MENTOR
THE NATIONAL MENTORING PARTNERSHIP

STEM MENTORING

Supplement to the

Elements of Effective Practice for Mentoring

RESEARCH-INFORMED RECOMMENDATIONS FOR YOUTH MENTORING PROGRAMS WITH A SCIENCE, TECHNOLOGY, ENGINEERING, OR MATHEMATICS FOCUS

2018

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ABOUT MENTOR: THE NATIONAL MENTORING PARTNERSHIP

MENTOR: The National Mentoring Partnership is the unifying champion for quality youth mentoring in the United States. MENTOR's mission is to close the "mentoring gap" and ensure our nation's young people have the support they need through quality mentoring relationships to succeed at home, school, and, ultimately, at work. To achieve this, MENTOR collaborates with its affiliates and works to drive the investment of time and money into high-impact mentoring programs and advance quality mentoring through the development and delivery of standards, cutting-edge research, and state-of-the-art tools.

Photo Courtesy of Northwestern/Science in Society

INTRODUCTION

Readers should note that this guide serves only as a supplement to the full *Elements of Effective Practice for Mentoring.* It is intended to provide additional guidance and nuance to the items found in the full *Elements*, and references Benchmarks and Enhancements described more fully in that document.

One of the fastest-growing areas of the mentoring movement is the use of mentors to get young people interested in, planning toward, and persisting in science-related educational and career opportunities. Much has been written in the last decade about the challenges America's students are having engaging in STEM subjects (those related to science, technology, engineering, and math[*]) and keeping up with their peers around the world in STEM academic performance[1,2,3], as well as the impact this achievement gap has on both scholarship and STEM industries in the United States. The struggles of girls and young women[4], youth with disabilities[5], youth of color[6], and first generation college students to engage in and persist in STEM are also well documented, as these groups continue to remain disproportionately underrepresented in academia and the STEM workforce[7]. This is an issue that not only limits the career choices being considered by young Americans, but the dilution of the talent pipeline hurts American competitiveness in many industries. Closing these gaps in STEM engagement, performance, and representation has become an issue of national importance.

In recent years, mentoring has become a cornerstone approach—from K12 settings through higher education and early career development—to increasing American performance in STEM and addressing issues of historical underrepresentation in STEM careers. Organizations like US2020 and Million Women Mentors have made tremendous progress engaging STEM companies and employees as mentors to a generation of students. In government, the Corporation for National and Community Service has started and already expanded a STEM-specific strand of AmeriCorps designed to get more STEM professionals mentoring and teaching young students. Many traditional K12 STEM education programs have introduced or deepened a mentoring component of their services, recognizing that a few scattered activities may not be enough to overcome systemic challenges to long-term youth engagement in STEM. And the research literature is full of examples in higher education designed to support women and other underrepresented students in persisting in STEM once they arrive on campus[8].

* Although some practitioners also include an additional "M" of medicine, for our purposes here, we are using the more common STEM acronym, although programs focused on medical sciences and careers may also benefit from the practices in this guide.
Similarly, we did not examine literature related to programs that include the "A" of arts in their STEM mentoring programming, something that has gained popularity in recent years to compliment the traditional focus of STEM education.

But while the popularity of STEM mentoring has grown, the research on what makes these programs effective, either in isolation or in combination with other supports, has lagged behind. While the past decade has seen tremendous progress in identifying program practices that can potentially improve outcomes for youth in mentoring programs more generally, there hasn't been much direct research on the unique nuances and strategies that can make STEM mentoring programs work most effectively. One major review of the literature on relationship-based STEM interventions found that the research to draw from was so thin that instead of producing a set of recommended practices, the authors took note of the gaps in our understanding of STEM interventions to set a research agenda that might shed light onto best practices[9].

BRINGING EVIDENCE-BASED PRACTICES TO STEM MENTORING

As a leading research-to-practice organization in the youth mentoring space, MENTOR has always worked with researchers and practitioners to develop and disseminate evidence-based and practice-informed guidelines for mentoring programs. Our cornerstone publication, the *Elements of Effective Practice for Mentoring*[10], now in its fourth edition, is heavily informed by research on the program practices that tend to yield safe and strong adult-youth mentoring relationships. This resource is widely considered to be the most globally applicable set of recommendations for mentoring practitioners, providing a broad set of practice recommendations across an increasingly diverse field, including STEM mentoring programs.

Despite the global applicability of the *Elements of Effective Practice for Mentoring* (hereafter referred to as the *Elements*), there is a growing body of research in implementation science indicating that not all interventions, even ones that are remarkably similar in services and populations served, will benefit from following the exact same practices[11]. We certainly see this dynamic in the mentoring field, with mentoring programs serving youth across the age spectrum in diverse settings with diverse goals in mind and varying resources at their disposal. There has been a growing sense that broad standards of practice such as the *Elements* might not provide the nuanced and context-specific guidance on practices that matter for mentoring programs using alternative models, serving narrower populations of young people, or emphasizing a narrow set of prescribed outcomes (e.g., pursuing a STEM career). Thus, in the spirit of supporting the increasingly diverse youth mentoring field, MENTOR has launched a series of "supplements" to the *Elements of Effective Practice for Mentoring.* The closer examination of STEM mentoring research and practices in this guide represents the first entry in this series and we hope that it can bring sharper focus to the work of STEM mentoring programs and ensure that all young people get the psychosocial and instrumental support they need to persist in STEM through the help of dedicated mentors.

Development of This Guide

This supplement was developed by the same team of researchers and technical assistance providers who developed the full fourth edition of the *Elements of Effective Practice for Mentoring* through generous funding provided by STEM mentoring leaders at Genentech, a member of the Roche Group, which operates several mentoring programs designed to get youth interested in STEM and persevering all the way through the undergraduate experience.

As with the full *Elements*, the recommendations in this guide are as grounded in the available research evidence as possible. To facilitate this effort, the team conducted an extensive literature review focused on identifying peer reviewed journal articles, government reports, and corporate literature detailing the structure and effectiveness of STEM mentoring programs. *See the text box on the next page for additional details about our literature search process.*

Reflections on the STEM Mentoring Literature

When looking at the results of the literature review as a whole, there are several characteristics that stand out for the research-to-practice work of this guide:

► ***The overall volume of research on STEM mentoring programs for youth is rather thin***

Very few STEM mentoring programs have been formally evaluated using any kind of experimental or quasi-experimental design. Most of the evaluations we encountered in this review either used qualitative methods to track and understand participant experiences or provided pre-post assessments of youth outcomes without utilizing a comparison or control group. None of the studies we reviewed tested variations in practices, meaning they shed little light on how STEM mentoring programs can improve services or try new approaches. And given that STEM mentoring programs often state long-term goals of helping youth matriculate through STEM higher education pathways and

LITERATURE SEARCH PROCESS

A comprehensive search of the literature was conducted to identify articles about mentoring related to the STEM fields. Both computer-based and manual search methods were used to locate studies. The computerized databases utilized were PsycINFO, ERIC, and Web of Science. The search of each computerized database included the following terms and combinations of terms:

- Youth + mentor + science
- Youth + mentor + technology
- Youth + mentor + engineering
- Youth + mentor + mathematics
- Mentor + science
- Mentor + technology
- Mentor + engineering
- Mentor + mathematics
- College student + mentor + STEM
- College student + mentor + science
- College student + mentor + technology
- College student + mentor + engineering
- College student + mentor + mathematics

These searches yielded peer-reviewed articles and program evaluation reports. Articles of prominent youth mentoring programs in STEM and literature reviews were manually searched to identify additional articles. To be considered for inclusion, articles had to address the utilization of mentoring to increase interest, skill, ability, engagement, or vocational goals in science, technology, engineering, and/or mathematics. This process resulted in 102 articles that met these criteria.

Once identified, articles were coded for participant and program characteristics. The age group of the target population of mentees (i.e., youth or adult) was coded, as well as any specific foci of the program/article (e.g., gender, underrepresented populations, disability). In addition, articles were coded for their STEM content (i.e., whether they focused on science, technology, engineering, math, or general STEM). Articles were also coded based on whether they addressed the following topics: mentor, mentee, and staff recruitment; mentor, mentee, and staff screening; mentor, mentee, and staff training; matching procedures; initiating (i.e., first meeting) procedures; monitoring of matches; support for matches; and match closure.

The 102 articles included the following breakdowns:

- **EIGHTY-TWO PEER-REVIEWED JOURNAL ARTICLES;**
  20 were a different kind of paper (e.g., a conference paper or program report);

- **FORTY-FIVE PROGRAM EVALUATIONS;**
  57 were other types of papers (e.g., literature reviews, empirical articles that were not program evaluations);

- **FORTY-NINE ARTICLES FOCUSED ON YOUTH MENTORING (K–12):**
  44 on undergraduate/graduate student focused mentoring, and 9 on STEM career/workplace mentoring.

Following this systematic search, the authors of this guide then supplemented this initial scan by manually retrieving additional articles and reports from related disciplines, such as general STEM education; concepts that influence STEM attrition, such as stereotyping and implicit bias; and group and workplace mentoring more broadly. These additional articles were critical in reinforcing and clarifying the final recommendations detailed in this guide. Including these articles, a total of 204 documents informed the content presented here.

into STEM careers, few of the studies attempted to track youth participants through some of these distal points to see if the program changed educational trajectories in a meaningful way. Most of the outcome evaluations were centered in higher education settings, examining programs offered on campus for undergraduate students. Few studies on programs led by STEM businesses as part of creating a talent pipeline were found in our review.

► *The diversity of STEM mentoring programs raises challenges when developing broad practice recommendations*

The research we reviewed covered everything from programs designed to get elementary and middle school students first interested in STEM activities all the way through providing undergraduate students with intensive hands-on research opportunities on a college campus. It included programs whose goals were purely around academic success and progress, as well as programs designed to shift demographic patterns in a specific STEM industry. Some were set in schools, others were housed at STEM businesses or nonprofit spaces. And each program emphasized unique relational aspects to meet very specific youth needs. All this diversity of programming and purpose made it challenging to develop recommendations that could globally apply to all STEM mentoring programs. Thus, readers should note that many of the recommendations in this guide come with caveats or clarifying statements that can help practitioners decide how critical a recommendation is to their work.

► *More rigorous evaluation is needed*

As noted above, very few of the studies in this review examined *how* mentors supported STEM development in a rigorous way. While we found many wonderful examples of qualitative research that described what participants gained from the experience and how their mentors encouraged them, most of the studies did not compare or contrast different mentor approaches, examine variations in program practice, or explore subgroup findings to see if mentoring was more or less effective for certain types of youth. We also found few studies examining one of the most critical questions regarding STEM mentoring: the "value added" of having *a mentor* in on top of simply engaging in STEM activities in educationally focused programs. A better understanding of how mentoring relationships enhance and deepen engagement beyond just participation in STEM learning opportunities and exploration would help in developing practice recommendations that would facilitate those relationships.

Please see section 3, "Program Evaluation and Outcome Measurement in STEM Mentoring," for further discussion of recommended practices for studying these types of programs.

STEM WORKING GROUP MEMBERS

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Please see the end of this section for more details about the programs and organizations that contributed to the development of this guide.

The STEM Mentoring Working Group

In addition to our review of the literature, we also convened a working group of representatives from high-quality STEM mentoring programs around the country (see sidebar for participants), as well as researchers with expertise in career-focused mentoring. These experts were instrumental in:

- Suggesting practices that they felt were critical to their work in the STEM mentoring space.
- Confirming, clarifying, or, in some cases, rejecting suggested practices from the research literature. Their review was especially helpful on issues related to matching mentors and mentees, match support and supervision, and closure of matches.
- Reviewing and approving of the final recommendations of this guide.

This group met a total of four times to discuss best practices, review drafts of recommendations, and to share details about their work and the outcomes they track. You can read more about the practices employed by these STEM leaders throughout this guide.

USING THIS GUIDE

Readers should note that this guide serves as only a supplement to the full *Elements of Effective Practice for Mentoring*. It is intended to provide additional guidance and nuance to the items found in the full *Elements*, and references Benchmarks and Enhancements described more fully in that document. Here we cover only the Benchmarks and Enhancements that we felt needed additional recommendations for STEM mentoring programs. However, STEM mentoring programs are still encouraged to implement all of the Benchmarks (and as many Enhancements as possible, when appropriate) from the entire set of Standards in the *Elements*. Please keep the supplementary nature of this resource in mind when considering how to start or improve a STEM mentoring program.

THE GUIDE IS DIVIDED INTO THREE MAJOR SECTIONS:

1 GENERAL PROGRAM DESIGN PRINCIPLES FOR STEM MENTORING PROGRAMS

This section builds on our review of the research and the guidance of our Working Group to review some of the major features and components of quality STEM mentoring programming. This section will be most useful to start-up efforts, or for STEM mentoring programs looking to refine or clarify their theory of change or the services they offer. An accompanying typology of STEM mentoring models and theories of change is also included in the Appendix.

2 STANDARDS OF PRACTICE FOR STEM MENTORING PROGRAMS

This section covers the six core Standards of the *Elements of Effective Practice for Mentoring.* Specific recommendations for STEM mentoring programs are offered around Benchmarks and Enhancements related to:

- RECRUITING
- SCREENING
- TRAINING
- MATCHING AND INITIATION
- MONITORING AND SUPPORT
- CLOSURE

3 PROGRAM EVALUATION AND OUTCOME-MEASUREMENT IN STEM MENTORING

This section offers tips for STEM mentoring practitioners on how they can strengthen their program evaluation strategies, as well as a list of common outcomes that STEM mentoring programs reported assessing based on their goals and target population of youth.

Throughout each of these sections, you will find small **case study examples** from our Working Group members of these practices in action. We hope these real-life examples help other practitioners better understand and implement innovations in their programs.

Readers are also encouraged to have a copy of the full *Elements of Effective Practice for Mentoring* handy as they review this guide so that they can have access to the full complement of practices that MENTOR recommends they implement in their STEM mentoring work, when applicable.

ABOUT THE PROGRAMS WHOSE WORK INFORMED THIS GUIDE

At **3M**, we apply science in collaborative ways to improve lives daily. With $32 billion in sales, our 91,000 employees connect with customers all around the world. Learn more about 3M's creative solutions to the world's problems at **www.3M.com** or on Twitter @3M or @3MNews.

As a science-based company that has thrived for 115 years, we understand the importance of investing in the next generation of scientists and innovators. That's why we're committed to generating interest and increasing achievement in STEM especially among underrepresented populations—and our student mentoring program is one of the ways we do this. STEP is one of four Science Encouragement Mentoring Programs that 3M created to empower employees and retirees to spark students' interest in STEM. Another opportunity, the 3M Visiting Wizards, is especially popular among 3M retirees. With a kit of science experiments in hand, the Visiting Wizards perform the magic of science in classrooms in the Twin Cities metro area. Through STEM-focused mentoring and outreach programs, 3M supports equitable education outcomes and equips the next generation of scientists with tools and experiences to support success.

GENENTECH'S FUTURELAB INITIATIVE

In South San Francisco, more than 30 percent of students are English-language learners and 40 percent come from low-income families. And, while schools here have higher graduation rates than the state average, only one in three students goes on to attend a four-year university. Futurelab, Genentech's partnership with South San Francisco schools, aims to change this. In 2015, Genentech launched Futurelab—a hyper-local science education initiative, in deep partnership with SSFUSD, which gives all students K–12 the opportunity to get excited about science, to equip and engage them in rigorous hands-on science, and to inspire them to pursue STEM-related careers. Through Futurelab, we're focused on achieving our ultimate goal: to inspire students to reach their potential as the next generation of innovators and to engage them in a lifelong exploration of science.

GIRLS INC. inspires all girls to be strong, smart, and bold. Our comprehensive approach to whole girl development equips girls to navigate gender, economic, and social barriers and grow up healthy, educated, and independent. These positive outcomes are achieved through three core elements:

PEOPLE: trained staff and volunteers who build lasting, mentoring relationships.
ENVIRONMENT: girls-only, physically and emotionally safe, where there is a sisterhood of support, high expectations, and mutual respect.
PROGRAMMING: research-based, hands-on and minds-on, age-appropriate, meeting the needs of today's girls.

Informed by girls and their families, we also advocate for legislation and policies to increase opportunities for all girls. Join us at **girlsinc.org**.

THE NYC SCIENCE RESEARCH MENTORING CONSORTIUM

is a group of New York City academic, research, and cultural institutions committed to providing NYC high school students from high-potential/under-resourced and underrepresented backgrounds with mentored, authentic research experiences in STEM. A key tenet of the Consortium is providing foundational coursework to these students to increase their comfort and competency when entering the lab, and ultimately result in a more successful experience for both the student and mentor.

Together, the 22+ partners of the Consortium share experiences and expertise, and identify opportunities and strategies to effectively support youth in developing science research skills and competencies. The Consortium model cultivates a community of practice that creates a social network of scientists, graduate students, educators, and like-minded peers with shared values and research endeavors. In building access in STEM academics and careers, we also provide students with college and career readiness resources and supports.

The **STEM TALENT PATHWAY** is a signature project of the SF Chamber of Commerce Education and Workforce Initiative, UniteSF. This collective impact effort was launched in 2015 with the Mayor's Education Council and the SF Chamber of Commerce to create stronger pathways for SFUSD students into STEM careers. The STEM Talent Pathway works closely with the city My Brother and Sister's Keeper initiative to address the lack of diversity representation in STEM college and career programs and in pursuing STEM degrees and careers. The role of the SF Chamber is to increase awareness and connection with business and education leaders to expand and align investments to increase the number of mentors, internships, and scholarships along a connected pathway of support for San Francisco youth into STEM careers.

SCIENCE CLUB is an award-winning after school program that utilizes a long-term mentoring strategy to raise underserved middle school (grade 5-8) students' science engagement, scientific skills, and support the long-term pursuit of STEM careers. The program was developed in 2008, in partnership with staff and leaders at the Boys & Girls Clubs of Chicago (BGCC) and teachers in Chicago Public Schools (CPS). Each week throughout the academic year, youth and mentors work in small groups—four youth and two mentors—on challenging, hands-on investigations at a community site (Boys & Girls Club, YMCA etc.). With key input from teachers and community site staff, youth groups are formed in an age- and aptitude-specific way.

Curricula, each lasting 7–10 weeks (90-minute meeting sessions per week), were developed collaboratively by CPS teachers and Northwestern staff to provide deeper exploration into scientific areas of strong interest to kids. These range from food science to biomedical engineering. Units are strongly grounded in authentic applications of science, and the eight scientific practices as outlined in the Next Generation Science Standards (NGSS). Finally, mentor training and ongoing support are key program elements. Mentors receive ongoing professional development in the areas of pedagogy, youth engagement, science communication, cultural awareness, program design, and evaluation. In this way, Science Club trains both the scientists and science education providers of tomorrow.

SEA RESEARCH FOUNDATION (SRF) is a 501(c)(3) nonprofit organization whose mission is to inspire people to care for and protect our ocean planet through conservation, education, and research. SRF operates Mystic Aquarium — one of America's premier nonprofit marine science research and education institutions, and an accredited member of the Association of Zoos & Aquariums and the Alliance of Marine Mammal Parks and Aquariums. STEM Mentoring is SRF's national group mentoring program for youth ages 6–10. The program brings together small groups of youth and mentors for fun, hands-on activities about STEM, with a particular focus on conservation.

