# Effective Mentoring in STEMM: Practice, Research, and Future Directions

Proceedings of a Workshop—in Brief

## INTRODUCTION

Mentoring has long been understood as a beneficial component of academic and professional development. But investigations of the attributes of effective mentoring interactions in science, technology, engineering, mathematics, and medical (STEMM) education are only now starting to shed light on how exactly these complex and dynamic relationships form, evolve, and impact the lives and careers of the current and next generation of STEMM professionals.

To explore the conversation surrounding this highly interdisciplinary field, the Board on Higher Education and Workforce and the Committee on Women in Science, Engineering, and Medicine, in collaboration with the Board on Science Education and the Teacher Advisory Council, convened a workshop in Washington D.C. on **February 9-10, 2017**. Educators, scientists, engineers, industry leaders, and scholars from a wide range of career stages focused on identifying successful practices and metrics for mentoring students in STEMM career pathways. Workshop sessions spanned topics across the mentoring field: definitions, theories, practices, perspectives, evidence, research, identity, and reflection, with a particular emphasis on identifying the evidence supporting successful mentoring practices for women and students of color across high school and postsecondary education. **Angela Byars-Winston**, chair of the planning committee, opened the workshop by saying "We did not want to lose the voices on the ground around what it's like to be experiencing mentoring."

This document provides a brief overview of the workshop discussions. The workshop was highly participatory, and speakers, panelists, and participants discussed a range of interrelated topics throughout the two days. In addition, two sets of breakout groups were held: on day one, the topics were Diversity and Critical Elements, Transitions and High School, Training and Mentoring over Time, and Evaluation and Context; on day two the topics were Evaluation and Metrics, Accountability, Diversity, and Implementation. Both sets of topics were selected by the participants at the meeting, using interactive audience polling software (Figure 1).

## DEFINITIONS AND TYPES OF MENTORING

A continuing theme of the workshop was framing mentoring as an interactive, mutual relationship in which both parties contribute. **Brad Johnson** described "a mentor relationship continuum" as relational rather than hierarchical, with the end goal of a strong working alliance. Other speakers emphasized the mutual trust and communication required for a mentoring relationship, in which both parties are responsible for the outcomes; similar to copilots of a plane (Figure 2). Several other metaphors were used to describe mentoring throughout the workshop.

A few definitions of the word "mentoring" were discussed at the workshop, but no single working definition was developed. Several participants noted that mentoring is difficult to define and many expressed the idea that there can be many types of mentors to meet the unique needs of students along the various stages and levels of interest and involvement in a field, including advisors, role models, and sponsors.

