of identity— the composite of who people are, the way they think about themselves, the way they are viewed by the world, and the characteristics that they use to define themselves. Specific dimensions of identity (e.g., science identity, cultural identities) have been linked empirically to academic and career development and to the experience of mentoring relationships in STEMM. However, despite mentorship's benefits for UR students and their development of a science identity, studies have reported that UR individuals enrolled in STEMM degree programs typically receive less mentorship than their well-represented peers.

Mentees without access to culturally responsive mentoring can experience situations where one identity (e.g., race or culture) interferes with the success of actions related to another identity (e.g., science identity), which can result in depression, reduced psychological well-being, and lower academic or professional performance.

## WHAT IS THE ROLE OF THE INSTITUTION?

Current mentoring systems are structured to benefit the prototypical STEMM mentee—white, male, heterosexual, able-bodied, continuing generation, upper or middle class. Creating a culture of inclusive excellence requires academic institutions to identify where student success is not equal across all demographics, discover which educational practices succeed in addressing those inequities, and work intentionally to build from those practices. Broader access to quality mentorship and support systems at academic institutions may entail significant institutional change. 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.

## ABOUT THE PROJECT

Over the course of the study, the committee held 18 listening sessions on university campuses and at a variety of professional society meetings, commissioned literature reviews, and convened public workshops across the country, hearing from experts about the study and practice of mentorship.

The report identifies specific practices for both mentors and mentees that increase the likelihood of developing effective mentoring relationships that account for differences in the demographic background, gender, race, ethnicity, sexual orientation, gender identity, or ability status of mentors and mentees. It also provides examples of programs that have included research-informed mentorship practices as a key component for increasing student success in undergraduate and graduate STEMM fields while reviewing the challenges of assessing mentorship and program effectiveness. Finally, it addresses the importance of institutional culture change to support widespread implementation of effective mentorship practices and makes specific recommendations for the range of actors that must engage to improve the practice of mentorship in STEMM.

## SELECTED RECOMMENDATIONS

The recommendations encourage a shift away from a culture of ad hoc mentorship and toward one of intentional, inclusive, and effective practices across institutional contexts. Recommendations 1-7 identify specific roles for participants in the mentorship ecosystem— including institutional leaders (e.g., presidents, provosts, deans), department chairs, program leaders (e.g., research, training, and graduate program directors), mentors (faculty members, staff, and others who have extensive contact with graduate and undergraduate students), mentees (undergraduate and graduate students participating in mentoring programs and other mentoring relationships), and professional associations. Recommendations 8-9 are directed at agencies that fund mentorship programs and scholars of mentorship.

### Recommendation 1: Adopt an Operational Definition of Mentorship in STEMM

Institutions and programs should adopt an evidence-based, operational definition of mentorship, such as the one used by the committee in its work:

*Mentorship is a professional, working alliance in which individuals work together over time to support the personal and professional growth, development, and success of the relational partners through the provision of career and psychosocial support.*

Mentorship is operationalized for STEMM contexts through the career support functions (e.g., career guidance, skill development, sponsorship) and psychosocial support functions (e.g., psychological and emotional support, role modeling) aimed at mentee talent development.

### Recommendation 2: Use an Evidenced-Based Approach to Support Mentorship

2.2: Program leaders should support mentorship by ensuring there are evidence-based guidelines, tools, and processes for mentors and mentees to set clear expectations, engage in regular assessments, and participate in mentorship education. Program design should take into account the stages of mentoring relationships and ensure that the evolving needs of undergraduate and graduate students are met as they shift to career stage–appropriate independence.

2.5: Mentees should acquaint themselves with evidence-based mentorship tools and strategies, including compacts, individual development plans, mentor maps, and mentoring accountability mechanisms. When possible, mentees should take advantage of any mentee-focused mentorship education and resources and be aware of which faculty members in their program, department, or institution have participated in mentorship education and which faculty use evidence-based mentorship tools.

### Recommendation 3: Establish and Use Structured Feedback Systems to Improve Mentorship at All Levels

Assessment and evaluation of mentorship are necessary to identify areas of strength and opportunities for improvement. Evaluation through structured systems may reduce unintentional bias and protect mentees who are in inherently more vulnerable positions as students and trainees.

3.1: 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. Such reviews should involve different stakeholders groups, check for alignment with stated program goals and missions, ensure that practices for effective mentorship are incorporated throughout activities and programs, and work to create a culture of accountability.

### Recommendation 4: Recognize and Respond to Identities in Mentorship

All participants in the mentorship ecosystem should recognize that identities influence academic and career development and thus are relevant and significant for effective mentorship.

4.2: Mentors should learn about and make use of inclusive approaches to mentorship such as listening actively, working toward cultural responsiveness, moving beyond "colorblindness," intentionally considering how culture-based dynamics like imposter syndrome can negatively influence mentoring relationships, and reflecting on how their biases and prejudices may affect mentees and mentoring relationships, specifically for mentorship of underrepresented mentees.

### Recommendation 5: Support Multiple Mentorship Structures

5.1: Institutional leadership 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.

5.4: Professional associations should proactively facilitate the development of mentoring relationships among individuals from different programs or institutions, as needed, who can provide complementary or supplementary mentorship functions. This could include activities such as pairing first-time conference attendees (mentees) with returning conference attendees (mentors) to orient them to conference events and support their networking or establishing and supporting online communities for mentees to find and make supportive connections outside their own institutions and environments (e.g., academia).

### Recommendation 6: Reward Effective Mentorship

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

institutional and national award for mentorship, and process measures that assess mentoring relationship quality from the perspective of the mentee and the mentor.

### Recommendation 7: Mitigate Negative Mentorship Experiences

Mentorship education for both mentors and mentees can help to reduce or prevent negative mentoring experiences. However, negative mentoring experiences do and will occur, and direct steps should be taken to minimize harm from such occurrences.

### Recommendation 8: Recommendations for Funding Agencies that Support Mentorship

Funding agencies play a key role in shaping the values of institutions and the projects that scholars pursue. As such, funding agencies' role in encouraging and supporting effective mentorship practices is essential.

8.1: 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.

### Recommendation 9: Recommendations to Scholars of Mentorship

More scholarship is needed on specific aspects of mentorship and mentoring relationships.

9.3: Scholars should define and characterize negative mentoring experiences or ineffective mentorship in STEMM and investigate their prevalence and impacts, specifically addressing the possibility that negative mentoring experiences may disproportionately harm underrepresented students and compromise science and research itself.

9.4: Scholars should intentionally expand the knowledge base for populations that remain little-studied in STEMM and account for how differing conditions and contexts of mentorship may differentially affect individuals with diverse sociocultural identities.

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