The overall goal of **STEM MENTORING** is to positively impact the social development and academic achievement of participating youth. Through weekly group mentoring sessions and additional STEM enrichment activities, youth are exposed to inspiring scientists, engineers, and conservationists, who represent a variety of careers and education pathways. By providing consistent, high-quality, STEM-focused mentoring experiences for youth, STEM Mentoring encourages decreased engagement in risk factor indicators, improvement of academic success indicators, and an overall increase in knowledge of and interest in STEM topics and careers. Since its inception in 2015, STEM Mentoring has engaged more than 6,000 youth and 1,500 mentors at more than 100 after-school sites across the country.

RESEARCHERS WHO INFORMED THIS GUIDE

WENDY MARCINKUS MURPHY, PHD, is an associate professor of Management at Babson College. Her research is at the intersection of careers, mentoring, and work-life issues, with particular attention to nontraditional developmental relationships and learning. She has served as the faculty adviser for the Mentoring Programs through the Center for Women's Entrepreneurial Leadership (CWEL) at Babson. In addition, she created an e-mentoring program at Northern Illinois University to connect students to working professionals. Murphy has published her work in a range of journals, including *Academy of Management Learning & Education, Human Resource Management, Gender in Management, Journal of Management,* and the *Journal of Vocational Behavior,* among others. Her book with Dr. Kathy Kram, *Strategic Relationships at Work: Creating Your Circle of Mentors, Sponsors, and Peers for Success in Business and Life*, bridges mentoring scholarship and practice. In 2014, she was recognized by Poets & Quants as one of the "40 Most Outstanding B-School Profs Under 40 in the World."

JEAN RHODES, PHD, is the Frank L. Boyden Professor of Psychology and the director of the Center for Evidence-Based Mentoring at the University of Massachusetts Boston. She has devoted her career to understanding and advancing the role of intergenerational relationships in the intellectual, social, educational, and career development of youth. She has published three books, four edited volumes, and more than 100 chapters and peer-reviewed articles on topics related to positive youth development, the transition to adulthood, and mentoring. Dr. Rhodes is a Fellow in the American Psychological Association and the Society for Research and Community Action, and was a Distinguished Fellow of the William T. Grant Foundation.

References

[1] National Science Board. (2010). *Preparing the next generation of STEM innovators: Identifying and developing our nation's human capital.* Arlington VA: National Science Foundation (NSB-1033).

[2] President's Council of Advisors on Science and Technology. (2010). *Report to the President. Prepare and inspire: K–12 education in science, technology, engineering, and math (STEM) for America's future.* Retrieved from https://nsf.gov/attachments/117803/public/2a--Prepare_and_Inspire--PCAST.pdf

[3] Kuenzi, J. J. (2008). *Science, technology, engineering, and mathematics (STEM) education: Background, Federal policy, and legislative action.* Congressional Research Service Reports, Paper 35. http://digitalcommons.unl.edu/crsdocs/35

[4] Freeman, C. E. (2004). *Trends in educational equity of girls & women: 2004* (NCES 2005–016). U.S. Department of Education, National Center for Education Statistics. Washington, DC: U.S. Government Printing Office.

[5] Leddy, M. H. (2010). Technology to advance high school and undergraduate students with disabilities in science, technology, engineering, and mathematics. *Journal of Special Education Technology,* 25(3), 3–8.

[6] National Academy of Sciences, National Academy of Engineering, Institute of Medicine. (2011). *Expanding underrepresented minority participation: America's science and technology talent at the crossroads.* Washington, DC: National Academies Press. Retrieved from https://www.nap.edu/read/12984/chapter/1

[7] National Science Foundation, National Center for Science and Engineering Statistics. (2017). *Women, minorities, and persons with disabilities in science and engineering: 2017*. Special Report NSF 17-310. Arlington, VA. www.nsf.gov/statistics/wmpd/

[8] Hernandez, P. R., Schultz, P. W., Estrada, M., Woodcock, A., & Chance, R. C. (2013). Sustaining optimal motivation: A longitudinal analysis of interventions to broaden participation of underrepresented students in STEM. *Journal of Educational Psychology,* 105(1), 89–107. http://dx.doi.org/10.1037/a0029691

[9] Gamse, B. C., Martinez, A., Bozzi, L., & Didriksen, H. (2014). *Defining a research agenda for STEM Corps: Working white paper.* Cambridge, MA: Abt Associates.

[10] Garringer, M., Kupersmidt, J., Rhodes, J., Stelter, R., & Tai, T. (2015). *Elements of effective practice for mentoring (4th ed.)*. Boston, MA: MENTOR: The National Mentoring Partnership. Retrieved from http://www.mentoring.org/images/uploads/Final_Elements_Publication_Fourth.pdf

[11] Fixsen, D L., Naoom, S. F., Blase, K. A., Friedman, R. M,. & Wallace, F. (2005). *Implementation research: A synthesis of the literature.* Tampa, FL: University of South Florida, Louis de la Parte Florida Mental Health Institute, The National Implementation Research Network (FMHI Publication #231).


Photo courtesy of Midlands Mentoring Partnership

1 GENERAL PROGRAM DESIGN PRINCIPLES FOR STEM MENTORING PROGRAMS

As noted in the Introduction, our literature review highlighted the tremendous diversity of programming that falls under the umbrella of "STEM mentoring." The programs discussed in the literature varied considerably in terms of the ages of youth served, their program goals, the structure and activities of the mentoring relationships, and the outcomes measured to determine success.

In this section, we offer an overview of some of the common features and objectives of STEM mentoring programs across the age spectrum, from elementary and middle school all the way through the undergraduate experience (for the purposes of our literature review's definition of "youth" we did include programs serving young adults up to the age of 24, allowing us to include undergraduate and early-career mentoring efforts, but leaving out most programs aimed at older doctoral students or internal mentoring programs for mid-level adult employees in STEM companies).

This section should be helpful to those looking to start a new STEM mentoring program or refine an existing one. To facilitate adoption of stronger STEM mentoring models, we review several **general program format and design considerations** that emerge from the literature. We also include a discussion of **program goals and activities**. These recommendations and program traits may not be applicable to all STEM mentoring programs, but they should be helpful to funders or practitioners who are interested in serving particular groups of youth or looking to better align program goals and activities.

We also provide a chart (see Appendix A) that offers a general typology of STEM mentoring programs and an overview of common STEM mentoring models, goals, mentors, settings, activities, and outcomes differentiated by the ages of the youth served roughly corresponding with elementary, middle, and high school programming, as well as undergraduate STEM mentoring at higher education institutions.

PROGRAM FORMATS

In reviewing the literature on STEM mentoring, we find that both in-person and online approaches are common. In-person mentoring, whether one-to-one or in groups, seems to be most common in programs intended to either spark initial interest in STEM for young children or in programs aimed at supporting older youth through some transition point (e.g., applying to college as a STEM major). Online models tend to be used in programs that seek to build large numbers of STEM relationships or to provide access to a wide variety of role models and perspectives. Online formats are also popular when in-person relationships are not possible due to geographic distance or other factors such as individual disability[1]. Both in-person and online formats demonstrated evidence of effectiveness in our review, but these different program formats often differ in key ways related to their structure and the focus of their mentoring relationships.

In-Person STEM Mentoring

In addition to models where one mentor is paired with one mentee, there are several additional varieties of in-person mentoring found in STEM mentoring:

- One mentor to many youth (often in programs that emphasize hands-on experiments)
- Many mentors to one youth (with each mentor filling a unique role or perspective)
- (Near) peer group programs (common in undergraduate mentoring programs where masters or doctoral students mentor groups of undergraduates, as well as programs where undergraduates mentor high school students)
- Many mentors to many youth (most common in online platforms or models where a cohort of youth is placed in internships together)

Another common configuration for STEM mentoring programs is what might be called a **"layered" approach** to mentoring. In these programs the primary mentor is supported by a more senior scientist or faculty member while in turn serving a child or adolescent mentee[2]. The most common configuration for this approach has a senior faculty member supervising/mentoring an undergraduate mentor who is in turn working with a high school or middle school student. These programs have the potential to both spark STEM interest and efficacy in younger students, while also strengthening the undergraduate experience and supporting persistence and completion of STEM majors[3].

As noted above, we also encountered examples of **multi-mentor approaches** where youth get several mentors or "engaged adults" working with them at once. The most common configurations for these programs have a student mentor working in tandem with a faculty mentor (in higher education settings) or a worksite supervisor offering mentoring related to job skills while another employee mentor offers more social and emotional support around workplace culture, belonging, and "soft skills" such as networking and professionalism. The appeal of these programs is to ensure that young people get support on multiple fronts and that those with some authority or supervisory obligation over mentees are not also tasked with providing deeper social and emotional support that might conflict with their supervisory role. A good example of this type of multi-mentor approach can be found in the case study of 3M's mentoring model *(see sidebar)*.

Online STEM Mentoring

Online mentoring formats are mostly used in programs where exposing youth to a large variety and volume of STEM professionals or academics is important to the goals of the program. This approach is common, for example, in programs designed to help high school–age girls engage with a number of female scientists so that they can develop a sense of belonging in STEM and access a wider variety of scientists who could be helpful to their academic or career aspirations[4]. Online platforms allow for considerable networking within STEM fields, offer youth a wider variety of perspectives and supports, facilitate youth finding rare STEM role models who come from similar genders or backgrounds, and may offset the negative experiences that can occur when one-to-one matches do not meet participants' satisfaction[5]. The research also suggests, however, that for some youth a closer personal relationship with one mentor may be most impactful for overcoming personal barriers to STEM participation[6]. These more intensive dyadic relationships can offer more focused and intensive support than a dispersed group of online mentors online.

For programs using an online platform, the research suggests that the **frequency of interactions** between mentor and mentee is a key factor in the success of the relationship. For programs using a group online format, the **number of mentors communicated with** by youth may also be an important metric that speaks to the amount and quality of support a young person is getting and how personally engaged they are with STEM as a whole[7].


Photo courtesy of 3M

STEM MENTORING IN ACTION:

The Value of Multiple Mentors at 3M

THE 3M STEP (SCIENCE TRAINING ENCOURAGEMENT PROGRAM), now in its 46th year, brings high school juniors and seniors into the 3M's laboratories to learn alongside scientists. This unique experience offers students from Minnesota's Saint Paul Public School District the opportunity to develop mentoring relationships with professionals in the STEM field. And, for numerous past participants, the program offers a stepping stone into a career as a 3M corporate scientist.

Through STEP, students are matched with two mentors—a Technical Mentor and a Networking Mentor—who serve distinct yet complementary roles throughout the internship. The Technical Mentor oversees the student's lab projects and provides feedback and support as the student learns new skills and collaborates with the team. On the other hand, the Networking Mentor interacts outside the lab and focuses on helping the student navigate professional obstacles and personal challenges, as well as connecting the student with additional opportunities, professionals, and experiences. Together, the two mentors meet with the student to get to know one another and discuss the student's goals.

This team mentoring approach provides students with a rich support system and comprehensive sounding board. Mentors are intentionally paired to have different areas of expertise, offering students access to a varied network of professionals with diverse skill sets. Encouraged to reach out with personal and career-related topics, students receive multiple perspectives in return. Some students find they're comfortable approaching different mentors for different topics, while other students connect better with just one mentor. Having two mentors increases the likelihood that the student will develop a personal connection with at least one, and it also enables students to develop a more robust professional network.


Photo courtesy of Genentech

YOUTH AGE AND PROGRAM PURPOSE

As noted above, our scan of the field identified programs serving youth across the K12 spectrum and into undergraduate higher education contexts. But we also noted a shift in program purpose as youth matriculate through their education.

Programs serving youth in elementary and middle school tend to use mentoring to generate enthusiasm for STEM, show how STEM subjects apply to real world settings and issues, share more information about STEM careers and the roles scientists play in solving problems, and nurture self-identification as someone who could someday be a scientist or apply STEM skills. Because many of these programs are set in schools, they often also have an explicit goal of improving performance and grades in STEM subjects. However, we did also note a theme that many of these programs taught “soft” skills that would also be very applicable to STEM careers, such as teamwork and collaboration, organizational skills, and clear communication, in addition to more academically focused goals.

Once students move into high school and undergraduate settings, the focus of these mentoring programs tends to shift to solidifying STEM identity (rather than creating it), building practical skills, offering hands-on research or laboratory experiences, and helping youth overcome systemic barriers. These programs tend to pair mentors and youth for longer periods of time and frequently use “embedded” experiences, such as internships or a role on a research team as a way of building both practical skills and a sense of belonging in STEM work. They also frequently emphasize planning for, or direct completion of, various transition point activities, such as applying to college as a STEM major, presenting research at an academic conference, or securing a first job at a STEM company.

There is some sentiment in the literature that creating the initial interest in spark is something that needs to happen before high school [8,9,10]. However, we did find examples of programs that were explicitly about trying to entice high school students, especially girls and youth of color, who might have potential in STEM but who had not connected to or identified with a STEM-related future[11]. In spite of these exceptions, most programs for younger students tend to focus on creating that STEM “spark” while those for older youth are more instrumental in nature and focused on *maintaining* STEM engagement.

There was considerable consensus in the literature, though, that neither approach was likely to be successful in the long-term without the other, that a more continuous series of mentoring opportunities might be most effective in growing the number of STEM professionals generally and closing race and gender gaps in STEM industries and academia[12,13,14]. What seems to be most needed, yet rarely provided to youth, are STEM opportunities across their childhood into adolescence and young adulthood[15,16]. Varied mentoring relationships (and programs) over time, each providing the right boost to engagement and self-efficacy at the right moment, may be most effective for helping youth overcome barriers to their STEM participation and persist in the face of institutional or systemic inequities.

A good example of this form of intentional “handoff” from one program to another over a student’s matriculation can be found in the profile on the next page highlighting the transitioning of mentees across Genentech’s many Futurelab STEM mentoring programs.

Photo courtesy of Genentech

STEM MENTORING IN ACTION:

Genentech's Futurelab Initiative

FUTURELAB is a hyper-local STEM education initiative that supports all K–12 students in the South San Francisco Unified School District (SSFUSD) and provides rigorous, hands-on science. While there are a number of programs that engage South San Francisco (SSF) students and teachers, there are three signature programs that highlight a continuum of programming that engages elementary, middle, and high school students: Gene Academy, Helix Cup, and Science Garage.

Gene Academy is an elementary after-school mentoring program for SSF third- through fifth-grade students that pairs approximately 200 students with two Genentech mentors to work together on homework and hands-on science experiments for an entire academic year.

Helix Cup is an annual, semester-long science competition designed to engage all eighth-grade students—approximately 630 students—from SSF middle schools to help them develop problem solving, teamwork, and science skills with the help of more than 100 Genentech coaches who guide student teams throughout the competition.

Science Garage is a high school classroom and lab that provides a four-year, and lab-focused biotech curriculum pathway. This program gives 1,000+ high school students in the district the chance to gain lab skills and increase their awareness of careers in biotech with the help of more than 140 Genentech scientists or "teachers assistants" who go into the classroom every week during the entire academic year to support lab execution and share more about their career journeys.

This continuum of programming establishes multiple touchpoints to engage students in STEM and helps students develop multiple relationships with STEM professionals from Genentech throughout their educational journey. In a field as challenging as STEM, students are at an advantage if they have multiple supportive relationships that can help them find a STEM internship or complete STEM programs. This continuum of programming empowers students to foster a passion for STEM at an early age that they can build upon during middle school and high school, as they develop practical STEM competencies and consider careers in STEM. Based on third party evaluation, this comprehensive approach has been successful in fostering excitement about STEM, boosting confidence in doing hands-on STEM, and cultivating STEM skills.

OTHER INFLUENCES ON PROGRAM PURPOSE

In addition to age-related shifts in program purpose, there were a few other factors that tended to shape the activities and areas of emphasis for STEM mentoring programs:

Closing Demographic Gaps in STEM Fields

The majority of the STEM programs discussed in the literature had an explicit focus on helping youth from underrepresented groups engage with and persist in STEM academic and career pursuits. These groups included girls and young women, members of specific racial and ethnic groups, youth with disabilities, and youth living in poverty. Even when programs did not explicitly state that their intentions were to close these gaps, they often noted that they worked in schools or nonprofit settings that served high numbers of youth of color or low-income youth or that some special outreach was conducted to support the involvement of similar groups.

Interestingly, we found examples of programs designed to support struggling and disengaged students[17,18,19], as well as programs that were explicitly supporting talented and gifted students who were already deeply engaged in STEM, keeping them on an existing pathway toward an eventual STEM career[20,21,22]. Obviously, mentors in these programs engaged in different strategies and forms of support, but this finding further highlights that mentors can be important for all types of students, regardless of their STEM abilities or current level of future STEM planning. Mentoring relationships seem to be valuable across the entire spectrum, especially when deployed in an effort to maximize the long-term engagement of groups that have traditionally struggled to show interest or persist in STEM fields.

Direct Talent Pipelines

Less frequent in the literature were examples of programs sponsored by STEM companies or industries. These programs tend to focus on engaging high school age youth, providing them with internships, summer bridge research opportunities, or other projects that would develop youth skills and potentially help identify students with high aptitude for specific STEM careers[23]. While these types of programs were not referenced much in the peer-reviewed literature (reflecting a lack of emphasis on producing academic papers as an outcome of evaluating these types of programs), our Working Group of STEM practitioners certainly reflects this emphasis on nurturing the pipeline of STEM talent with programs sponsored by organizations as varied as a teaching aquarium (Sea Research Foundation), a biotechnology company (Genentech), and a multi-industry corporation like 3M. Each of these programs serves as an example of a company or industry investing in the next generation of workers directly through mentoring.

PROGRAM GOALS AND ACTIVITIES

As noted above, the main intentions of STEM mentoring programs are largely reflective of the ages of the youth served with corresponding activities that are appropriate for their developmental stage and current level of STEM engagement. In general, when looking across all ages, we see that specific goals of STEM mentoring programs tend to cluster around three main outcomes:

- ***Changing mentees' attitudes, beliefs, and plans related to STEM***

  Much of the work of STEM mentoring programs focuses on **building confidence and feelings of self-efficacy** around STEM subjects. These programs are grounded in a belief that youths' desire to continue in STEM pursuits will be strengthened if they feel like they have *the ability* to do well in STEM subjects. In addition to building confidence, these programs also tend to build a **sense of belonging** and **"STEM identity,"** in which youth feel like a STEM class or career is a place that fits who they are and where they are welcomed and encouraged[24]. We found support in the literature for programs that help develop feelings of "self as scientist," in which mentored youth are able to not only see their future self in a STEM career or role but feel that engaging in STEM is an essential part of who they are as a person[25]. Helping youth see themselves in this light is particularly important in programs serving groups traditionally underrepresented in STEM fields who may need the extra support and personal connection with mentors to truly embrace STEM in this deep way. For a good example of a program that emphasizes making students feel welcome in the "culture of science" see the case study on the work of the New York City Science Research Mentoring Consortium later in this section.