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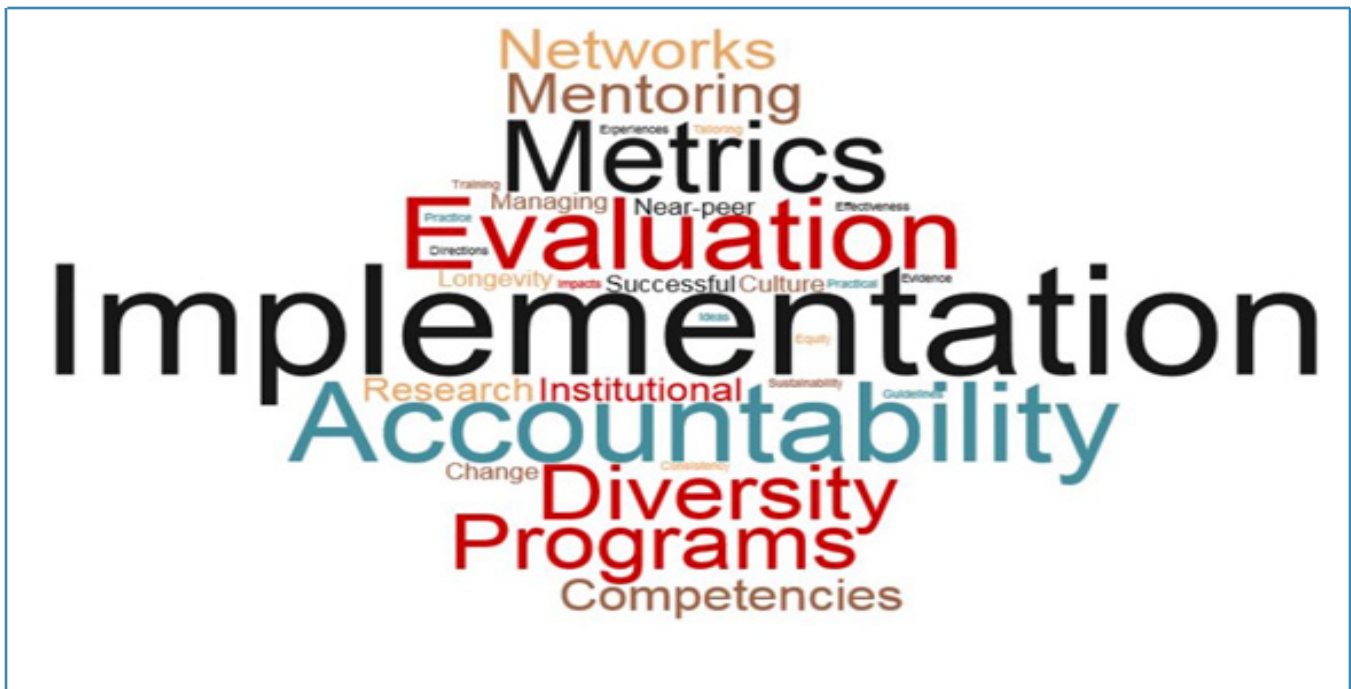
**FIGURE 1:** Re-creation of the word cloud produced from responses to a freeform participant poll held at the workshop on possible topics for the second set of breakout groups. Note: This word cloud reflects the interests of the responding attendees and does not necessarily represent a thorough portrait of available topic areas.

Speakers at the workshop noted that a STEMM student's formal advisor is often referred to as a student's primary mentor. In addition to providing disciplinary grounding and intellectual support, **Sandra Laursen** described this role as supplying "practical support to do the work and the emotional support to recognize that failure is normal, to brainstorm together through a problem that seems difficult." Other participants cautioned that formal advisors do not always fulfill mentoring roles.

Several speakers noted that some mentors serve as role models in lieu of or in addition to their mentoring roles. **Paul Hernandez** described role models as people who "inspire [students] and show them the way that they got to that position." He continued that mentees may or may not have a deep, personal, or any relationship with a role model, "but they can still provide inspiration for you as you choose your career path." Many speakers pulled from their own experiences with mentoring; **Adegboyega (Ade) Akinsiku** recalled learning from role models, suggesting "as mentors, we have to remember that we're always role models."

A slightly different mentoring role was that of "sponsors" who, as **Kay Lund** said, "go out there and advocate for your career advancement." Several participants noted that sponsors can also help a student advance their career by helping them access and connect to resources and power.

Each of these mentoring roles could be categorized as a developmental relationship: "a relationship that has, as a primary purpose, learning, whether it is a short-term relationship or a long-term relationship. What we know now about the best developmental relationships is that they are mutual" said **Kathy Kram**. Other participants commented on the reciprocal nature of mentoring relationships and the agency (i.e., capacity to act independently) that students ought to have in the process.

## NETWORKS

Workshop speakers noted that the many types of mentors can work collectively as an individual's mentoring network. **Kram** suggested a model where "individuals should be encouraged to [proactively] develop a small developmental network of individuals to help in the various ways that are needed." She stated that these networks of mentors should fulfill three types of support: career, psychosocial, and role modeling. Participants suggested that mentoring networks could include peer mentors, coaches, and sponsors, which, as **Robert Trevino** remarked, brings "the best of several worlds" to mentees.

**Laursen** described the intentional mentoring network development in the SOARS program at the National Center for Atmospheric Research,[1] which has four mentors for each incoming student: a science mentor, a writing

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[1] For more information on SOARS, visit: https://www.soars.ucar.edu; accessed April 13, 2017.

mentor, a community mentor, and a peer mentor. She high-lighted that this type of program is especially beneficial for students who have been at a structural disadvantage, saying "you really make sure nobody falls through the cracks." Multiple participants also noted that developmental networks facilitate support from peers, colleagues, and coworkers within an institution can be far more effective in supporting students than an individual mentor.