  Lastly, we find that STEM mentoring programs often take these mentee gains in confidence and belonging and leverage that change in service of **increased planning to participate or continue** in STEM classes, applying to college as a STEM major, or transitioning into graduate school or a STEM career. While helping youth feel at home in the world of STEM is valuable, it means little if they don't actually follow through on practical steps along the pathway toward a STEM career. Thus, many programs provide instrumental supports (e.g., help with college access[26] or internships to gain job experience) that make those gains in confidence and belonging actionable.

- ***Increased participation in STEM***
  In addition to changes in attitudes and plans, another set of goals is focused on measurable **increases in engagement and participation** in STEM activities[27]. This can be measured in terms of taking more STEM classes, consuming more STEM-related media, engaging in additional STEM opportunities outside the program, and enrolling in higher education as a STEM major. Many STEM mentoring programs view themselves as a "gateway" to a world of other STEM opportunities, often providing that first initial spark or hint of success that helps a mentee connect to STEM subjects or see STEM careers in a new light. Mentors in these programs encourage their mentees to engage more in STEM activities, including at home and with parents and siblings who can be instrumental in facilitating additional learning.

- ***Increased STEM knowledge, skills, and achievement***
  These are common goals for programs working in educational settings, where the involvement of STEM mentors is intended to produce **improvements in mentees' STEM test scores, grades, and other markers of academic achievement.** While these goals are hoped for across the age spectrum, they are most common in programs for older students that offer hands-on research opportunities, longer-term projects, and embedded experiences in STEM settings. These programs tend to emphasize "mastery skills" that allow mentees to take the next steps in their STEM education or careers and apply what they have learned to real-world projects and tasks[28].

Many of the programs described in the literature combine all three by getting youth engaged in STEM mentoring activities and conversations with their mentor that, in turn, build confidence and feelings of belonging in STEM, which further translates into increased knowledge and attainment in STEM. Northwestern's Science Club program is one such example (reference; see vignette on p.71).

It is worth noting that most STEM mentoring programs address more than one of these goal areas. Many of the programs described in the literature combine all three by getting youth engaged in STEM mentoring activities and conversations with their mentor that, in turn, build confidence and feelings of belonging in STEM, which further translates into increased knowledge and attainment in STEM. Mentors in these programs, however, may be tasked with a role related to only one of these goal areas. For example, a program may choose to have volunteer mentors talk with youth about overcoming racial, gender, or other systemic barriers to a STEM career, while program staff or other professionals lead tutoring or other instructional time designed to increase STEM skills and knowledge. Alternatively, mentors may be focused on direct teaching of STEM skills and processes for doing research, while others address the more relational or social-emotional aspects of engaging in STEM. Programs should think carefully about what roles mentors need to fill and if there is a need to have a wider range of caring adults step in to address barriers to youths' STEM engagement.

In addition to these broad goals, it's worth noting that many programs, particularly those trying to get traditionally underrepresented groups engaged in STEM, also provided **additional tutoring or hands-on instruction**, along with mentoring, as part of their services[29,30]. These programs rightly recognize that it is unrealistic to expect mentees to become more engaged with STEM or to see themselves in a STEM career if they are struggling in the classroom or are behind their peers in STEM knowledge. Thus, one strategy of many programs is to help youth "catch up" to their peers in order to lay the foundation for the growth in confidence and burgeoning STEM identity that follows.

There is no "right" configuration of activities for STEM mentoring programs, but each program should have a theory of change that explains which of these goals are important to them and how mentors and others work together to address these three broad program goals.

Program Activities for Older Mentees

For older mentees, particularly high school–aged students who have already expressed an interest or aptitude in STEM, one of the more prominent activities was participating in **direct research experiences**, often as part of a **summer bridge program**. These types of summer programs offer a chance for mentees to work directly alongside more experienced scientists and build their

STEM MENTORING IN ACTION: New York City Science Research Mentoring Consortium

Programs within the **NEW YORK CITY SCIENCE RESEARCH MENTORING CONSORTIUM** are committed to immersing mentees into the culture of science. As with many fields, scientists have a unique set of norms that influence how professionals generally approach teamwork and collaboration, literature and language, and work in laboratories. Consortium mentors strive to bring mentees into that culture so they can better understand how science operates and are empowered to develop their own identity within the science community.

Mentors expose mentees to various aspects of science culture by inviting them to meetings and events within the science community. Mentees often attend their lab's meetings, where the principal investigator, other researchers, and students in the lab provide updates on their research. Some labs ask mentees to present their own work or discuss a challenge and receive feedback from the team; this provides mentees with experience communicating about their research and offers them insight into how their work fits into the team's overarching goals. Science is rarely done in isolation—something that is often surprising to high school researchers—and learning to collaborate with others within the science community is critical.

Mentors might also invite mentees to attend presentations by visiting researchers, where they can learn what types of questions people ask regarding a researcher's methods and results, or to journal clubs, where mentees can acclimate to the language used in scientific literature. Mentees often don't have STEM role models before participating in a Consortium program, so this experience exposes mentees to different types of scientists and enables them to build a professional network that can help connect them with science opportunities later on. They are also exposed to professional behavior and learn the often unspoken expectations of how to interact with professionals at many levels.

Mentees who integrate into the culture of science are able to foster an identity as part of the science community and develop skills that equip them to succeed and persist in the field. Some mentees participating in a Consortium program get published, while others get additional research placements based on skills they've developed. Because mentees have been active in science experiences, they can see themselves belonging to the science community.

research skills, while also maintaining and deepening engagement in STEM during the summer months when youth may lose interest. Longer direct research experiences during the school year were also offered via internships, often at STEM companies or in collaboration with a local college or university. These types of activities can help youth get a sense of truly being part of the "STEM world" and can build or reinforce a sense of STEM identity. When possible, STEM mentoring for older youth provides opportunities to experience a tangible feeling of what it would be like to be in a STEM career or environment.

But this type of real-world experience can come with challenges. One of the key considerations in bringing older mentees to laboratories, workplaces, and universities is that youth may need some **coaching and training around behavioral expectations** and professionalism in these environments[31]. Several of the programs in our literature review noted challenges around helping mentees understand rules of workplace behavior, which ranged from participating in meetings, staying on task, and communicating effectively with other employees or team members, to more procedural topics such as laboratory safety or rules around use of equipment. These are the subtle nuances of professionalism and exposing youth to these concepts in a supportive mentoring context can serve them well in any professional setting down the line. *See the "Training" section for more details on how programs can address this consideration.*

Programs serving older mentees, particularly those who already have solid STEM engagement, often directed mentors or other adults to provide **practical information about the college application process**. In one study, youth in the program (and their parents) made substantial gains in knowledge about the application process and next steps, even though the program had spent limited time on the topic[32]. This suggests that combining STEM engagement activities with college access services might be a potent combination for ensuring that more youth enter higher education as STEM majors. The "Training" section of this supplement offers more guidance on preparing mentors to support college attendance work.

Program Activities for Younger Mentees

Programs serving mentees in grades K–8 often focus on hands-on STEM activities that generate enthusiasm and excitement, facilitate teamwork or peer sharing, and allow students to learn and apply science or math concepts. These activities are often mentor-led, with a STEM professional or older student assisting mentees in conducting an experiment or a completing a STEM project.

When selecting specific activities for youth and mentors to engage in, programs working to spark youths' initial interest in STEM may prioritize activities or experiments that support an **inquiry-based approach,** designed to get students thinking about the scientific process, reasons behind results, and lessons learned from how they approached the challenge or question at the heart of the activity[33]. These types of activities emphasize asking questions, explaining results, and thinking about practical implications regardless of the result of the activity. They are less focused on finding a "right" answer, which can discourage mentees who are struggling with the content, instead focusing on the problem-solving and creative thinking aspects of science.

Programs working with elementary and middle school youth also frequently emphasize **fun activities** that are not directly related to STEM learning or content, but are instead intended to build rapport, trust, and connectedness between mentors and mentees. We did find some examples across our literature review of programs for older youth that stressed relationship-focused activities[34], even into college-age programs[35], but generally, programs serving older youth focus much more on skill-building and work toward goals, while programs for younger students offered a more even blend of STEM-learning and relationship-developing activities.

It is worth noting that one of the key challenges for STEM mentoring programs—one that was suggested in the research reviewed for this guide[36] and reflected in the experiences of our Working Group members—is ensuring that program activities aren't so task-focused that the relationship at the heart of all good mentoring is neglected. **Because STEM mentoring programs can rely so heavily on hands-on activities and completion of research tasks and academic skill building exercises, the relationship itself may not receive the attention it deserves.** Programs may struggle to offer mentors and mentees the time they need to get to know each other, to talk about things other than STEM, and to share a good laugh or connect in ways that will make their STEM work more authentic and meaningful. If there is one core recommendation at the heart of this guide, it is that STEM mentoring programs should embrace and facilitate true mentoring by implementing and adhering to practices that ensure the expected frequency and duration of mentoring interactions and foster the development of a real mentoring relationship that goes beyond doing experiments and cool projects together.

OTHER KEY PRACTICES IN IMPLEMENTING STEM MENTORING

There were several other aspects of STEM mentoring program design and implementation that were noted in the research reviewed:

- Many STEM mentoring programs, particularly those serving the younger grades, offered some form of **parent and family engagement**. This commonly took the form of activities that mentees could take home and do with their parents or siblings. Programs serving older youth often engaged parents in college access supports[37]. Those that involved a longer-term research project often engaged parents in some kind of presentation or capstone event at the end of the program where they could see the STEM work their child and mentor had engaged in. See the Training and Closure sections for more information on how parents and families can be brought into the work of STEM mentoring programs. (And for a good example of STEM parent engagement in action, see the sidebar on Sea Research Foundation's end-of-year events.)

- **Transportation challenges** were noted in studies of programs in our literature review[38]—and confirmed by our practitioner Working Group. We found examples of this impacting both rural and urban programs. Getting youth out to STEM businesses or off-site locations to participate in STEM activities can be challenging. Frequently, these programs were located at mentees' schools or other easy-to-get-to locations, rather than asking mentees and families to travel to a company or university. Having the school as a central location to host the STEM program can alleviate transportation and resource concerns. But there can also be challenges in bringing mentors to the school site, especially when trying to get STEM employees or college students who might have different schedules to the same location at once. Programs may find it easier to arrange transportation themselves, if possible, in an effort to increase participation.

- Regardless of how mentors and mentees get to their meetings, STEM mentoring programs can also face challenges in **securing appropriate meeting spaces** for matches to conduct hands-on STEM activities. Finding space to do mentoring activities in schools can often be a challenge, but it is especially important for STEM mentoring where mentors and youth often need larger or open spaces where they can conduct experiments or do other hands-on STEM projects. This issue can be most acute in programs where a nonprofit or university-based coordinating agency is bringing mentors to meet with students at their school or in another physical space the program does not manage. Some physical space limitations can be mitigated by proactively selecting activities that match what the school can realistically offer during the design and planning stages (e.g., avoiding selecting an experiment that requires ventilation for smoke for a school setting where matches are meeting in small, unventilated rooms).

- Finally, one common practice in programs utilizing a structured curriculum to guide mentoring activities is to **review and refine the curriculum annually based upon mentor and mentee feedback**. This practice ensures that activities that don't quite work as expected are improved or replaced with something better and that training for mentors can be adjusted or reworked to give next year's mentors and mentees a stronger experience.

Additional considerations for program design and implementation are covered in the following section 2, "Standards of Practice for STEM Mentoring Programs."

References

1 Sowers, J., Powers, L. E., Shpigelman, C-N. (2012). *Science, technology, engineering, and math (STEM) mentoring for youth and young adults with disabilities: A review of the research* [Monograph]. Portland, OR: Regional Research Institute on Human Services, Portland State University.

2 Cutucache, C. E., Luhr, J. L., Nelson, K. L., Grandgennett, N. F., & Parreich, W. E. (2016). NE STEM 4U: An out-of-school time academic program to improve achievement of socioeconomically disadvantaged youth in STEM areas. *International Journal of STEM Education, 3*(6), 1–7. doi:10.1186/s40594-016-0037-0

3 Banks, K. H. (2010). A Qualitative investigation of mentor experiences in a service-learning course. *Educational Horizons, 89*(1), 68–79.

4 Stoeger, H., Hopp, M., & Ziegler, A. (2017). Online mentoring as an extracurricular measure to encourage talented girls in STEM (science, technology, engineering, and mathematics): An empirical study of one-on-one versus group mentoring. *Gifted Child Quarterly, 61*, 239–249. doi:10.1177/0016986217702215

5 Dawson, A. E., Bernstein, B. L. & Bekki, J. M. (2015). Providing the psychosocial benefits of mentoring to women in STEM: CareerWISE as an online solution. *New Directions for Higher Education, 171,* 53–62. doi:10.1002/he.20142

6 Sowers, et al., 2012.

7 Stoeger, et al., 2017.

8 Caleon, I., & Subramaniam, R. (2008). Attitudes toward science of intellectually gifted and mainstream upper primary students in Singapore. *Journal of Research in Science Teaching, 45,* 940–954.

9 Subrahmanyan, L., and & Bozonie, H. (1996). Gender equity in middle school science teaching: Being “equitable” should be the goal. *Middle School Journal, 27*(5), 3–10.

10 Tyler-Wood, T., Ellison, A., Lim, O., & Periathiruvadi, S. (2012). Bringing Up Girls in Science (BUGS): The effectiveness of an afterschool environmental science program for increasing female students’ interest in science careers. *Journal of Science Education and Technology, 21*(1), 46–55. doi:10.1007/s10956-011-9279-2.

11 Bystydzienski, J. M., Eisenhart, M., & Bruning, M. (2015). High school is not too late: Developing girls’ interest and engagement in engineering careers. *The Career Development Quarterly, 63*, 88–95. doi:10.1002/j.2161-0045.2015.00097.x

12 Bystydzienski, et al., 2015.

13 Manson, S. M., Martinez, D. F., Buchwald, D. S., Rubio, D. M., & Moss, M. (2015). Vision, identity, and career in the clinical and translational sciences: Building upon the formative years. *Clinical and Translational Science, 8:* 568–572. doi:10.1111/cts.12316

14 Sowers, et al., 2012.

15 Sadler, P. M., Sonnert, G., Hazari, Z., & Tai, R. (2012), Stability and volatility of STEM career interest in high school: A gender study. *Science Education, 96,* 411–427. doi:10.1002/sce.21007

16 Salto, L. M., Riggs, M. L., Delgado De Leon, D., Casiano, C. A., & De Leon, M. (2014). Underrepresented minority high school and college students report STEM-pipeline sustaining gains after participating in the Loma Linda University summer health disparities research program. *PLoS ONE, 9*(9). doi:10.1371/ journal.pone.0108497

17 Bystydzienski, et al., 2015.

18 Stevens, S., Andrade, R., & Page, M. (2016). Motivating young Native American students to pursue STEM learning through a culturally relevant science program. *Journal of Science Education and Technology, 25*(6): 947–960.

19 Cutucache, et al., 2016

20 Dawson, et al.,2015.

21 Stoeger, et al., 2017

22 Phelan, S. A., Harding, S. M., & Harper-Leatherman, A. S. (2017). BASE (Broadening Access to Science Education): A research and mentoring focused summer STEM camp serving underrepresented high school girls. *Journal of STEM Education, 18*(1), 65–72.

23 Danner, O. K., Lokko, C., Mobley, F., Dansby, M., Maze, M., Bradley, B., Williams, E., Matthews, L. R., Harrington, E., Mack, L., Clark, C., Wilson, K., Beech, D., Heron, S., & Childs, E. (2017). Hospital-based, multidisciplinary, youth mentoring and medical exposure program positively influences and reinforces health care career choice: "The Reach One Each One Program early experience". *American Journal of Surgery, 213*(4), 611–616. doi:10.1016/j.amjsurg.2016.12.002

24 Callahan, C. N., Libarkin, J. C., McCallum, C. M., & Atchison, C. L. (2015). Using the lens of social capital to understand diversity in the earth system sciences workforce. *Journal of Geoscience Education, 63*(2), 98–104. http://dx.doi.org/10.5408/15-083.1

25 Manson, et al., 2015.

26 Phelan, et al., 2017.

27 Gamse, et al., 2014.

28 Salto, et al., 2014.

29 Packard, B. W-L. (2012). Effective outreach, recruitment, and mentoring into STEM pathways: Strengthening partnerships with community colleges. In National Academy of Engineering and National Research Council (Ed.), *Community colleges in the evolving STEM education landscape: Summary of a summit,* 57. Washington, DC: The National Academies Press. Retrieved from https://www.nap.edu/read/13399/chapter/11

30 Kabacoff, C., Srivastava, V., & Robinson, D. N. (2013). A summer academic research experience for disadvantaged youth. *CBE Life Sciences Education, 12*(3), 410–418. http://doi.org/10.1187/cbe.12-12-0206

31 Kabacoff, et al., 2013.

32 Phelan, et al., 2017.

33 Parsley, D., & Ristvey, J. (2014). Cosmic Chemistry: A proactive approach to summer science for high school students. *Afterschool Matters, 19*, 20–27.

34 Powers L. , Schmidt J. , Sowers J. , & McCracken K. (2015). Qualitative investigation of the influence of STEM mentors on youth with disabilities. *Career Development and Transition for Exceptional Individuals, 38*(1), 25–38.

35 Zaniewski, A. M., & Reinholz, D. (2016). Increasing STEM success: a near-peer mentoring program in the physical sciences. *International Journal of STEM Education, 3*(1). https://doi.org/10.1186/s40594-016-0043-2

36 Powers, et al., 2015.

37 Phelan, et al., 2017.

38 Stevens, et al. 2016.

Photo courtesy of Sea Research Foundation

STEM MENTORING IN ACTION: Sea Research Foundation

SEA RESEARCH FOUNDATION'S STEM MENTORING PROGRAM has found that family engagement is a key component to program success. For example, when families have opportunities to access and understand the program, they're able to discover its value and are less likely to pick up their children early or skip a day of programming.

STEM Mentoring has developed several opportunities to engage families throughout the program's duration. Each site is asked to hold an information session for participating youth, families, and mentors to kick off the program, during which sites share program goals and expectations for mentees and mentors. Additionally, each STEM Mentoring module includes a multitude of resources for youth to share with family members at home, including websites, games, online videos, and printed books on STEM topics. The resources are age-appropriate, relevant, and fun, so mentees are more likely to be excited and share them with siblings and parents/guardians.

Families are also invited to participate in select STEM enrichment activities during the program year as well as the graduation event at the end of the year, where mentees share what they learned during the program. Mentees are encouraged to present their work in their native language if English is the second language at home. These events are sometimes the first time that families are able to see first-hand what mentees and mentors have been working on together, and families are often amazed at the new skills mentees have acquired.

2 STANDARDS OF PRACTICE FOR STEM MENTORING PROGRAMS

► RECRUITMENT

MENTOR RECRUITMENT

Program recruits mentors whose skills, motivations, and backgrounds best match the goals and structure of the program. (B.1.3)

▶ **STEM RECOMMENDATION**
Recruit volunteers with scientific backgrounds or current employment in a STEM field to serve as mentors, particularly if mentors will be teaching STEM content, leading complicated STEM activities, or serving as role models to mentees who are members of a group (e.g., African-Americans, women) that is underrepresented among students majoring in a STEM field or among employees in a STEM job.

▶ **STEM RECOMMENDATION**
Recruit mentors who express interest in developing a supportive, caring relationship and friendship with their mentee(s), and not just promoting their mentees' interest in, or commitment to, a STEM career.

MENTEE AND PARENT OR GUARDIAN RECRUITMENT

Program recruits mentees whose needs best match the services offered by the program. (B.1.7)

▶ **STEM RECOMMENDATION**
Program engages in recruitment strategies directed at potential mentees that show people who are working in STEM careers as part of a collaborative community of talented, interesting people.

▶ **STEM RECOMMENDATION**
Program engages in recruitment strategies showing people working in STEM who are concerned with helping people or applying their work to improving the world.

Justification

The recruitment process provides the first contact that a volunteer mentor, mentee, or parent or guardian of a mentee may have with a STEM mentoring program. This means that, as in any mentoring program, recruitment can contribute to setting the stage for a sustainable and high quality mentoring relationship through communicating clear expectations; reinforcing motivations; and generating excitement, enthusiasm, and commitment for entering into a mentoring relationship.

Aligning Recruitment with the Stage of Mentees' STEM Engagement and Interest

As noted in the Introduction, when our literature search did find empirical studies on STEM mentoring, they were often designed for undergraduate students (and occasionally graduate students who were being encouraged to enter or remain in a STEM major). In fact, many colleges are so aware of the national STEM workforce problems that they have developed well-articulated, comprehensive plans for recruiting and retaining students into STEM majors[1,2].

Although this literature focuses, for the most part, on undergraduate students, it remains relevant for our recommendations to those serving K–12 students with STEM mentoring for several reasons. The plans are carefully thought out and include a range of different models of mentoring programs that can be applied to K–12 or college summer bridge programs. In addition, they typically have goals and strategies that are designed to further students' STEM involvement or engagement, which has implications for our recruitment recommendations here.

For example, recruitment strategies for a K–12 STEM mentoring program might consider the following broad target audiences, based upon the program's goals.

▶ ***Recruitment into STEM***

When a program is focused on initially engaging mentees in a STEM field, then a diverse set of mentors—who may or may not be teaching or working in a STEM field—may be recruited. In other words, mentor expertise or knowledge around STEM subjects is less important to program success than a general interest in STEM. Furthermore, mentee recruitment may also be more broadly defined. By "casting the net widely," mentoring programs focusing on STEM recruitment might capture the interest of students who might not have had previous experiences in STEM that were exciting, fun, engaging, creative, or stimulating.

▶ ***Retention in STEM***

In contrast, mentoring programs aimed at *retention* of mentees in a STEM major or career path tend to have program recruitment goals, target populations, and program activities that are more intense and focused than more entry-level programs. Mentors recruited into STEM retention programs tend to be people who are currently working in or retired from a STEM field, who have the education and expertise to direct activities that may be complicated and require having technical skills. In addition, STEM professionals can contribute to supporting STEM retention efforts through being a role model or providing information and connections. Mentees recruited into a STEM retention program may be enrolled in a STEM major or STEM courses, or engaged in extracurricular STEM activities.

These broad goals clearly will influence the target populations of mentors and mentees for a STEM mentoring program. In addition, the mentees' stage of involvement in STEM will also influence when, where, and how to recruit mentors and mentees, and what messages to include in recruitment activities and materials. These issues are discussed below.

MENTOR RECRUITMENT

Some STEM mentoring programs operate at somewhat of an advantage with regard to recruitment of mentors because they are located within a workplace or educational setting where they have a readily accessible audience of prospective mentors. In addition, mentors in these setting may receive some form of compensation or incentive (e.g., course credit, release time) for participating in the mentoring program. Despite these advantages, STEM mentoring programs, including members of our Working Group, still report challenges with mentor recruitment and match retention.

Unfortunately, the empirical literature on STEM mentoring provides little direct guidance regarding effective recruitment practices. In fact, participant recruitment *locations* are frequently mentioned in studies or reports of STEM programs (e.g., flyers in the lunchroom, announcements at faculty meetings), whereas the *content* of recruitment messages or strategies is usually missing from program descriptions. The messaging used during the recruitment process is equally, if not more, important than the locations for conducting recruitment. This topic is an important direction for future research.

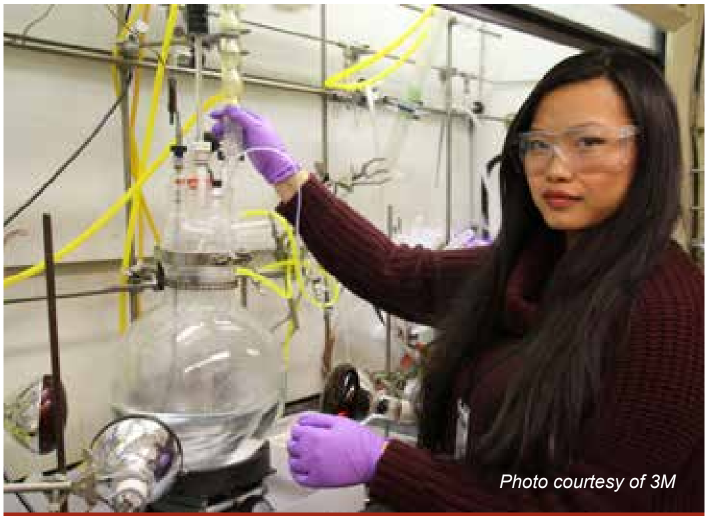

Photo courtesy of 3M

STEM MENTORING IN ACTION: **3M**

With its commitment to apply science to improve lives around the world, **3M** has fostered a strong culture of service and community engagement. STEP recruits 3M volunteer mentors by promoting the opportunity at internal events—including networking events, technical forums, and outreach events—as well as through communication channels such as 3M's LinkedIn community, newsletters, the employee intranet, and digital monitors on display throughout corporate headquarters in St. Paul. Some of STEP's most enthusiastic mentors are those who participated in the program back in high school and work at 3M today. You can find information about 3M's mentoring programs in the Introduction.

Characteristics of Mentors Recruited for STEM Mentoring Programs

Benchmark.1.3 states that mentoring programs should recruit mentors whose skills, motivations, and backgrounds best match the goals and structure of the program. There are two major recommendations related to this benchmark.

1 RECRUITMENT OF MENTORS WITH STEM EDUCATION OR WHO ARE EMPLOYED IN A STEM FIELD

Our first recommendation is to recruit volunteers for the program who have **scientific backgrounds or current employment** in a STEM field to serve as mentors. This recommendation is considered to be particularly relevant if mentors will be teaching STEM content in the program or leading complicated STEM activities. See the sidebar for one example of how a leading company encourages their employees to get involved in their STEM mentoring work with youth through a variety of channels.

The recruitment of mentors of this type has several factors for programs to consider:

Technical Skills Needed to Mentor in the Program

The types of *technical skills* that may be needed to be a mentor in a STEM mentoring program will depend on the *goals* of the program.

- ***Initial engagement goals***
  STEM mentoring programs that have the goal of interesting K–12 students in STEM may be less focused on the need for advising and connecting, and may hope to instill a spark of interest or curiosity about STEM in mentees. At this stage of development, activities may be designed to be fun and engaging, and less related to professional STEM work activities. To serve as a mentor in this type of program, at a minimum, mentors need to be interested in STEM.

- ***Retention goals***
  Sustaining an interest in STEM requires mentoring that may initially focus on helping mentees to acquire knowledge of a STEM field to, ultimately, supporting mentees attempts to create new knowledge in the field. To support these more advanced efforts, programs should recruit mentors who have substantive knowledge and expertise of the discipline. In the case of STEM mentoring, recruiting mentors with scientific backgrounds or current employment in a STEM field is also grounded in social learning theory principles. When students have repeated exposure to STEM professionals who are not just a group instructor or facilitator, and develop a more personal helping relationship with a mentor, they can observe and learn how to enter and navigate STEM careers. Although theoretically, mentors in a STEM profession should add to the magnitude of the impact of a STEM mentoring program on youth, we were unable to locate any studies that actually tested this hypothesis.

Influence of Activity Features on Mentor Qualifications

The types of technical skills that may be needed to be a mentor in a STEM mentoring program will also depend upon the *activities* included in the program.

- ***Program complexity***
  If matches complete STEM activities together, it may be helpful if mentors have some level of education or employment in a STEM field. The depth of knowledge and experience will depend on the complexity of the STEM projects being done and the presence of other instructors or advisers who can assist with instructions and monitoring progress.

- ***Level of technical knowledge***
  Often there are sophisticated technical skills that need to be learned and mastered to conduct STEM projects or research in mentoring programs aimed at deepening an interest in STEM[3].

- ***Safety considerations***
  Having a background in the STEM field can be useful for practical and safety reasons in that mentors who are familiar with the procedures for conducting a STEM activity can focus their energies on their mentoring relationship and mentee(s) rather than the logistics and instructions for completing the activities.

STEM MENTORING IN ACTION: Girls Inc.

THE GIRLS INC. EUREKA! PROGRAM provides STEM education to underserved girls and young women by facilitating hands-on STEM experiences and professional and personal development activities in a college campus environment. Girls Inc. is intentional about recruiting women as mentors so that mentees have positive and successful female role models in a field disproportionally represented by men. Girls Inc. has found that when girls gain exposure to successful women in STEM, they're able to envision themselves in a field where they may have previously felt they didn't belong. As Calista, a third-year participant in the Eureka! program at Girls Inc. of Worcester, Massachusetts, said:

> ***"During my time at UMASS, I met amazing women in the field of medicine. (My mentor) helped me to see that even in a male-dominated industry, women can succeed . . . Before this program, I didn't really know what I wanted to study in college or become when I finished my degrees. Now, I see that there are many opportunities for women in STEM."***

Girls Inc. recruits women from STEM professions by tapping into groups, communities, and companies that align with Girls Inc.'s mission and model, including local STEM companies and women's interest groups. Girls Inc.'s local chapters have developed partnerships with the Society of Women Engineers and The Links, Incorporated—a nonprofit comprised of 15,000 professional women of color—to recruit mentors and develop the next generation of STEM professionals.

These partners, along with women's interest groups embedded in local STEM companies, have been great sources to recruit diverse mentors, many of whom are from underrepresented populations in their professions and can relate to navigating through adversity in the workplace. Mentors can shine as examples of women who have survived and thrived in STEM, and they can also communicate with mentees about the challenges they experienced—from being left out of study groups to not feeling heard in meetings—and support girls as they encounter the same obstacles.

Workplace Incentives for Being a STEM Mentor

- ***Incentives for professionals who work in STEM jobs***
  Sometimes mentors have been incentivized to volunteer to participate in a mentoring program through release time at work or even direct funding to hire students to work in their labs[4].

- ***Incentives for college faculty mentors***
  These incentives can be instrumental, particularly at the college level, because the workload of STEM faculty members is heavy and has been growing over time[5]. Furthermore, promotion and tenure decisions are primarily based upon reviews by peers from other institutions concerning research quality and productivity, and they are often unfamiliar and uninvolved in the faculty member's mentoring of undergraduate students or volunteering to mentor K–12 students.

Recruitment of STEM Professionals Who Are Also Members of an Underrepresented Group

Some mentoring programs—particularly those who focus their mentee recruitment efforts on students from groups that are underrepresented in STEM—carefully target mentors who are similar demographically to their mentees. In other words, they recruit mentors who both work in a STEM profession and who themselves are members of a group underrepresented in STEM, such as women, members of specific racial or ethnic groups, or those with disabilities. For a real-life example of a program that specifically targets female STEM professionals in this way, see the previous page on the recruitment strategies of Girls Inc.

The roots of this decision come from an understanding of the definition of mentoring and forms of support that mentoring programs hope that their mentors will provide to mentees. In STEM mentoring, three common roles of effective mentors include being a trusted adult friend, a nurturer of possibilities, and a positive role model[6]—and each role can be operationalized in terms of meeting program goals.

Being a trusted adult friend might mean providing emotional support, acceptance, and coaching regarding coping with educational or career-related challenges. Being a nurturer of possibilities in this context might mean increasing mentee's knowledge of and exposure to STEM-related professionals, experiences, institutions, and educational or career opportunities. Being a positive role model might be passively observed in a STEM-related educational pathway or job position that mentees can emulate, or behaving intentionally in prosocial, healthy ways related to STEM education or work that mentees can imitate.

It has been hypothesized that when mentees and their mentors share being a member of a group underrepresented in STEM, these roles may be enhanced in several ways. For example,

- Observing how senior professionals handle complex situations at work[7]. For example, female STEM mentors can help female mentees cope with different work situations that may be prejudicial or discriminatory.
- Psychological identification with a same-race senior mentor can provide an example of academic success[8].
- Identification is also important for retention and successful performance. By identifying with someone who is successful in a field and similar in important ways to oneself, it can help reduce negative stereotypes about one's group's abilities. An example of a negative stereotype is that women are less capable than men in STEM. When someone is both a member of the stereotyped group and aware of the stereotype, it can result in anxiety and underperformance in testing situations (which is referred to as stereotype threat)[9,10,11]. In turn, awareness of negative stereotypes and low performance can result in a feeling of not belonging.

  With few women in male-dominated fields to serve as role models, fields such as physics are vulnerable to women being impacted by negative stereotypes. In fact, one study found that awareness of stereotypes about women having inferior ability in physics was related to a lower sense of belonging and worse academic performance in a college physics class for women, but not men[12]. This study demonstrates how negative stereotypes effect a sense of belonging and these attitudes can be a significant barrier to women entering STEM.

  In another study of high school students enrolled in a STEM summer camp program, analyses were conducted that divided students into one of five groups[13]. Group membership was based on students' ratings at the beginning and end of the program of how important they thought it was to have a mentor that shared their ethnicity, gender, and social class background, and how much contact they had previously had with mentors who shared their background. Group

> membership was related to outcomes of science self-efficacy, identity as a science student, and commitment to pursue a science career. Notably, students in the stably high group (i.e., those who consistently reported receiving high levels of mentoring from mentors who shared their backgrounds and thought that sharing a background was important) reported increases in efficacy, identity, and commitment as a science student.
>
> Other groups in this study also reported increases in one or more aspects of their scientific identity. For example, students who had stable contact with mentors over time, but decreased in their reports of the importance of background similarity to mentors increased in their science self-efficacy. The findings from this study were interpreted in terms of the positive future self and identity theories[14,15]. Consistent with these theories, by observing and having a close relationship with successful STEM professionals from similar back-grounds, students were able to envision themselves working successfully and competently in a similar career in the future.

Thus, by being able to identify with someone like yourself in a STEM career, it can build a sense of belonging and commitment to a STEM field.

Recruitment of Guest Visitors or Presenters

In addition to having mentors (who may not be in a STEM field), some STEM mentoring programs also recruit additional STEM experts to visit as guests or presenters[16]. Having these guests can expand mentees' professional networks and give mentees the opportunity to meet people who are working in a STEM profession, even if they aren't able to develop close, mentoring relationships with them. Because the free time of STEM professionals is often so limited, this approach can be a quick and easy way to initially get them involved in the program and perhaps ease them into an eventual full mentor role.

Recruitment of Near-Peer Mentors in STEM Mentoring Programs

Because there may not be a sufficient number of adult expert STEM mentors in geographic proximity to a mentoring program, some have explored models utilizing other types of mentors[17]. The engagement of peer leaders (sometimes called ambassadors) or near-peer mentors has been frequently reported as a potential structural solution to solving mentor scarcity and mentee retention[18,19] problems.

Notably, recent research suggests that student engagement is enhanced by peer mentoring[20,21]. Near-peer mentoring still utilizes a hierarchical approach[22], but mentors and mentees are matched together based upon similarities in age, experience, rank, and/or power[23]. Relationships with successful near-peer mentors help to create a welcoming environment where younger students can begin to envision themselves working in a STEM major or career. In addition, near-peer mentoring can be very efficient in that mentors can be trained to provide mentees with more regular and ongoing instrumental and psychosocial support than many employees, graduate students, or faculty members can provide.

Recruitment of near-peer mentors has been found to be effective in some studies of STEM mentoring programs delivered to students from groups that are underrepresented in STEM careers and near-peer mentoring programs have been implemented at many universities[24]. In several small studies, upper-level undergraduate students were recruited to serve as STEM mentors to high school students[25] or first- or second-year undergraduate students[26,27] with positive and complimentary effects on both the mentors and mentees. In another small, near-peer STEM mentoring program involving middle and high school mentees and undergraduate mentors from under-resourced communities and schools, mentors reported a wide range of personal and professional benefits, while mentees increased in their interest and engagement in STEM[28]. In another study, middle school students positively rated after-school STEM activities led by high school and graduate student mentor volunteers indicating a high level of engagement and strong interest in science after participation[29] .

The fact that near-peer mentors, who are often upper-level undergraduate students from underrepresented groups, benefit from mentoring is an added advantage of this model, because these near-peer mentor students are also at high risk of dropping out of STEM majors and being a mentor may increase their retention in a STEM field. The recruitment of near-peer mentors should be implemented with caution due to findings that matches with college-aged mentors have been reported to be at increased risk for premature closure compared to matches involving older mentors[30,31].

2 VOLUNTEERS NEED TO BE INTERESTED IN RELATIONSHIP DEVELOPMENT IN ADDITION TO HAVING AN INTEREST IN STEM

The second recommendation related to **Benchmark 1.3** is to recruit mentors who are interested in developing a supportive, caring relationship and friendship with their mentee(s), and not just enhancing or sustaining their mentees' interest in a STEM career.

Mentors in STEM programs are motivated to volunteer for many reasons[32] in addition to typical motivations for being a mentor. They may be:

- Passionate about sharing their research and/or their discipline;
- Committed to STEM education across all ages;
- Committed to developing the scientific competencies of students;
- Cognizant of the shortage of underrepresented groups in their STEM field; and
- Excited about sparking an interest in their STEM field in young people.

However, these motivations alone might not result in an authentic mentoring experience for young people. It is important to recruit mentors who are also interested in being a special type of adult to a young person, one who does more than just hang out for some activities. Recruitment messages need to include an appeal to potential mentors who are interested in developing a close, supportive, helping relationship with a mentee. This means that mentors are not only willing to be a strong role model and provide mentees with instrumental or informational support, and access to resources, people, experiences, and events related to STEM, but they should also be enthusiastic about developing a friendship that runs deeper than simply doing the program activities. Being a trusted adult friend includes things such as providing emotional support; discussing hurdles and ways of coping with challenges along the pathway to a STEM career; and the importance of being trustworthy, empathetic, and authentic with mentees. Not every STEM professional or major will want to build that depth of relationship with a mentee, but it's worth noting that almost all successful mentoring hinges on some meaningful level of mutuality, trust, and personal connection.

Thus, it is important to recruit mentors who are not just externally incentivized to participate or interested in sharing their field with mentee(s), but also motivated to establish that helpful, supporting, caring relationship and friendship with their mentee(s).

MENTEE AND PARENT OR GUARDIAN RECRUITMENT

Similar to the literature on mentor recruitment, descriptions of mentee recruitment tend to focus on defining the target population of mentees and *location* of recruitment activities, with little said about the content of recruitment messages.