## IDENTITY, DIVERSITY, AND CONTEXT

The workshop planning committee stressed identifying effective mentoring practices for women and students of color across high school and postsecondary education because of the central role that identity and diversity play in developmental relationships. Therefore, discussions of diversity within mentoring relationships dovetailed throughout the workshop, including diversity within a mentoring network, intersections of mentoring with personal and demographic identity, and the role of context in mentoring.

Workshop participants had various definitions of diversity and identity, which included considerations of race, ethnicity, gender, learning differences, disability, economic background, and more. They suggested strategies for exploring identities such as the Daisy Model, where each petal is a different social identity, or the Culture Box, where individuals present objects representing their identity. **Michael Summers** stressed that, in STEM fields, it is "also important from the student's perspective to identify as a scientist," and spoke to a mentor's role in developing that identity.



Mentoring as a Co-Pilot Relationship:

- Build trust over time
- Both parties guide the relationship
- Conditions will change (turbulence may occur!)
- Communication is essential
- A skill that improves with guidance and commitment

**FIGURE 2:** The co-pilot relationship metaphor for mentoring relationships, adapted from the graphic facilitation conducted throughout the workshop. Source: Layne Scherer, National Academies of Sciences, Engineering, and Medicine.
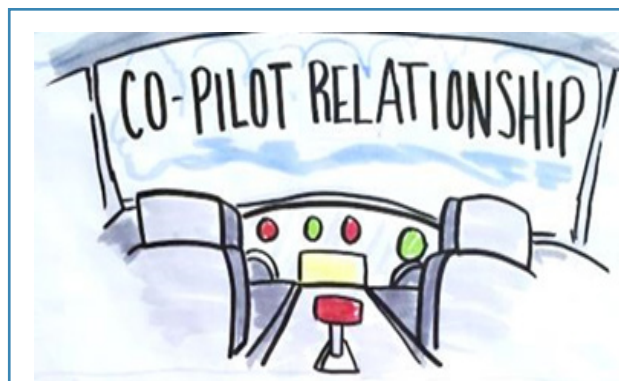
### Identity within Mentoring Relationships

"When we're looking for a mentor," **Anthony Keyes** asked, "do they have to be diverse themselves, or are we just looking for diversity in their thought or the diversity of the people that they've worked with?" Along these lines, some workshop participants hinted that having a mentor with a different identity—whether defined by racial/ethnic, gender, professional, or other demographic characteristics—could be a benefit.

**Lillian Eby** noted that "female mentors in general—at least in organizational settings—don't have the kind of power that male mentors have." Eby cited research indicating a lack of correlation between demographic similarity and protégé outcomes. However, she also noted that a sense of deep level similarity "is the strongest and most consistent predictor of all of the types and indicators of relationship success." A few participants built on the idea that mentors do not need to share the mentee's demographic identity in order to be effective, pointing out that mentors need to be able to work with all students, regardless of demographics.

### Context Changes over Time

Reflecting on the ideas of identity and diversity, several participants noted that mentoring relationships exist in the context of culture and can change over time as individuals evolve. "We talked about identity, but what about the context of a person's entire identity development over the lifespan and where mentoring plays in?" asked **Belinda Huang**. Participants also pointed out the more direct relationship between diversity and the changing context in which mentoring takes place over time. For example, **Dixie Ross** commented that "once somebody is to the point where they are pursuing an undergraduate degree, we're already filtering out a lot of the students that we really want to have an impact on," emphasizing that retaining diverse students requires early mentoring.

## IMPLEMENTATION OF MENTORING IN PRACTICE

Some of the workshop participants expressed a need to put the theory on mentoring into practice; as **Erin Dolan** stated, the field needs to distinguish "the opportunities for innovation" from "opportunities for good practice." Many participants suggested good practices that would be particularly relevant for structured mentoring programs. One suggestion was for mentoring programs to develop a set of guidelines for mentors and mentees to review before beginning a relationship, allowing both parties to enter with a similar set of expectations. Some of the participants in the Implementation breakout group suggested that the vision of mentoring programs should be made clear and should balance sustainability with room for change. Others noted that mentoring programs need to foster a sense of community and connection among their members, and that professional development such as facilitation training was needed for managers of various mentoring programs to encourage the spread of promising practices. **Christine Pfund** placed these structures, infrastructures, and contexts under the "umbrella of facilitating conditions" for mentoring practices.