Despite the fact that we have little to no direct research on the content of mentee recruitment messages, we can draw on findings from a broader body of literature on the factors that attract youth to STEM fields for making recommendations to STEM mentoring programs. We can also draw inferences from research findings on the reasons why students, and even STEM professionals, *leave* a STEM major or career. Luckily, there are robust empirical literatures on attraction, engagement, and retention of students to STEM majors and careers, and we turned to these studies and writings to inform most of the recruitment recommendations suggested here.

Recruiting Mentees Who Will Most Benefit from the Program and the Importance of Tailoring Recruitment Messages Based on Mentees' Current Engagement or Interest in STEM

Benchmark 1.7 addresses matching the needs of mentees to the services offered by the program. Whether programs recruit broadly or focuses on specific types of students to serve as mentees, their materials need to include basic information about their mentoring program components so that mentees (and parents) are well informed and have realistic expectations about what the mentoring program will offer. Topics for mentee recruitment materials include such things as a description of the program activities and requirements; brief biographies of mentors, particularly if they are faculty members; logistical commitments, such as program length, and meeting frequency, duration, and location; and whether the mentees receive any kind of compensation (in programs that offer internships or others work-like experiences).

Photo courtesy of Midlands Mentoring

Beyond these basic elements, STEM mentoring programs may use different strategies based on whether they are focused on *recruitment into* or *retention in* STEM fields.

Recruiting Students Already Engaged in STEM to Prevent Their Attrition

Whether STEM mentoring programs are focused on mentee recruitment to or retention in STEM, they may want to recruit students with an *intrinsic interest in or curiosity* about STEM (e.g., honor students in a STEM class in high school). If limited resources are available for implementing a STEM mentoring program, efforts may be best spent focusing on a population of mentees who may be most receptive to ultimately working in a STEM career.

Programs may recruit in locations where they can find these types of students (e.g., after-school clubs). Some mentoring programs focus on recruiting students at high risk for leaving a STEM field who have already decided to apply to study STEM or are enrolled in a STEM major, and therefore, they keep the bar low and attractive for program entry[33].

Regardless of who the program is recruiting, building mentoring experiences specifically to combat the reasons youth leave STEM pathways may maximize program success.

Reasons for Attrition in STEM Majors and Careers

▶ *Personal performance doubts*

Research on factors related to STEM attrition has revealed that students may leave a STEM field for a wide variety of reasons. For some students, their interests change and they become attracted to another discipline, while others may leave, not because their interests have changed, but for more personal performance reasons. Specifically, some students retain an interest in STEM, but leave a STEM major or career path because they don't feel like they belong or can be successful in a STEM major or career; they feel that they lack creativity; or they feel isolated[34,35]. Low feelings of self-competence or self-efficacy in STEM can result in students not persisting in a major or discipline when they encounter challenges, obstacles, or failure experiences. These types of negative experiences are potentially manageable from an academic scholarship or performance perspective for many students, but become overwhelming and feel insurmountable for students who feel unsupported.

▶ *Negative feelings, which are worse for students in underrepresented groups*

Students who are underrepresented in STEM fields such as women, first-generation college students, student with disabilities, and students in racial or ethnic minority groups[36,37] are often found in this group of disenfranchised and alienated students. Furthermore, these underrepresented groups are also less likely to have relationships that help them in their education and career development[38] and report dissatisfaction in their careers due to a feeling of professional isolation[39,40]. Feelings of isolation emerge early in one's education. In fact, one study noted that females were most likely to switch out of a STEM major between their freshman and sophomore years in college[41]. One implication of these findings are that STEM mentoring programs focused on retention might direct their efforts to recruiting students to participate during the summer after high school, as well as during the first year in college.

▶ *The type of STEM experience*

Another key predictor of STEM retention is related to student's actual experiences in the STEM field. In fact, ongoing persistence in a STEM major has been found to be associated with having an academic adviser; experience participating in authentic professional events, such working on research projects; and attending or presenting at scientific conferences[42,43].

Implications for Mentee Recruitment Messages

Taken together, the findings from these studies on student retention provide ideas regarding content that might be included in recruitment messages into STEM mentoring programs:

- Being mentored may reduce feelings of isolation in a STEM class, major, or job.
- Being mentored may help mentees build communities that support a feeling of belonging in a STEM field.
- Normalizing the experience in science of experimentation sometimes works out differently than planned or hypothesized to reduce feelings of failure when experiments don't work.
- Mentors are available to help with educational and career advising in STEM and in general.
- The STEM mentoring program provides opportunities to engage in authentic STEM activities related to being in a STEM career with the support of a mentor.
- The STEM mentoring program sponsors or has mentees attend authentic professional STEM events with the support of a mentor.

Recruitment Messages Targeted to Students from Groups Underrepresented in STEM

Students from underrepresented groups frequently report that their teachers or professors were not welcoming and hence, they felt like they didn't belong[44]. These findings suggest that recruitment materials should be warm and welcoming. They should also include messaging to prospective mentees that they have a place in the discipline and that it is inclusive of a diverse population of students and mentors. In other words, showing photographs or videos of mentors that are diverse with respect to gender, racial and ethnic background, and disability status will communicate acceptability of diversity within the STEM mentoring program.

The basic literature on STEM recruitment and retention suggests that messaging for underrepresented groups should directly address motivational factors associated with pursuing a STEM major or career. Motivation can be thought of in terms of one's goals and values, and in this case, goals related to one's career are particularly relevant.

Two types of goals have been found to be important to students from underrepresented groups:

- ***Anchoring STEM activities to real-life or relevant issues or questions***
  Many students, even around the world[45], view STEM as irrelevant[46], particularly when STEM education, findings, or activities are presented in ways that are decontextualized from their everyday lives. This framing can be a barrier to engagement, but if understood and acknowledged, this perspective can also be leveraged in instructional design of curricula used in STEM programs, and consequently, in recruitment materials for STEM mentoring programs. In other words, STEM can be taught in a contextualized way, meaning that it can be made relevant to students by having them complete projects or activities that show how STEM can help us better understand the world students live in and by integrating its social, economic, environmental, (etc.), components[47]. In fact, studies that examined the impact of contextualized STEM interventions with students have reported a range of positive effects.

- ***Communal goals and personal values of improving the world and the lives of others***
  Working in a career that has personal relevance or meaning and that is consistent with one's values is particularly important to youth from underrepresented groups. These values tend to be communal and prosocial, meaning that students make helping their community a priority.

Implications for Mentee Recruitment Messages

- ***Showcase professionals engaged in science because of communal goals***
  Many studies have now examined the career goals of groups who are underrepresented in STEM including women[48,49,50,51], minority groups (e.g., Native Americans, Latinos)[52,53], students from low socioeconomic backgrounds[54,55], and first-generation college students[56]. Students in all of these groups have been found to be more likely to endorse communal goals of wanting to help others, the value of interdependence, and deep commitment to helping improve the lives of individuals in their communities than other goals or than their peers. For example, Black and Latino STEM students have reported having more altruistic goals focused on working for social change, as well as caring about equity and social justice issues more than White STEM students[57,57]. Even students who choose to pursue graduate work in a STEM field report having a bigger purpose in life and hope to serve as a role model for other students from underrepresented groups[59].

Another way these general goals get manifested is in a choice of major. For example, girls report a stronger interest in life sciences than in the physical sciences, because they believe that they will have a greater opportunity to help others in a career in the life sciences[60]. Given these attitudes and beliefs, additional information about how STEM careers in the physical sciences, as well as life sciences, can help society may broaden girls' interests.

Another important message for attracting youth from underrepresented groups is to connect explicitly that working in a STEM career, and even simply completing the STEM activities in the mentoring program, can provide mentees with a means of helping others and contributing to improving the world. In fact, recruitment materials showing matches completing service learning projects in STEM or projects that connect science and society may be helpful for both recruitment to and retention in the mentoring program. Another approach to validating the communal nature of STEM is to ask mentors who are working or being educated in a STEM field to share why they chose their field of study or work and why they do the work that they are doing[61]. Their career goals and choices can be shared in print materials, in videotaped interviews or testimonials, through social media, and/or on the mentoring program's website. Mentors may have well-articulated and passionate reasons for their chosen field that may be motivating and affirming to students with similar communal goals.

Remember, "One size does not fit all" when it comes to career motivation. Although the research suggests that students from underrepresented groups are, on average, more motivated by communal goals or wanting to help people than other goal, these goals are not held by all students. Other goals are also important to represent when recruiting students into a STEM program such as having an intellectual curiosity about a topic, or simply finding certain STEM activities pleasurable.

- ***Collaboration is desirable over solitary work***
  Communal goals not only include science that gives back to the community, but also work that involves collaboration[62].

Having collaborative goals predicted interest in science, particularly for women[63]. Collaboration is important, but not at the expense of prosocial goals for a STEM career, which are paramount[64].

Students frequently have negative stereotypes about people working in STEM careers, unfortunately believing that STEM work results in a lonely and solitary life[65]. These common, but inaccurate, stereotypes depict scientists as geniuses toiling away alone through the night in a lab, or as a quirky computer geeks obsessed with writing computer code and sitting for days on end alone at the computer. In addition, scientists are frequently stereotyped as having poor social skills, and being temperamental, hard to work with, and socially awkward. These negative stereotypes can undermine attempts to recruit students to participate in STEM who want to be socially competent, if not popular, and have communal goals focused on collaboration. Unfortunately, much of the popular culture reinforces these stereotypes—however, it is worth noting that these stereotypes are malleable and can be modified through positive media representations of people in STEM jobs where STEM professionals are shown as sociable, interesting, fun to work with, and even “cool”[66].

Taken together, these findings suggest that mentee recruitment materials for STEM programs would benefit from showing examples of mentors and mentees having fun together working collaboratively on a STEM project that may involve innovative forms of technology (e.g., virtual reality) and games[67]. These recruitment materials would be designed to counter directly the negative stereotypes of people working in STEM fields and what it is like to work in a STEM field[68].

One noteworthy caveat is that all students do not enjoy working collaboratively with others and may prefer an independent working environment, for a variety of reasons. Working in a STEM field allows for very diverse working environments that can include students who prefer not to work on a team.

References

1 Bowling, B., Doyle, M., Taylor, J., & Antes, A. (2015). Professionalizing the role of peer leaders in stem. *Journal of STEM Education*, *16*(2), 30–3.

2 Manson, S. M., Martinez, D. F., Buchwald, D. S., Rubio, D. M., & Moss, M. (2015). Vision, identity, and career in the clinical and translational sciences: Building upon the formative years. *Clinical Translational Science*, *8*(5), 568-572. doi:10.1111/cts.12316

3 McGee, R. (2016). Biomedical workforce diversity: The context for mentoring to develop talents and foster success within the 'pipeline'. *AIDS Behav*, 20, 231–237.

4 National Academy of Sciences, N. A. o. E., and Institute of Medicine. (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. Author, Washington, DC.

5 Eagan, M. K., Sharkness, J., Hurtado, S., Mosqueda, C. M., & Chang, M. J. (2011). Engaging undergraduates in science research: Not just about faculty willingness. *Research in Higher Education*, *52*(2), 151–177.

6 Kupersmidt, J. B., & Rhodes, J. E. (2014). Mentor training. In D. L. DuBois & M. J. Karcher (Eds.), *Handbook of Youth Mentoring, Second Edition* (pp. 439–456). Thousand Oaks, CA: Sage Publications.

7 Blake-Beard, S., Bayne, M. L., Crosby, F. J., & Muller, C. B. (2011). Matching by race and gender in mentoring relationships: Keeping our eyes on the prize. *Journal of Social issues*, *67*(3), 622–643.

8 Walton, J. M. (1979). Retention, role modeling, and academic readiness: A perspective on the ethnic minority student in higher education. *The Personnel and Guidance Journal*, *58*(2), 124–127.

9 Steele, C. M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist*, **52**(6), 613.

10 Spencer, S. J., Steele, C. M., & Quinn, D. M. (1999). Stereotype threat and women's math performance. *Journal of Experimental Social Psychology*, *35*(1), 4–28.

11 Steele, C. M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans. *Journal of Personality and Social Psychology*, *69*(5), 797.

12 Stout, J. G., Ito, T. A., Finkelstein, N. D., & Pollock, S. J. (2013). *How a gender gap in belonging contributes to the gender gap in physics participation.* Paper presented at the AIP conference proceedings.

13 Syed, M., Goza, B. K., Chemers, M. M., & Zurbriggen, E. L. (2012). *Individual differences in preferences for matched-ethnic mentors among high-achieving ethnically diverse adolescents in STEM. Child Development*, *83*(3), 896–910.

14 Markus, H., & Nurius, P. (1986). Possible selves. *American Psychologist*, *41*(9), 954.

15 Oyserman, D., Gant, L., & Ager, J. (1995). A socially contextualized model of African American identity: Possible selves and school persistence. *Journal of Personality and Social Psychology*, *69*(6), 1216.

16 Gamse, B. C., Martinez, A., Bozzi, L., & Didriksen, H. (2014). *Defining a research agenda for STEM Corps: Working white paper.* Cambridge, MA: Abt Associates.

17 Pluth, M. D., Boettcher, S. W., Nazin, G. V., Greenaway, A. L., & Hartle, M. D. (2015). Collaboration and near-peer mentoring as a platform for sustainable science education outreach. *Journal of Chemical Education*, *92*(4), 625–630.

18 Bowling, B., Bullen, H., Doyle, M., & Filaseta, J. (2013). *Retention of STEM majors using early undergraduate research experiences.* Paper presented at the Proceeding of the 44th ACM Technical Symposium on Computer Science Education.

19 Zaniewski, A. M., & Reinholz, D. (2016). Increasing STEM success: A near-peer mentoring program in the physical sciences. *International Journal of STEM Education*, *3*(1).

20 Chesler, N. C., & Chesler, M. A. (2002). Gender-informed mentoring strategies for women engineering scholars: On establishing a caring community. *Journal of Engineering Education*, *91*(1), 49–55.

21 Wilson, Z. S., Iyengar, S. S., Pang, S., Warner, I. M., & Luces, C. A. (2012). Increasing access for economically disadvantaged students: The NSF/CSEM & S-STEM Programs at Louisana State University. *Journal of Science Education and Technology*, *21*(5), 581–587. doi:10.1007/S10956-01

22 Wilson, Z. S., Holmes, L., deGravelles, K., Sylvain, M. R., Batiste, L., Johnson, M., . . . Warner, I. M. (2012). Hierarchical mentoring: A transformative strategy for improving diversity and retention in undergraduate STEM disciplines. *Journal of Science Education and Technology*, *21*(1), 148–156.

[23] Angelique, H., Kyle, K., & Taylor, E. (2002). Mentors and muses: New strategies for academic success. *Innovative Higher Education*, *26*(3), 195–209.

[24] Terrion, J. L., & Leonard, D. (2007). A taxonomy of the characteristics of student peer mentors in higher education: Findings from a literature review. *Mentoring & Tutoring*, *15*(2), 149–164.

[25] Tyler-Wood, T., Ellison, A., Lim, O., & Periathiruvadi, S. (2012). Bringing up girls in science (BUGS): The effectiveness of an afterschool environmental science program for increasing female students' interest in science careers. *Journal of Science Education and Technology*, *21*(1), 46–55.

[26] Trujillo, G., Aguinaldo, P., Anderson, C., Bustamante, J., Gelsinger, D., Pastor, M., . . . Riggs, B. (2015). Near-peer STEM mentoring offers unexpected benefits for mentors from traditionally underrepresented backgrounds. *Perspectives on Undergraduate Research and Mentoring: PURM*, *4*(1).

[27] Zaniewski & Reinholz, 2016.

[28] Tenenbaum, L. S., Anderson, M. K., Jett, M., & Yourick, D. L. (2014). An innovative near-peer mentoring model for undergraduate and secondary students: STEM focus. *Innovative Higher Education*, *39*(5), 375–385.

[29] Pluth, et al., 2015.

[30] Grossman, J. B., Chan, C. S., Schwartz, S. E., & Rhodes, J. E. (2012). The test of time in school-based mentoring: The role of relationship duration and re-matching on academic outcomes. *American Journal of Community Psychology*, *49*(1–2), 43–54.

[31] Kupersmidt, J. B., Stump, K. N., Stelter, R. L., & Rhodes, J. (2017). Predictors of premature match closure in youth mentoring relationships. *American Journal of Community Psychology*, *59*(1–2), 25–35.

[32] Eagan, et al., 2011.

[33] Bowling, et. Al., 2013.

[34] Beghetto, R. A. (2007). Factors associated with middle and secondary students' perceived science competence. *Journal of Research in Science Teaching*, *44*(6), 800–814. doi:10.1002/tea.20166

[35] Brainard, S. G., & Carlin, L. (1997). A longitudinal study of undergraduate women in engineering and science. Paper presented at the Proceedings Frontiers in Education 1997 27th Annual Conference. *Teaching and Learning in an Era of Change*.

[36] Brainard, S. G., & Carlin, L. (1998). A six-year longitudinal study of undergraduate women in engineering and science. *Journal of Engineering Education*, 369–375.

[37] National Science Foundation, N. C. f. S. a. E. S. (2017). *Women, minorities, and persons with disabilities in science and engineering: 2017*. Author, Arlington, VA. www.nsf.gov/statistics/wmpd/

[38] Etzkowitz, H. (2000). Why are minority and women scientists still treated so badly? In J. Campbell, George, R. Denes, & C. Morrison (Eds.), *Race, Ethnicity, and the Scientific Enterprise* (pp. 295–306). New York, NY: Oxford University Press.

[39] Dasgupta, N., & Stout, J. G. (2014). Girls and women in science, technology, engineering, and mathematics: STEMing the tide and broadening participation in STEM careers. *Policy Insights from the Behavioral and Brain Sciences*, *1*(1), 21-29.

[40] De Welde, K., & Laursen, S. (2011). The glass obstacle course: Informal and formal barriers for women PhD students in STEM fields. *International Journal of Gender, Science and Technology*, *3*(3), 571–595.

[41] Brainard and Carlin, 1998.

[42] Brainard and Carlin, 1998.

[43] Momoh, J. A. (2014). Outreach program in electrical engineering: Pre-college for engineering systems (PCES). *IEEE Transactions on Power Systems, 29*(4), 1880–1887. doi:10.1109/tpwrs.2014.2320279

[44] Foor, C. E., Walden, S. E., & Trytten, D. A. (2007). "I wish that I belonged more in this whole engineering group:" Achieving individual diversity. *Journal of Engineering Education*, *96*(2), 103–115.

[45] Jidesjö, A., Oscarsson, M., Karlsson, K.-G., & Strömdahl, H. (2012). Science for all or science for some: What Swedish students want to learn about in secondary science and technology and their opinions on science lessons. *Nordic Studies in Science Education*, *5*(2), 213–229.

[46] Potvin, P., & Hasni, A. (2014). Interest, motivation and attitude towards science and technology at K–12 levels: a systematic review of 12 years of educational research. *Studies in Science Education*, *50*, 85–129.

[47] Potvin & Hasni, 2014.

[48] Diekman, A. B., Brown, E. R., Johnston, A. M., & Clark, E. K. (2010). Seeking congruity between goals and roles: A new look at why women opt out of science, technology, engineering, and mathematics careers. *Psychological Science, 21*(8), 1051–1057.

[49] Diekman, A. B., Clark, E. K., Johnston, A. M., Brown, E. R., & Steinberg, M. (2011). Malleability in communal goals and beliefs influences attraction to stem careers: Evidence for a goal congruity perspective. *Journal of Personality and Social Psychology*, *101*(5), 902–918.

[50] Diekman, A. B., & Steinberg, M. (2013). Navigating social roles in pursuit of important goals: A communal goal congruity account of STEM pursuits. *Social and Personality Psychology Compass, 7*(7), 487–501.

[51] Diekman, A. B., Weisgram, E. S., & Belanger, A. L. (2015). New routes to recruiting and retaining women in STEM: Policy implications of a communal goal congruity perspective. *Social Issues and Policy Review, 9*(1), 52–88.

[52] Smith, J. L., Cech, E., Metz, A., Huntoon, M., & Moyer, C. (2014). Giving back or giving up: Native American student experiences in science and engineering. *Cultural Diversity & Ethnic Minority Psychology*, 20(3), 413–429. doi:10.1037/a0036945

[53] Thoman, D. B., Brown, E. R., Mason, A. Z., Harmsen, A. G., & Smith, J. L. (2015). The role of altruistic values in motivating underrepresented minority students for biomedicine. *BioScience, 65*(2), 183–188.

[54] Kraus, M. W., & Stephens, N. M. (2012). A road map for an emerging psychology of social class. *Social and Personality Psychology Compass, 6*(9), 642–656.

[55] Stephens, N. M., Fryberg, S. A., Markus, H. R., Johnson, C. S., & Covarrubias, R. (2012). Unseen disadvantage: How American universities' focus on independence undermines the academic performance of first-generation college students. *Journal of Personality and Social Psychology, 102*(6), 1178–1197.

[56] Allen, J. M., Muragishi, G. A., Smith, J. L., Thoman, D. B., & Brown, E. R. (2015). To grab and to hold: Cultivating communal goals to overcome cultural and structural barriers in first-generation college students' science interest. *Translational Issues in Psychological Science, 1*(4), 331.

[57] Garibay, J. C. (2015). STEM students' social agency and views on working for social change: Are STEM disciplines developing socially and civically responsible students? *Journal of Research in Science Teaching, 52*(5), 610–632.

[58] Thoman, et al., 2015.

[59] McGee, E. O., White, D. T., Jenkins, A. T., Houston, S., Bentley, L. C., Smith, W. J., & Robinson, D. H. (2016). Black engineering students' motivation for PhD attainment: Passion plus purpose. *Journal for Multicultural Education, 10*(2), 167–193.

[60] Baker, D. R., & Leary, R. (1995). Letting girls speak out about science. *Journal of Research in Science Teaching, 32*(1), 3–27.

[61] Boucher, K. L., Fuesting, M. A., Diekman, A. B., & Murphy, M. C. (2017). Can I work with and help others in this field? How communal goals influence interest and participation in STEM Fields. *Frontiers in Psychology*, 8, 901.

[62] Diekman & Steinberg, 2013.

[63] Diekman, A. B., Steinberg, M., Brown, E. R., Belanger, A. L., & Clark, E. K. (2017). A goal congruity model of role entry, engagement, and exit: Understanding communal goal processes in STEM gender gaps. *Personality and Social Psychology Review, 21*(2), 142–175. doi:10.1177/1088868316642141

[64] Allen, et al., 2015.

[65] Diekman, et al., 2010.

[66] Cheryan, S., Plaut, V. C., Handron, C., & Hudson, L. (2013). The stereotypical computer scientist: Gendered media representations as a barrier to inclusion for women. *Sex Roles*, *69*(1–2), 58–71.

[67] Gilliam, M., Jagoda, P., Fabiyi, C., Lyman, P., Wilson, C., Hill, B., & Bouris, A. (2017). Alternate reality games as an informal learning tool for generating STEM engagement among underrepresented youth: A qualitative evaluation of the source. *Journal of Science Education and Technology*, *26*(3), 295–308. doi:10.1007/s10956-016-9679-4

[68] Boucher, et al., 2017.


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2 STANDARDS OF PRACTICE FOR STEM MENTORING PROGRAMS

SCREENING

MENTOR SCREENING

Program has established criteria for accepting mentors into the program as well as criteria for disqualifying mentor applicants. (B.2.1)

▶ STEM RECOMMENDATION

STEM mentoring programs should emphasize screening for mentors who:

- Exhibit strong social skills (in addition to strong subject matter expertise).
- Are willing to talk about their personal experiences in the STEM field, especially in programs designed to help youth overcome systemic or personal challenges to a STEM education or career.

▶ STEM RECOMMENDATION

When appropriate, and to the degree possible, STEM mentoring programs should screen mentors on the demographic or background characteristics that match the youth who will be served by the program, particularly if the program is designed to interest underrepresented youth in STEM fields.

Prospective mentors agree in writing to a one-year (calendar or school) minimum commitment for the mentoring relationship, or a minimum time commitment that is required by the mentoring program. (B.2.6) And prospective mentors agree in writing to participate in face-to-face meetings with their mentees that average a minimum of once a week and a total of four or more hours per month over the course of the relationship, or at a minimum frequency and amount of hours that are required by their mentoring program. (B.2.7)

▶ STEM RECOMMENDATION

STEM mentoring programs should assess during the screening process whether prospective mentors may have scheduling challenges or conflicts that would hinder their full participation in the program, screening out those who may be unable to meet with mentees consistently (e.g., potentially challenging groups may include college students, employees at local STEM companies, and faculty in higher education).

MENTEE SCREENING

Program has established criteria for accepting youth into the program as well as criteria that would disqualify a potential youth participant. (B.2.8)

▶ STEM RECOMMENDATION

STEM mentoring programs, when appropriate and particularly in programs with capped enrollment, may want to prioritize accepting youth of color, girls and young women, youth with disabilities, first-generation college students, and other groups that may be underrepresented in STEM fields and careers.

▶ STEM RECOMMENDATION

STEM mentoring programs may want to set eligibility criteria around STEM experience or skills, accepting mentees who can participate fully in the STEM content of the program (while offering supplemental instruction and other supports to those screened out of participation in the program).

Parent(s)/guardian(s) and mentees agree in writing to a one-year (calendar or school) minimum commitment for the mentoring relationship, or the minimum time commitment that is required by the mentoring program. (B.2.11) And parents(s)/guardian(s) and mentees agree in writing that mentees participate in face-to-face meetings with their mentors that average a minimum of once a week and a total of four or more hours per month over the course of the relationship, or at a minimum frequency and number of hours that are required by the mentoring program. (B.2.12)

▶ STEM RECOMMENDATION

STEM mentoring programs may want to utilize screening tools to assess whether or not applicants to be mentees can:

- Meet logistical expectations regarding the timing, frequency, and length of match meetings.
- Commit to full participation in all required program activities, especially in programs focused on matches completing longer-term research projects.

Justification

As with all mentoring programs for young people, STEM mentoring programs should put considerable effort into ensuring that prospective mentors are both safe and suitable for the task at hand and that youth participants and their families meet eligibility and participation requirements. Unfortunately, much of the specific practice that informs screening is largely ignored in the research literature we reviewed—no studies or reports mentioned safety practices such as conducting criminal background checks and only a handful described participant eligibility requirements[1,2,3,4]. Similarly, we found no STEM mentoring studies that tested the effectiveness, or compared variations, of a specific screening practice. However, there is information in the research literature, subsequently confirmed by the project's Working Group of STEM practitioners, which speaks to screening practices that are theoretically important for screening program participants for suitability.

We do assume that the programs described in the literature are also engaging in safety-related screening practices, although it is unclear if programs using university faculty and students or employees of STEM companies as mentors are doing additional safety-related screening beyond what is mandated for involvement in those institutions more generally. As noted in the fourth Edition of the *Elements of Effective Practice for Mentoring*, we encourage *all* programs to conduct relevant criminal record checks, as well as in-person interviews and reference checks to ensure that mentors are safe prior to engaging young people directly through the program. Thus, the recommendations for STEM mentoring that follow here are primarily focused on suitability and ensuring that all participants are a good fit for the program experience.

MENTOR SCREENING

One of the core challenges of running an effective STEM mentoring program is ensuring that mentors and youth are put in positions to form an authentic, mutual, and rewarding relationship that exists beyond the STEM activities and academic opportunities provided by the program. Relationships can sometimes take a back seat to doing hands-on STEM work in these programs. While many of these relationship concerns can be addressed by simply building explicit relationship-building activities and interactions into the design of the program, there are some screening-related practices that can help facilitate more meaningful mentoring relationships in the STEM context.

As noted in **Benchmark B.2.1**, all mentoring programs are encouraged to think carefully about the eligibility criteria for mentor participation. Going beyond safety-related eligibility criteria (e.g., passing a background check), many programs develop eligibility requirements around the life experiences, skills, personalities, and other characteristics that mentors bring to the table (for an example of a program that has put considerable thought into mentor characteristics, see Bowling, Doyle, Taylor, & Antes, 2015[5]).

For STEM mentoring programs, several criteria stood out as being potential "must-haves" in terms of mentors' ability to build effective relationships in these types of programs:

- ***Strong social skills***

  While most programs seek out adults with STEM expertise to serve as mentors, the members of our practitioner Working Group felt strongly that mentors also need to bring at least adequate relational skills to the mentoring role. Programs may want to screen out prospective mentors who, while they may bring STEM content knowledge or connections to STEM environments to the program, might struggle to form relationships with the youth and provide the kind of empathy, trust, guidance, and understanding that we commonly associate with quality mentoring relationships.

  Several programs in our literature review specifically noted the effort they put into the relationship-fostering components of their interventions, such as providing matches with "open" meeting times not focused directly on STEM[6], asking about social skills and the ability to motivate students in positive ways during the interview process[7], and by emphasizing that the mentoring role is grounded as much in psychosocial and emotional support as it is in direct STEM work during mentor training[8]. This last strategy implies that some relationship skills can be enhanced via pre-match training, but programs will want to avoid thinking that STEM expertise alone will make for a good mentor and screen out participants who don't seem right for the more personal and empathetic aspects of the mentor role.

- ***A willingness to talk about their personal journey in STEM***

  This recommendation was strongly implied in the research literature as a core strategy in programs designed to serve girls, youth of color, youth from low socioeconomic backgrounds, youth with disabilities, and other groups who are traditionally underrepresented in STEM higher education settings and careers. In those programs, having a mentor, ideally one with a shared background or similar personal challenges to a STEM career, openly talk with youth about their experiences and strategies for overcoming systemic and institutional barriers is one of the key drivers of helping youth build STEM identity and see STEM careers and something achievable (i.e., seeing their possible "future self" in the mentor). Research on this aspect of STEM mentoring programs notes that some mentors may not be comfortable discussing their own struggles to persevere in STEM fields[9], which may limit the effectiveness of their interactions. Each STEM mentoring program will need to decide for themselves just how critical this type of self-disclosure and personal sharing by mentors is to their theory of change and screen out mentors who are unable to complete this aspect of their roles and responsibilities accordingly.

The only other recommendation related to B.2.1 is that mentors, to the degree possible, should be reflective of the population being served by the program and that screening processes represent an opportunity for program staff to emphasize diversity when accepting mentors into the program. Members of our Working Group were, however, adamant that it was logistically challenging to match *every* youth with a STEM mentor who shares their background, gender, or disability status, and that there were strong reasons to emphasize other criteria, such as expertise in specific STEM fields. There were also hints in the research literature that *only* selecting mentors who fit a certain demographic profile can limit the appeal and effectiveness of the mentoring experience for youth[10]. But given that so much of the STEM mentoring field is aimed at addressing issues of systemic underrepresentation in STEM careers, it only makes sense that programs consider emphasizing demographic characteristics when trying to place mentors into limited spaces in the program. We certainly noted many examples in the literature of programs explicitly centered on gender[11], disability[12], and racial barriers[13] and how mentees can overcome related challenges, indicating that maximizing diverse youths' exposure to diverse mentors is likely important for effective STEM mentoring. These types of same-vs-cross-demographic considerations are addressed in more detail in the following section on Matching and Initiation.

Another key consideration in screening mentors, covered in the main *Elements* under **B.2.6** and **B.2.7**, is screening out mentors that are unlikely to be able to meet the minimum participatory requirements of the program. Many of our Working Group participants noted that it could be challenging, especially when working with employees of STEM companies or with students from colleges and universities, to find mentors who could consistently meet with their mentee or mentoring group. This challenge was rarely mentioned in the research literature, but we know from previous research on mentoring more broadly that mentors who cannot meet consistently with youth for the intended duration of the program are unlikely to be effective and may actually harm youth with their sporadic and unpredictable engagement[14]. Given that many STEM mentoring programs involve mentors and youth meeting at a location (e.g., a school or worksite) that requires one or both parties to travel and perhaps take time away from classroom or work time, these types of logistical and scheduling-related challenges seem like predictable obstacles to matches meeting as intended. At least one program in the research literature noted struggling with this particular issue, ultimately needing to directly transport mentors from STEM companies to the school to ensure their consistent participation[15]. Programs will want to emphasize participation frequency and schedule availability when assessing whether mentors can effectively fill their role.

It should be noted, however, that STEM mentoring programs for middle and high school students frequently use college students in the mentoring role, something cautioned against in **Enhancement E.2.5** of the main Elements. Given that many successful STEM programs rely on mentors that the literature suggests can be a challenge getting to adhere to match expectations, one can infer that there are solutions to these challenges, such as engaging campus faculty in monitoring undergraduate mentors' attendance or having the program itself provide transportation to groups of student mentors, as noted in the previous program example. For an example of how one STEM mentoring program ensures that college students can meet the expectations of the program, see the case study on Sea Research Foundation on the next page.

Photo courtesy of Sea Research Foundation

STEM MENTORING IN ACTION:
Sea Research Foundation

Many STEM mentoring programs utilize college students as mentors, but **SEA RESEARCH FOUNDATION'S STEM MENTORING** initiative has found that their sites must take special precautions during the screening process to determine whether a college student can successfully fulfill the expectations of the program. College students often have large swaths of availability during the day, making them uniquely able to participate in programs that occur during school or after-school hours; however, their changing schedules and transience means that their availability may be seasonal and vary across semesters.

To ensure that college students can accommodate the program's schedule, STEM Mentoring sites discuss timelines and scheduling as soon as mentors are recruited. Mentors must complete an application and an interview in which they're asked about their availability and whether they understand that the program is a year-long commitment. Sites also tell prospective mentors that matches that end early or without proper closure can negatively impact the young person, so it's important to commit to the full mentoring engagement period.

When college students aren't able to commit to the year-long program because they leave the area for the summer or during school vacations, STEM Mentoring has several options. Some sites do not accept college students who can't fulfill the program requirements. Other sites have chosen to match young people with two mentors, so a second mentor—often a teen mentor—will be present if the college student leaves for school break. Finally, other sites that are more reliant upon college students compress their program's timeline to align with the local college's academic calendar, so that the full program is completed over a nine-month period instead of a full calendar year.

MENTEE SCREENING

As with mentor screening, Benchmarks **B.2.11** and **B.2.12** address using screening procedures to ensure that youth (and their parents) can effectively meet the programs' expectations around meeting frequency and duration. While few of the research articles we reviewed directly addressed logistical and scheduling challenges (only one noted that it would end up being a major barrier[16]), our practitioner Working Group did note that their programs emphasize the time and travel commitments of the program to youth and families, screening out youth who were unlikely to participate at the highest level. Most of this emphasis on full participation was not inherently born out of concerns related to fidelity of implementation of the program model (i.e., ensuring youth are positioned to get the "dosage" of mentoring the program desired) but rather reflected concerns about competition for limited program slots. STEM mentoring programs often have greater demand than they have available openings and many wanted to ensure those limited slots went to youth who could fully engage in program activities and maximize the use of program resources.

Far more common in the research literature were descriptions of the eligibility criteria programs placed on youth applicants. These eligibility criteria are generally covered under **Benchmark B.2.8** in the main *Elements*, where the identification of specific eligibility criteria has largely been left to individual programs to decide what is appropriate to their services and what they hope to achieve for young people. In our literature review, we found many articles and reports detailing extensive eligibility criteria for youth participants, most of which fell into two categories:

► ***Criteria around demographic characteristics of participants***

As noted above, many of these programs are structured rather intentionally around specific groups of young people underrepresented in STEM fields and their eligibility and selection criteria often reflected this emphasis. About two-thirds of the articles we initially reviewed for this supplement dealt explicitly with strategies or programs to increase the engagement of underrepresented groups in STEM higher education and careers. Given this emphasis in the field, it seems logical that many STEM mentoring programs would want to prioritize screening in girls and young women, youth with disabilities, youth of color, or youth from low-income backgrounds. Given limited spots in these types

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of programs, this type of emphasis on demographic selection criteria seems in spirit with the intention of many STEM mentoring programs.

► ***Criteria related to mentees' academic achievement and readiness for the mentoring experience being offered***

Many STEM mentoring programs in our review noted the rigorous academic eligibility criteria they placed on program participants[17,18,19,20]. Simply put, many of these programs required students to have demonstrated some mastery or aptitude for STEM subjects in school and only selected those who were, in theory, ready to participate fully in the academic tasks of the program. This was most common in programs serving high school- or college-age youth, which were often centered on laboratory internships or other direct, hands-on research projects requiring a certain level of STEM proficiency. Many programs noted that their application process was highly competitive and had lofty criteria for eligibility in the program.

But other programs approached issues of diversity in STEM mentoring from a different perspective. Some explicitly sought out students of color who had exhibited some STEM potential but whose grades lagged behind their peers in an effort to support those STEM students who were most likely to leave their potential untapped[21]. Others explicitly sought out youth who were disengaged from STEM altogether in a last-chance effort to spark an interest in STEM with older students[22].

What seems critical for STEM mentoring programs is that they carefully consider the basic level of STEM competence and skills needed to successfully participate in their program. The last thing STEM programs need to do is place mentees in settings that are far beyond their demonstrated skills and abilities, thus worsening youths' self-perception of their STEM competence and identity. On the other hand, focusing only on students who have shown no or little STEM aptitude or interest leaves programs with a tougher task and potentially might keep the best prospects from getting the hands-on, intensive STEM experiences that research suggests can ensure that high achievers continue on with their STEM education in the face of challenges. Ideally, programs would be able to respond to the needs of youth on multiple levels: both screening out mentees who may not yet possess the academic qualifications to participate fully in programs centered on deeper research experiences, while also referring those youth to additional tutoring or instruction that can better prepare them for future program cycles or mentoring opportunities in other settings. Research suggests[23,24] that helping youth catch up to their peers via additional tutoring or academic instruction so that they are positioned for future mentoring opportunities can increase diversity in STEM education and industries.

As with most screening of mentoring participants, the best thing STEM mentoring programs can do is think carefully about who can best benefit from their mentoring services and what skills mentors and youth need to bring to the table to be successful. In addition to ensuring the safety of participants, screening around issues of suitability will help maximize program impact and the wise use of limited resources.