Workshop participants also addressed the question of how best to match mentors and mentees. "The best mentorships arise organically," **Juan Pablo Ruiz** said, with people "you feel comfortable with, and with people that you admire." A few participants pointed out that some mentoring programs are designed with structured processes for matching mentors; for example, short questionnaires about what participants like to do in their free time, in order to highlight overlaps and help mentors and mentees bond. **Taylor Johnson** noted that mentoring matches through structured processes can be successful, citing one of her own mentoring relationships that started with a matching program.

## ROLES AND EXPECTATIONS

Whether in a formal mentoring program or an informal mentoring relationship, questions of expectations and the roles of each participant were mentioned by many workshop participants. Speakers at the workshop laid out roles for mentors, including meeting students where they are, understanding what each individual student needs, and being clear about what they as a mentor can offer, from providing emotional and psychosocial support and guidance to simply broadening the student's network. **Lund** encouraged mentors to engage in "assumption-less mentoring" which she described as "allowing the student to follow their dream with no preconceptions" while being fair as well as supportive.

**Amy Prunuske** outlined the expectation that a mentor should "understand what is that particular mentee's passion, how that fits with the market, and what skills they have right now." Other participants also spoke to the idea of tailoring mentoring to the mentee's needs. For example, Ruiz provided a metaphor for his ideal mentoring relationship, saying "rather than seeing ourselves as mentors as carpenters and carving out this person into something that they might not be, we actually need to be a gardener and provide a nurturing environment that promotes growth, that promotes communication, and that promotes general feelings of belonging so that those students can feel comfortable in seeking out their own growth and their own pathways."

Because mentoring was considered by many participants to be a mutual relationship, there were also some suggestions for mentees. A few participants noted that student mentees can bring valuable student perspectives to their mentors, to improve mentors' teaching. Many speakers also presented the idea that individuals who are mentored well will "pay it forward" when they in turn mentor others. **Renetta Tull** gave an example of these "multiplying effects," citing several students who were mentored through the Promise AGEP[2] structure and are now faculty with their own mentees.

## COMPETENCIES

The idea of mentoring requiring a set of skills or 'competencies' was highlighted throughout the workshop. Several participants articulated the need for competency development, noting that generally faculty are interested in being mentors but don't necessarily have the knowledge and resources they need to be good mentors. A few of the participants in the Training and Mentoring over Time breakout group noted, "approaching the topic of mentoring as a student, and not an expert, is fruitful."

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[2] For more information on Promise Alliance for Graduate Education and the Professoriate Program, visit: https://promiseagep.com; accessed April 13, 2017.

## Competencies in Mentoring Relationships

Several participants listed the competencies that they thought were critical to mentoring relationships, including authenticity, listening, curiosity, openness, understanding expectations, sustaining the relationship, not predefining success, and being prepared for the required competencies to change over time.

Many competencies focus on relationship building because, as **Derrick Simmons** said, "building a relationship is not intuitive—it takes work," including caring about students outside of one's own professional expertise. In this vein, participants noted multiple relationship-related competencies, including a shared purpose between mentors and mentees.

One particular aspect of relationships that a few participants pointed to as needing competency is navigating identity, broadly defined. Several participants in the Diversity breakout group suggested that competencies required to embrace diversity include "discomfort, active listening skills and knowledge, empathy and vulnerability, and intentionality."

A few workshop participants referred repeatedly to communication as a critical competency. Ideally, other participants suggested, the mentee knows what they need from a mentoring relationship and how to communicate it, and the mentor knows their strengths and limitations in addressing those needs and can point mentees to other resources if needed. In contrast, participants spoke to struggles in mentoring relationships due to poor communication, in situations which lead to misunderstandings or simply hinder the transfer of knowledge.

## Developing Competencies

A number of workshop participants repeatedly emphasized that competencies were skills to be developed, rather than fixed abilities. "I really want to make the case that we should be not only screening people who are going to be mentors, but also training them and building competencies," said **B. Johnson**. A few participants spoke to personal experiences of mentoring training that helped them identify their strengths and weaknesses so that they could, as **Keyes** said, "be honest as mentors" and "know what capacities we can serve other people in."