References

1 Bystydzienski, J. M., Eisenhart, M., & Bruning, M. (2015). High school is not too late: Developing girls' interest and engagement in engineering careers. *The Career Development Quarterly, 63,* 88–95. doi:10.1002/j.2161-0045.2015.00097.x

2 Chang, J., Kwan, C., Stevens, L., & Buonora, P. (2016). Strategies to recruit and retain students in physical sciences and mathematics on a diverse campus. *Journal of College Science Teaching, 45*(3), 14–22.

3 Salto, L. M., Riggs, M. L., Delgado De Leon, D., Casiano, C. A., & De Leon, M. (2014). Underrepresented minority high school and college students report STEM-pipeline sustaining gains after participating in the Loma Linda University summer health disparities research program. *PLoS ONE, 9*(9). doi:10.1371/ journal.pone.0108497

4 Wilson, Z., Holmes, L., DeGravelles, K., Sylvain, M., Batiste, L., Johnson, M., McGuire, S. Y., Peng, S., & Warner, I. (2012). Hierarchical Mentoring: A Transformative Strategy for Improving Diversity and Retention in Undergraduate STEM Disciplines. *Journal of Science Education and Technology*, 21(1), 148–156. Retrieved from http://www.jstor.org/stable/41413293

5 Bowling, B., Doyle, M., Taylor, J., & Antes, A. (2015). Professionalizing the role of peer leaders in STEM. *Journal of STEM Education*, *16*(2), 30–39.

6 Stevens, S., Andrade, R., & Page, M. (2016). Motivating young Native American students to pursue STEM learning through a culturally relevant science program. *Journal of Science Education and Technology, 25*(6): 947–960.

7 Momoh, J. A. (2014). Outreach program in electrical engineering: Pre-College for Engineering Systems (PCES). *IEEE Transactions on Power Systems, 29*(4), 1880–1887.

8 Zaniewski, A. M., & Rienholz, D. (2016). Increasing STEM success: a near-peer mentoring program in the physical sciences. *International Journal of STEM Education*, 3(14). doi:10.1186/ s40594-016-0043-2

9 Sowers, J., Powers, L. E., Shpigelman, C-N. (2012). *Science, technology, engineering, and math (STEM) mentoring for youth and young adults with disabilities: A review of the research* [Monograph]. Portland: Regional Research Institute on Human Services, Portland State University.

10 Syed, M., Goza, B. K., & Chemers, M. M., & Zurbriggen, E. L. (2012). Individual differences in preferences for matched-ethnic mentors among high-achieving ethnically diverse adolescents in STEM. *Child Development, 83,* 896–910. doi:10.1111/j.1467-8624.2012.01744.x.

11 Phelan, S. A., Harding, S. M., & Harper-Leatherman, A. S. (2017). BASE (Broadening Access to Science Education): A research and mentoring focused summer STEM camp serving underrepresented high school girls. *Journal of STEM Education, 18*(1), 65–72.

12 Listman, J. D., & Dingus-Eason, J. (2016). How to be a deaf scientist: Building navigational capital. *Journal of Diversity in Higher Education*. Advance online publication. Retrieved from http://dx.doi.org/10.1037/dhe0000049

13 Carpi, A., Ronan, D. M., Falconer, H. M., & Lents, N. H. (2017). Cultivating minority scientists: Undergraduate research increases self-efficacy and career ambitions for underrepresented students in STEM. *Journal of Research in Science Teaching, 54*(2), 169–194. doi:10.1002/ tea.21341

14 Grossman, J. B., & Rhodes, J. E. (2002). The test of time: Predictors and effects of duration in youth mentoring relationships. *American Journal of Community Psychology*, *30,* 199–219.

15 Stevens, Andrade, & Page, 2016.

16 Stevens, Andrade, & Page, 2016.

17 Chang, et al., 2016.

18 Marrero, M. E., Riccio, J. F.; Ben-Jacob, M., Canger, A., & Maliti, C. (2017). A crash course in undergraduate research. *Journal of College Science Teaching, 46*(5), 26–31.

19 Phelan, et al., 2017.

20 Salto, et al., 2014.

21 Wilson, et al., 2012.

22 Bystydzienski, et al., 2015.

23 Kabacoff, C., Srivastava, V., & Robinson, D. N. (2013). A summer academic research experience for disadvantaged youth. *CBE Life Sci Educ, 12*(3), 410–418.

24 Tsui, L. (2007). Effective strategies to increase diversity in STEM fields: A review of the research literature. *The Journal of Negro Education, 76*(4), 555–581. Retrieved from http://www.jstor.org/stable/40037228

2 STANDARDS OF PRACTICE FOR STEM MENTORING PROGRAMS

▶ TRAINING

MENTOR TRAINING

Program provides a minimum of two hours of pre-match, in-person, mentor training. (B.3.1)

▶ STEM RECOMMENDATION

STEM mentoring programs that involve mentors and mentees conducting STEM activities together should require training not only in how to develop an effective, close mentoring relationship with one or more mentees, but also training on other topics. Because of the increased training demands on STEM mentors, pre-match mentor training will need to last more than a minimum of two hours.

Program provides pre-match training for mentors on the following topics [see main *Elements* for full listing of original topics] (B.3.2):

▶ STEM RECOMMENDATION

STEM mentoring programs often focus their training on the role of being a positive role model to mentees with the goal of building mentees' sense of belonging in a STEM field and establishing their scientific identity. Two additional key roles need to be incorporated into mentor training content.

- Mentors need to be trained to be a connector or advocate for their mentees to connect them to other people, places, experiences, or opportunities related to STEM.
- Traditional mentor training should be included in STEM mentor training with a focus on the importance of being a trusted, adult friend to mentees in order to establish a caring, supportive mentoring relationship.

▶ STEM RECOMMENDATION

Because communal goals may be highly valued by female, first-generation, and racial and ethnic minority students, mentor training needs to include strategies to highlight communal opportunities in STEM for programs targeting these populations.

▶ STEM RECOMMENDATION

Because female and minority students frequently encounter negative stereotypes and lower expectations of their intellect and abilities, additional topics for pre- (or post) match training for mentors in a STEM mentoring program are needed to help mentees overcome barriers to success in STEM coursework or common challenges experienced when exploring or entering STEM careers. These topics include:

- Cultural awareness training on negative stereotypes and lower expectations, unconscious biases, and diversity and inclusion;
- Strategies for supporting feelings of self-efficacy and belonging;
- Communicating admiration and respect for mentees;
- Talking with their mentees about traditional barriers to STEM education and STEM careers including race, gender, socioeconomic status, and disability;
- Teaching and providing feedback on workplace norms and behaviors in ways that are culturally responsive and empowering for youth; and
- Fostering a growth mindset in youth.

▶ STEM RECOMMENDATION

Mentors can be trained to help build sustained career interests in STEM by communicating a meaningful passion for their work, as well as a strong sense of purpose participating in a deeply fulfilling, positive, and meaningful career.

▶ STEM RECOMMENDATION

Because STEM mentoring programs are often group-based and conducted at program sites, mentor training should address how to establish a caring, supportive, and individual mentoring relationship with each member of the group.

Program provides pre-match training for the mentor on the following risk management policies that are matched to the program model, setting, and population served. [See main *Elements* for full listing of original topics.] (B.3.3)

▶ **STEM RECOMMENDATION**

STEM mentoring programs that include conducting scientific experiments or going on field trips may need to develop risk management policies and mentor training on these policies to protect the safety of mentees and mentors.

Program uses training practices and materials that are informed by empirical research or are themselves empirically evaluated. (B.3.4)

▶ **STEM RECOMMENDATION**

STEM mentoring programs may consider adopting or adapting general or STEM-specific mentor training materials that have been informed by empirical research or are themselves empirically evaluated.

Program provides additional pre- and post-match mentor training opportunities beyond the two-hour, in-person minimum for a total of six hours or more. (E.3.1)

▶ **STEM RECOMMENDATION**

When STEM mentoring programs have matches conduct STEM activities or experiments together, ongoing mentor training is likely needed in the following topics:

- Facilitating STEM activities. Training could be conducted in advance of the meeting or just-in-time, and virtually (e.g., online videos, video or web conferences) or at an in-person, instructor-led workshop.
- How to conduct the program's STEM activities in a safe and successful way.
- Being cautious about using an overly technical vocabulary with mentees without providing them with definitions or explanations.
- The importance of simplifying explanations and instructions so that they are developmentally appropriate for the target audience of mentees.
- The scientific method, critical thinking, and continuing problem-solving.

MENTEE AND PARENT/GUARDIAN TRAINING

Program provides training for the mentee on the following topics [see main *Elements* for full listing of original topics] (E.3.4):

▶ **STEM RECOMMENDATION**

Because many STEM mentoring programs involve having mentees work in authentic STEM settings or with STEM professionals serving as mentors, some additional mentee training topics should be addressed that may support a positive mentoring relationship, but are not necessarily central to being a mentee.

- Bioethics in research with human subjects
- Professional ethics (licensing, plagiarism, authorship credit)
- Coursework prerequisites
- Scientific research methods
- Career opportunities
- Networking skills

Program provides training for the mentee on the following risk management policies that are matched to the program model, setting, and population served. [See main *Elements* for full listing of original topics.] (E.3.5)

▶ **STEM RECOMMENDATION**

STEM mentoring programs that include conducting scientific experiments or going on field trips may need to develop risk management policies and mentee training on these policies to protect the safety of mentees and their mentors.

Program provides training for the parent(s) or guardian(s) (when appropriate) on the following topics [see main *Elements* for full listing of original topics] (E.3.6):

▶ **STEM RECOMMENDATION**

STEM mentoring programs provide parents or guardians with training on how they can support and encourage the mission, goals, and activities of the STEM mentoring program, as well as provide support to the STEM mentoring relationship.

Program provides training for the parent(s) or guardian(s) on the following risk management policies that are matched to the program model, setting, and population served. *[See main Elements for full listing of original topics.] (E.3.7)*

▶ **STEM RECOMMENDATION**

STEM mentoring programs that include conducting scientific experiments or going on field trips may need to develop risk management policies and parent or guardian training on these policies to protect the safety of mentees and their mentors.

Justification

Training, both prior to initiating the mentoring relationship and over time as the relationship evolves, is considered to be fundamental to mentoring program success. STEM mentoring programs should adhere to all of the training benchmark practices described in the *Elements of Effective Practice for Mentoring (4th Ed.)*. This chapter describes some ways in which these practices and program enhancements may be most applicable to STEM mentoring programs. Most of the empirical research on mentor or mentee training in STEM programs was conducted with undergraduate student mentees, and some even with graduate student, postgraduate student, or junior faculty/employee mentees. The findings from these studies are often integrated into the recommendations below because they do not appear to be only relevant to a particular setting or age group. In addition, some suggestions for program practices were based upon suggestions from the practice experiences of members of this project's Working Group.

MENTOR TRAINING

Increase the Minimum Duration of Pre-match Mentor Training

The first training benchmark **(B.3.1)** addresses the required minimum duration for pre-match training of mentors and defines it as being two hours. For STEM mentoring programs, two hours is not sufficient to address all of the topics needed to establish the readiness and competency of a STEM mentor. As discussed later in this section, we recommend a total of at least six hours of pre- and post-match training combined so that mentors are prepared for the tasks and activities of the program based on the following considerations.

It Takes Time to Train Mentors to Lead STEM Activities

In general, STEM mentoring programs that include training in activities and/or a focus on fostering an interest in ongoing education or building a career in STEM can't address all of the topics needed to prepare STEM mentors adequately in only two hours. For example, one program in our research review offered a *full-day* orientation workshop prior to the start of the mentoring program[1]. For a real-life example of a program that emphasizes training mentors to successfully lead STEM experiments and activities, see the work of Sea Research Foundation on the next page.

Many STEM Mentoring Programs Involve Group-Based Mentoring and Curricula

Serving as a mentor to one or more students, while simultaneously leading STEM activities, can be a challenging job. When STEM activities require technical expertise, attention to task, or complex steps, this can take most of your attention. In these situations, actual mentoring and the establishment of a mentoring relationship may be diminished. Because of these challenges, some mentoring programs have moved away from having volunteer mentors deliver or lead activities, and instead, utilize their paid staff members in this role[2]. However, if a STEM mentoring program does have mentors lead activities, it will take extra time in training to teach the instructions for completing the activity in addition to more general mentor training topics.

One training model that programs have tried is to have volunteer mentors experience the activity first, so they are familiar with the steps and subject matter, and then, have them lead their mentees in the activity. This approach may be helpful for group-based STEM mentoring. It is worth noting that this curriculum-centered approach is more rigid in that all mentors and mentees might need to complete the same activities at the same time.

Photo courtesy of Sea Research Foundation

STEM MENTORING IN ACTION: **Sea Research Foundation**

THE STEM MENTORING PROGRAM we run does not require that mentors have expertise in STEM, so an important component of mentor training covers how to conduct the program's hands-on STEM activities with mentees. STEM Mentoring's initial mentor training focuses on best practices in mentoring, boundaries, communication, and program structure, as well as information on how to facilitate STEM activities with young people. The mentors get into groups of five, with four assuming the "mentee" role and one assuming the "mentor" role; the group then conducts an activity together to help mentors experience what these activities and group dynamics might look and feel like.

Matches conduct new activities every session, so Program Coordinators communicate with mentors beforehand to walk them through each activity. STEM Mentoring has found that when mentors are oriented to the activities and materials, they are more confident and better able to concentrate on building and strengthening relationships during the sessions with mentees. If mentors aren't busy looking for materials or figuring out technology, they can be more attuned to their group's needs and can solve interpersonal issues and answer mentees' questions as they arise.

Approaches to helping mentors learn activities vary by site. Some sites meet with mentors 15 minutes before each session to review the day's activities and materials. Program Coordinators walk mentors through the activity and introduce them to any needed equipment. This model has worked well, although mentors need to be advised upfront that their weekly commitment will include an extra 15 minutes for preparation. Other sites conduct a content training with mentors before the start of each new curriculum module to review the activities for the entire module at once. Some sites find it difficult to convene mentors for extra sessions, so they instead send instructions and videos virtually through a weekly newsletter. All sites are also provided with PDFs of the Mentor Guides and links to webinar trainings for each curriculum module that they are encouraged to share with mentors.

Other approaches are more individualized, where mentors and mentees complete activities that reflect the goals and interests of the mentees. This more individualized approach may better lend itself to a one-to-one mentoring relationship or small mentor-to-mentee ratios.

Training Demands, Particularly Those Related to STEM Activity Instruction, May Be Reduced if Mentors Are STEM Professionals

Mentoring programs that integrate mentees into pre-existing STEM activities in educational or research institutions or workplaces, and that rely on mentors who are already experts in their field, don't have the same burden of training mentors in the instructions for carrying out the STEM content and can focus mentor training on the development of a mentoring relationship. In these cases, it may be possible to complete mentor training in two hours, but more time will likely be needed.

Train STEM Mentors to Build a Scientific Identity and Commitment to STEM in Mentees

The second training benchmark **(B.3.2)** addresses the core topics for pre-match mentor training. Training topics need to reflect the main goals of the mentoring program, especially in how the program is attempting to create or solidify youths' sense of STEM identity. There are at least two stages in the typical mentee's trajectory to entering a STEM profession. First, as noted in the Introduction, programs can be designed to pique students' interest in learning more about a STEM field and that make STEM activities seem exciting, rewarding, and interesting. Mentor training for mentoring youth in these types of programs might focus on instilling excitement for STEM.

However, once a student has declared an interest in a STEM major in school or STEM career, then programs may need to focus more on supporting and sustaining those existing interests, and less on just generating excitement for STEM. Consistent with this idea, receiving mentoring has been shown to have a positive impact on students from groups that are underrepresented in STEM majors and careers. Unfortunately, these youth are frequently less likely to receive mentoring than their peers who are not members of underrepresented groups[3]. Thus, once mentees are recruited into mentoring programs, retaining them in the program and designing it to meet their needs is critically important.

There are several key things to consider emphasizing in STEM mentor training:

Training on Being a STEM Connector or Advocate

STEM mentors need to help connect their mentees to opportunities, people, and places to support their growth and development in STEM, as well as to advocate for their mentees at their institution and other educational or career settings. In fact, students in groups traditionally underrepresented in STEM will likely need help locating resources (e.g., financial, informational) and role models in STEM and should be encouraged to build both weak and strong ties with others in their field[4].

In addition to being a connector, STEM mentors need to advocate for their mentees. Part of being an advocate is also socializing mentees into the profession and helping them with their personal and career development in addition to exposing them to research skills which can enhance their identity as a scientist[5,6] and their commitment to a research career[7]. Learning about the scientific method, scholarly writing, and professional behavior with colleagues are all ways that mentors in STEM can serve as role models, instructors, and advocates to mentees. For example, women and other underrepresented groups may benefit more from sponsorship than just mentoring[8], meaning that they may need less advice and more advocacy to advance in their careers.

Training on Being a Trusted, Adult Friend to Mentees

Many STEM mentoring programs discuss the importance of training mentors in the STEM-related activities conducted in their programs; however, STEM mentoring programs acknowledge that the most important factor related to mentoring success is the quality of the relationship between the mentor and mentee[9], which reflects the findings reported in the general literature on mentoring. Thus, friendship is central to relationship success.

There is a large amount of literature on mentor training in undergraduate STEM mentoring programs that has many interesting and relevant implications for K–12 STEM mentoring programs. Research findings show that when mentors support students' personal and career development, as well as learning research skills, it contributes to strong positive outcomes. In fact, students' self-efficacy for conducting research and science identity were enhanced by close relationships with mentors[10,11,12] and participation in research-focused mentoring relationships[13], which further contribute to a stronger interest in and commitment to having a STEM career[14]. For example, when faculty showed concern and were supportive and accessible in the context of talking about substantive topics (e.g., discussing papers, projects, and feedback on coursework; assisting on a research project; and discussing career plans), one study found academic performance in Latina/o college students was enhanced[15].

In another example, encouragement and support from mentors were mentioned by high school students attending a summer bridge program as one of the most valuable aspects of the research experience[16]. Training on how to provide psychosocial support through statements of encouragement and by communicating belief in the students' capacity to be successful in STEM—while acknowledging and discussing struggles, concerns, and fears—is particularly important for mentees with a disability[17]. The importance of training mentors on being encouraging and positive with mentees by using microaffirmations is discussed later in this section.

Training on Highlighting Communal Goals and Opportunities in STEM

There are many studies that have examined the career goals of groups of students who are underrepresented in STEM including women[18,19,20,21], minority groups (e.g., Native Americans, Latinos)[22,23], students from low socioeconomic backgrounds[24,25], and first-generation college students[26]. Notably, students in all of these groups are more likely to endorse communal goals of wanting to help others, the value of interdependence in their work, and a deep commitment to helping improve the lives of individuals in their communities than other goals or than their peers. Many mentees, particularly from underrepresented groups, are turned off from STEM because they perceive the work to be lonely or solitary, or that the goals of STEM jobs are not altruistic or for the common good. This topic was addressed in the Recruitment Standard, but is also relevant for mentor training, which can teach mentors to address mentee's goals and desired work contexts. Communicating communal goals and providing communal opportunities in STEM mentoring programs may enhance interest in a STEM career. For example, in one study, high school students attending a precollege, summer mentoring program on electrical engineering had near-peer mentors who worked closely with them on team projects[27], enabling mentees to experience the collaborative and interactive nature of STEM projects.