Several participants spoke to the general lack of training for and forethought around how individuals approach mentoring; as **Hernandez** said, "it is assumed that you know how to mentor." He noted that "this is something that we know people can get better at," indicating that there is evidence to suggest that individuals can learn and improve. **Simmons** quoted one of his mentors, Lisa Nichols, who said "every mentor needs a mentor," and spoke of mentorship professional development as "teaching how to be an educator, teaching how to be a mentor, teaching how to be an advocate."

A few participants in multiple breakout groups suggested strategies for developing mentoring competencies. According to several participants in the Training and Mentoring over Time breakout group, one strategy is to help mentors identify good mentoring skills that they already possess and produce awareness of their expectations and values in a mentoring relationship. Several members of this breakout group also suggested training with multi-disciplinary groups and faculty in multiple career stages, and a few participants in the Accountability breakout group emphasized the need for training in communication skills, identified by many participants as a key competency.

Many speakers noted that mentors need training to meet the many needs of different mentees. **Elizabeth Boylan** expanded on this idea to include training for faculty on challenges faced by underrepresented groups, such as marginalization, stereotype threat, and social identity threat, in order to better help students with these unique concerns.

A number of participants also emphasized that competency training was as needed for mentees as it was for mentors; as **Ross** and **Huang** noted in a joint presentation, "train both the mentors and the mentees so that they can make the best use of this mentoring relationship." Other competencies mentees could develop that participants outlined throughout the workshop included professional skills, expectation setting, mapping and understanding the need for mentoring networks, how to find mentors, and using mentoring relationships effectively.

## EVALUATION

Metrics and evaluation of mentoring practices ranked among the topics of great interest for many workshop participants according to interactive polls conducted to determine the breakout group discussions.

## Types of Data

Multiple participants discussed the various forms of data that could be used to evaluate mentoring relationships. Some participants requested qualitative data to evaluate mentoring effectiveness, such as that from interviews with both

mentees and mentors about the overall success of the relationship. The goal of these qualitative data would be to learn about what both parties are gaining from their mentoring relationships. Individual participants in the Evaluation and Context breakout group generated the following ideas for potential metrics: (1) quantitative metrics, (2) measures of quality such as a "rapport indicator," and (3) indication of the alignment of mentor and mentee goals, among others, but they also asserted that the metrics currently used to study effective mentoring are not always validated due to lack of support for that area of research.

## Collecting and Using Data

Many participants commented on challenges in evaluating mentoring, noting that the quality of relationships is intrinsically difficult to study, especially as needs change from one developmental phase to the next. Several participants in the Metrics and Evaluation breakout group framed this issue by pointing out that programs and researchers often measure what is easily measurable, rather than what is valued, and asked that stakeholders instead consider methods to measure what they value in the short, medium, and long term.

Another challenge to collecting data about mentoring is that the demand for this information is not always clear. Participants spoke to the difficulty of articulating the "return on investment" of mentoring to funders that have goals which do not always align with the goals of mentoring programs, and suggested framing mentoring as a potential incentive for increasing interdisciplinary cooperation. Some funders do support collection of data on mentoring, including the National Institutes of Health via Individual Development Plans[3, 4], said **Lund**.

Several participants also discussed the best practices for using data once they are collected. **Anne Marie Weber-Main** suggested that every mentoring program have a built-in "quality improvement model, so that you're constantly innovating and revising as you go along," including soliciting a range of input and sharing promising practices for different institutional settings. Other speakers suggested that programs collaborate, sharing both successful and unsuccessful aspects of their structures, in order to best utilize gathered data. One resource for cross-program data-sharing mentioned by participants in both the Training and Mentoring over Time breakout group and Evaluation and Context breakout group was the Center for the Improvement of Mentored Experiences in Research, or CIMER,[5] which aims to organize mentoring data from different institutions to improve evaluation and use of data.

## ACCOUNTABILITY AND ACKNOWLEDGMENT

A number of workshop participants spoke to two aspects of accountability in mentoring: holding mentors accountable and giving credit where it is due. Although mentors were a focal point of these conversations, **Kimberly Griffin** emphasized that both parties should be accountable, asking "How do we make sure that mentors are engaging in good mentoring practice and making sure that students are holding up their end of the bargain, as well?"

## How can People in Mentoring Relationships be held Accountable?

Many workshop participants responded with an emphatic "Yes" when **B. Johnson** asked "is there such a thing as bad mentoring?" **Eby** explained that negative experiences along the continuum from minor to severe explained variability in mentee outcomes far more than positive experiences, citing data that indicated a seven-fold impact of negative experiences compared to positive ones. Because ineffective mentoring can have highly detrimental effects on mentees, workshop participants showed great interest in accountability.

**Eby** indicated that increased institutional support for mentoring improves the quantity and quality of mentoring at that institution, deterring relationship problems. Participants in the Accountability breakout group suggested that strong institutional leadership and a culture that upholds values is critical, and cited research from workplace settings that suggests positive incentives are more effective than punishment in cultivating desired behaviors. One suggested culture change was a shift from focusing on accountability in mentoring relationships to establishing a sense of responsibility in mentors.

## How can People in Mentoring Relationships be Acknowledged?

Several participants also contributed ideas about how mentoring should be rewarded, speaking to the need to consider how we value mentoring and how we define "success" in that relationship.

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[3] For more information on NIH guidance on use of Individual Development Plans (IDPs), visit: https://grants.nih.gov/grants/guide/notice-files/NOT-OD-14-113.html; accessed April 13, 2017.

[4] For more information on IDPs, visit: http://myidp.sciencecareers.org; accessed April 13, 2017.

[5] For more information on CIMER, visit: http://cimerproject.org; accessed April 13, 2017.

A few participants in the Implementation breakout group recognized that "rewards are not aligned to give value to mentorship" and remarked on "resistance to implementation among those who are comfortable with the way things are." **Weber-Main** described the inclusion of mentoring expectations in faculty promotion criteria at some institutions and the ability of mentors to obtain recognition through the National Mentoring Research Network[6] as effective rewards. As one participant noted, "communicating mentor incentives, intrinsic and extrinsic, to overstretched investigators, remains challenging."

**Summers** told a story of how his institution's mentoring practices changed systemically when a campus leader, instead of taking a top-down approach to improving student performance, encouraged the students to mentor their teachers, reporting that "we got accustomed to seeing a completely different behavior." Institutions also address the need for mentoring with peer recognition programs such as the master mentor program at Johns Hopkins University,[7] which **B. Johnson** described as being effective because it is "an honor to be selected." **Boylan** described competitions the Sloan Foundation holds for institutions to become centers of exemplary mentoring,[8] and individual participants in the Implementation breakout group suggested a variety of incentives for institutions to promote mentoring, including applying mentorship to address recognized institutional problems, framing mentorship as an investment that can save time later, or tying mentorship to institutional reputation.

## PATHWAYS OVER PIPELINES: REFOCUSING ON MENTEES

Many times, the value of mentoring students is framed as a way to help fix the metaphorical leaky STEMM pipeline. Several workshop participants, however, highlighted the need for a different metaphor. Participant **Jay Labov** noted that "pipelines are constraining and they are set by institutions. 'Pathways' is much more mentee-focused and allows people to understand they have options." He suggested switching to a student-oriented approach and redefining our measures of success. The student-centered approach was also discussed in the Metrics and Evaluation breakout group; several participants in that discussion suggested that the construct of mentoring needs to change to focus on students.

**David Asai** summarized the conversations around pipelines and pathways during his closing remarks by saying "the pipeline metaphor also has two other problems, which is that the students or the trainees are viewed as inert, they're just flowing through the pipeline, and that suggests that they have no agency. And second, the pipe is inert in the pipeline metaphor, and indeed we are all the pipe, and we have a responsibility. It's not just that they flow past us, but we have to interact with them and we have to work with them."

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[6] For more information on Mentoring certification through the NIH National Research Mentoring Network, visit: https://nrmnet.net/nrmn-mentor-certifications; accessed April 13, 2017.

[7] For more information on Johns Hopkins University School of Medicine Master Mentor Program, visit: http://ictr.johnshopkins.edu/collaboration/collaboration-mentoring-training/mentoring-programs/master-mentor-program; accessed April 13, 2017

[8] For more information on Sloan Foundation University Centers of Exemplary Mentoring, visit: http://sloanphds.org/mphd.html; accessed April 13, 2017.

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