Additional training topics for building STEM-related career skills

Training in how to support specific STEM-related career development activities could be helpful to mentors to provide structure to their activities and discussions. For example, one program trained mentors in how to engage mentees in six STEM activities, such as shadowing the mentor at work or in college; reviewing the mentee's high school transcript and developing a plan for taking STEM courses; and meeting with parents or guardians to share what mentees were learning in the program[28]. Programs may want to consider how they train their mentors to address career-related topics such as:

Supporting Mentees' Sense of Competency

Studies have investigated factors that may diminish interest in STEM education or careers, even among those who have strong STEM interests. Factors including not having a sense of belonging or identity in a STEM field as well as not believing that one can grow and learn challenging material (i.e., not having a growth mind-set) have been examined in relation to STEM persistence. Even high achieving STEM students have been found to be plagued by feelings of self-doubt, low confidence, and a sense of not belonging in their field, particularly when they have teachers who pick favorites in their classes from students who are from more privileged backgrounds[29]. When students are aspiring to be in a STEM field, it is important for mentors to counter these self-critical feelings and communicate that their mentees are capable and competent, as well as the fact that they will make meaningful contributions to their field[30,31,32]. For example, training has been designed to help young professional STEM mentors develop a close, supportive relationship as well as foster feelings of competence in science in their college freshman mentees in Quebec (same age as high school seniors in the United States)[33]. By affirming these skills, abilities, and belonging in science, mentor training focused on research mentoring of undergraduates has increased both mentors' and mentees' satisfaction in their mentoring relationships[34,35,36].

Supporting Mentees' Tolerance for Failure

These attitudes about competency and belonging, while important, appear to be less important than having low performance avoidance goals. In other words, working in a STEM field requires a high tolerance for failure and not avoiding performance for fear of failure. Scientists can spend years designing and executing an experiment or study, and it is highly possible that it may not work out. Individuals who blame themselves for failure or lack of significant findings are at risk for leaving STEM—in other words, the more someone's sense of competency or sense of self feels threatened, the greater the likelihood that they will quit. That is why students not only need exposure to fun and interesting STEM activities that may be easy to execute or whose outcomes are well-known, but they also need exposure to authentic or less predictable STEM experiences that can enhance research skills, career knowledge, and research self-efficacy[37,38]. STEM mentors can be trained to talk about the research method, normalize failure experiences (e.g., failed experiments, rejections of grant proposals, submissions to conferences for presentations, submissions of journal articles to peer-reviewed journals), and help build fortitude and stamina for coping with rejection.

Mentors also need the message that it's alright to let the mentee fail at something reinforced in their training. Often mentors will rush to step in and do activities themselves if the mentee is struggling. But, as noted above, failure is part of learning and central to the scientific method and mentors need to know when to back off and allow their mentee to learn through failure in a growth mind-set perspective.

Providing Mentee's with Authentic Research Experiences

Engaging in authentic research projects has many benefits for career preparation in a STEM field[39]. For example, in one study, mentors who showed interest in mentee's research projects, appreciated their mentee's contributions to the projects, offered constructive feedback, helped mentees to understand how the mentee's research activities fit into an overall research project, and made the mentee feel included in the lab increased mentee's self-efficacy and academic outcomes[40].

In another example, a report from the U.S. Department of Education indicated that failure to be engaged with rigorous and interesting STEM course work during one's freshman year in college and the level of success in these STEM courses were better predictors of switching to another major than many other factors[41]. Thus, mentoring programs designed for students who have already expressed an interest in STEM may shift their focus from simple, light activity-based programming to programs where mentees engage in challenging, high-skill, authentic STEM activities.

Cultural Awareness Training to Support and Encourage Mentees from Groups That are Traditionally Underrepresented in STEM Fields

Avoiding and Mitigating Stereotype Threats

Mentors need to understand how stereotype threats can negatively impact students' academic functioning[42], as well as how to manage stereotype threats, to reduce the likelihood that students from underrepresented groups in STEM misinterpret or attribute lack of success in research projects to themselves[43]. Evaluations of interventions suggest that mentors' and mentees' reports of relationship quality can be enhanced with training[44,45,46]. Furthermore, "colorblind mentoring," where mentors have the belief that race should not and does not matter, can have a negative effect on mentee's development because ignoring race in STEM will not help equip mentees with knowledge and skills to address racism in the classroom or workplace[47]. Beyond race and ethnicity, the consequences of stereotype threat are also a concern in mentoring of youth with disabilities. Mentors in one study we reviewed reported wanting training in how to talk to their mentees about disabilities and how having a disability could impact the student's career development[48]. Mentees from other underrepresented groups may also want to address these issues with their mentors. For example, another study found that women mentees in underrepresented racial and ethnic minority groups in science and engineering want to discuss issues of race and ethnicity with their mentors more than their white peers do[49].

One way that mentors can be helpful to traditionally underrepresented youth is to teach them skills to cope with and manage the barriers they may encounter entering a STEM field. However, mentors often come from middle-class backgrounds, or because of their education or career trajectories have moved into middle- or upper-class status. The expectations, perceptions of academic ability, and interpretations of behavior of white teachers and mentors are often negatively affected when their protégés are from ethnic and racial groups[50,51]. Thus, mentees may see them as outsiders or not credible sources of information. Mentors who aren't from traditionally underrepresented groups may benefit form additional training to uncover their own biases and avoid stereotyping their mentees.

Being Aware of Microaggressions

Microaggressions are subtle assaults, insults, or invalidations directed at people of color that can be intentional or unintentional and that may be expressed verbally or nonverbally[52]. These often brief, everyday forms of aggression and discrimination can result in perceptions of discrimination, which can have an immediate effect on someone's mood, self-esteem, and sense of acceptance and belonging[53] as well as more long-term, debilitating effects on social isolation, mental and physical health, and academic performance and persistence[54,55,56,57]. Mentor training can help raise their awareness and skills about the ways that race, class, and gender may effect disparities in STEM careers, and strategies for mitigating these factors. For example, heightening mentors' awareness that their mentees are often the recipients of racial stereotypes and microaggressions both in educational and workplace contexts and teaching them to deal effectively with their own unconscious biases[58] can help build their empathy and advocacy skills with their mentees[59].

Engaging in Microaffirmations

Some researchers have suggested that engaging in microaffirmations, small acts to enhance inclusion and support such as communicating to students that they are "welcome, visible, and capable of performing well" in school, can be helpful in positively supporting the academic resilience and persistence of minority students, particularly in STEM fields[60,61]. Mentor training topics could build upon effective educator training that focuses on microaffirmation messages including how they can positively impact student success, support a growth mind-set and self-efficacy, and promote mentees' STEM educational and career opportunities[62].

Providing Feedback in Culturally Sensitive Ways

One of the most valuable things a mentor can do when orienting a mentee to the STEM world is teach the workplace norms, behavioral expectations, and other "soft skills" that define STEM work. However, they also need training to illustrate how to provide feedback around behavioral and procedural expectations that doesn't cause underrepresented youth to feel alienated in STEM environments. As noted previously, the people who are defining what professional behavior is in these environments may not have a shared background or culture with the youth in the program. They can, albeit inadvertently, say things or correct behavior that is subjectively unprofessional (like not being friendly, not participating fully in a meeting, not asking questions) that may be grounded more in cultural differences than other reasons. Mentors should note cultural differences and make sure that all youth feel welcome in STEM environments, even when providing feedback about behavioral expectations.

Establishing Trust

Mentors will benefit from learning about issues of cultural awareness and diversity. Minority youth often feel that they are the victims of negative stereotypes about the group that they are a member ("stereotype threat") and that they may not be competent in their work despite past success or accomplishments ("imposter syndrome"), which together may contribute to their lack of persistence in a STEM career. Mentor training in the importance of and skills for being dependable, trustworthy, and respectful are fundamental topics for inclusion in all pre-match mentor training[63,64]. However, the interpersonal vulnerability of students in underrepresented groups makes the trustworthiness of mentors potentially even more important for establishing a high-quality mentoring relationship, and supporting the motivation to pursue STEM majors and careers, than it is for students who are not members of a racial or ethnic minority group[65].

Furthermore, explaining what trust means in this context and applying it to specific examples can help STEM mentors orient their behavior in ways that can be most helpful going beyond simple issues of trust (e.g., being respectful and fair, being on time, maintaining confidentiality, following through on commitments). In this context, demonstrating trustworthiness may include behaviors such as keeping the mentee's goals and needs paramount in the relationship; benevolence; affirming the accomplishments of mentees; and engagement through frequent supportive academically focused interactions (e.g., discuss ideas for a paper or research project, assist on research project, provide constructive feedback on work, discuss career plans)[66]. Finally, interpersonal trust in mentors may not be sufficient to overcome societal, institutional, or structural barriers to a sense of belonging and competence. Mentors should be aware of ways in which their institution may create or sustain environments that make students in underrepresented groups feel unwelcome or not included.

Communicating Passion for STEM Work and a Sense of Purpose

Because of the research on students from groups underrepresented in STEM endorsing having communal career goals, STEM mentors need training in communicating their personal passion for their work, as well as having a strong sense of purpose. They should not take for granted that mentees know how mentors feel about their work and it is important for them to share the fact that they find their work deeply fulfilling, positive, and meaningful. In a precollege, summer mentoring program on electrical engineering for high school students, mentees were given experience working together as a team on real-world, hands-on projects related to renewable energy applications, smart grid technologies, and applications to home-based energy-efficient appliances[67]. One main goal of this program is to spark students' creativity and interest in the relevance and need for young people to enter meaningful and rewarding careers in power engineering.

Additional Training for Group Mentoring Programs

When mentors are engaged in a group-mentoring program, training on group leadership skills will be needed in addition to core training on mentoring. For example, training on both interpersonal (e.g., conflict management, identifying strengths in mentees, meeting facilitation) and intrapersonal (e.g., time management, stress management, emotion regulation, adaptability) skills have frequently been implemented by STEM group-mentoring programs[68,69]. Mentors in one study reported they highly valued that the program helped them develop skills to manage multiple students in a group simultaneously, particularly when the students varied in their ability levels (Banks, 2010).

Training in topics related to group-based mentoring including Tuckman's stages of group development will help mentors understand that group cohesion takes time to develop[70]. Also, after the polite forming stage of group development, there is typically the storming stage where the group may experience a little conflict and limit testing. Group mentors could benefit from understanding that minor degrees of group conflict after the forming stage does not necessarily mean that members need to be moved to another group. In fact, enough time needs to transpire to allow for the group to move beyond the storming stage to the norming stage. Thus, in addition to training on the stages of development of mentoring relationships with an individual mentee, understanding how to form relationships and manage the group as a whole will be an important topic for pre-match training.

Other group mentoring training topics include:

- Training in establishing ground rules for the group including confidentiality and providing mutual help to one another;
- Recognizing when a group member is being excluded or left out and strategies for enhancing inclusion of ostracized members;
- Managing group dynamics to help resolve conflict;
- Establishing roles for groups members that are fluid across sessions, so that one person doesn't always serve as the group leader or secretary or other role and;
- Supporting activity completion by students who have different levels of ability.

Furthermore, for STEM mentoring programs that utilize group mentoring with youth with behavioral challenges, mentors and staff should be trained to be aware of signs that group members are having a negative effect on one another[71]. The iatrogenic effects of group interventions that include antisocial youth are well-established and managing the social influence effects of antisocial youth on their peers is very challenging even for highly supervised and trained mental health clinicians[72]. This need is discussed further in the "Monitoring and Support" section.

Photo courtesy of Sea Research Foundation

Mentor Training Needs to Address Lab Safety

The third training benchmark **(B.3.3)** addresses training mentors in a mentoring program's risk management policies. Because many STEM mentoring programs involve either working in a lab, conducting authentic or canned scientific experiments, or other STEM activities, mentors may need additional training in lab procedures or awareness of being safe and keeping their mentees safe while completing STEM activities.

Mentoring Programs Should Adopt or Adapt, and Then Test, Mentor Training Materials Designed for STEM Mentors

The fourth training benchmark (B.3.4) suggests that mentoring programs use training materials or programs that have been empirically evaluated or that are informed by research in their content. Several curricula have been used in STEM mentoring programs and some have been empirically evaluated. One thing to note is that most STEM mentor training programs have been developed for use with the mentors of undergraduate students for increasing retention in a STEM major or with the mentors or junior faculty. Thus, the mentor training programs described below may inform the development or evaluation of K–12 STEM mentor training programs, but will likely need to be adapted or modified for use with mentors volunteering with a younger age group.

A well-established mentor training program, Entering Mentoring, was developed at the University of Wisconsin-Madison as a workshop series for developing skills in mentors and preparing them to participate in effective mentoring relationships[73,74]. Topics covered include communication skills, aligning expectations, assessing understanding, addressing diversity, fostering independence, promoting professional development, and articulating a mentoring philosophy and plan. Notably, this program has mentors reflect on "how their own work habits, cognitive styles, attitudes, gender, ethnicity, physical ability, educational background, and nationality differ from that of their mentees and complements readings on stereotypes and unconscious prejudices," and furthermore, how to overcome cultural biases (p. 473)[75]. Mentors rated the training as being highly useful and interesting. In addition, trained mentors reported discussing student's expectations of the mentor, considering diversity, and asking for advice when faced with a challenge with their mentee more than untrained mentors[76]. Furthermore, mentees reported that trained mentors were more available to and interested in them and gave them more independence[77]. An adapted version of this program has been evaluated in a randomized controlled trial conducted at 16 academic health centers across the United States. Trained mentors reported that their mentoring skills levels were higher than untrained mentors, particularly in their competencies related to communications, expectations, and professional development, and these gains in mentoring skills were also retrospectively reported by mentees of trained mentors[78,79].

Alignment of expectations is a key goal for mentoring relationships[80] and one of the competencies for which mentors in their training report the highest gains. Training on expectations as well as practical matters and basic topics related to being an effective mentor was also a central part of a three-hour training program for volunteers mentoring Native American and Hispanic elementary and middle school students[81].

Another training program, Mentoring for Mentors, lasts two days and is designed for preparing mid-level and senior HIV researchers to learn to be effective leaders and mentors to early stage investigators from underrepresented ethnic and racial minority groups[82]. Mentors reported an increase in self-efficacy related to their mentoring skills as well as greater awareness of the microaggressions and unconscious bias experienced by mentees in underrepresented groups.

A more comprehensive curriculum, informed by research, was developed for use with undergraduate student STEM Ambassadors, who served as informal, near-peer mentors to other undergraduate STEM students[83]. The training addressed an extensive array of topics related to leadership, teamwork, and professionalism in STEM (e.g., stress and time management, sustaining motivation, dealing with personality differences in the workplace, personal accountability, and creative problem-solving).

Another comprehensive curriculum was developed by Dow Chemical Company and Women in Engineering ProActive Network (WEPAN) that includes general mentoring topics, such as the need for training; goals; benefits to, expectations of, and responsibilities of mentor and mentees; types of relationships; challenges related to stereotypes, biases, and discrimination; navigating both cross-gender and cross-racial mentoring relationships; resources and where to go for help; faculty as mentors and how mentoring is different than advising; and interpersonal communications skills for use in undergraduate mentoring programs[84]. Despite the fact that this curriculum was developed for college students, it has also been used in STEM mentoring programs conducted in community colleges, high schools, corporations, nonprofit organizations, and state public agencies.

STEM Mentors May Need Supplemental Pre- and Post-match Training Around Communication Skills

The first Training Enhancement **(E.3.1)** suggests that mentors may need additional pre- or post-match training. In the case of STEM mentoring, we recommend training specifically on communication skills that will facilitate close and mutual mentoring relationships, although this may vary based on who is serving in the mentoring role. If mentors do not have training or education in STEM, but are enthusiastic about the topic and want to inspire youth to engage in STEM, then they will need training in how to lead STEM activities and do the “science” aspects of the program in an effective way. A range of competencies have been identified that are needed to be able to effectively lead STEM activities with communication skills being the most frequently identified competency for volunteers, followed by organization, planning, subject matter, and other group leadership skills[86]. Mentors who are not STEM experts, could be so unfamiliar with the activities being conducted that their lack of knowledge and skills could interfere with their being able to focus on getting to know their mentee(s) and their mentoring relationship development. In fact, one program reported that mentees and mentors began quitting the program when mentors weren’t sufficiently competent in leading STEM activities[87].

On the other hand, mentors who are STEM professionals are likely used to talking about their work with their peers using a highly technical and specific vocabulary. This expertise could be a barrier to relationship development. In fact, much work in STEM is based on a deep body of knowledge and skills that aren’t always understandable to a layperson—especially to a young student. Some mentors who are STEM professionals report worrying about communicating with their mentees about STEM and being understandable (e.g., to middle-school girl mentees)[88]. These mentors may need training in communication skills about discussing their work or communicating instructions in clear, simple language to their mentees.

The scientific method is defined by hypothesis generation and hypothesis testing. Following the scientific method requires being able to think logically and critically, suspend judgment, brain-storm, let data lead, and continuously problem solve, often with others. Thus, mentors need training in how to train, apply, develop, and support these cognitive skills in mentees. One program in our literature search trains mentor and mentees in how to brainstorm with a team of other peers and engage in interactive problem-solving to solve complex engineering problems[89].

For another example on how a leading STEM mentoring program trains mentors both before and after the match in a variety of critical topics, please see the next page on Genentech’s Futurelab program.

Photo courtesy of Genentech

STEM MENTORING IN ACTION:

Genentech's Futurelab Initiative

GENENTECH'S FUTURELAB INITIATIVE offers all employee mentors extensive training and professional development opportunities throughout the mentors' engagement with Futurelab. Futurelab's first touchpoint with mentors is a 90-minute orientation led by a Futurelab staff member. Mentors are given an overview of the program, including what the mentor role is; what the time commitment looks like; what's expected of mentors in terms of preparation, collaboration, and meeting with co-mentors; attending booster trainings throughout the academic year; and what an ideal engagement looks like with students. The Futurelab team offers a recap of detailed expectations mentors can access throughout the year.

The second component of the orientation is an interactive experience where mentors can hone their relationship-building skills, practice addressing STEM concepts in an age-appropriate manner, and then regroup to discuss and reflect on lessons learned. Mentors are given different situations that commonly arise during mentoring relationships and are asked to practice their responses and reactions. Situations vary from students being discouraged because they're not yet succeeding at designing an effective egg drop vessel, to mentors translating complex STEM concepts into language students of all ages and backgrounds will understand.

The orientation closes with a panel discussion in which teachers and former mentors answer frequently asked questions. This can be anything from what to do if a student doesn't engage, to who to approach when a mentor doesn't understand an aspect of common core math. These interactive activities give mentors a powerful opportunity to prepare for their role by facing real-life situations and discussing questions that may arise in their mentoring relationships.

In 2017, Futurelab piloted booster training opportunities for volunteers. For this pilot, Futurelab partnered with EnCorps STEM Teachers Program—a nonprofit that helps STEM professionals transition careers into teaching in high needs schools—to envision and develop one booster session on Unconscious Bias in the fall and another on Growth Mind-set in the spring. These booster trainings are designed to deepen mentors' engagement with students and enhance their own professional and skills development, delivered by Genentech's Futurelab program team with support from Genentech's Human Resources and EnCorps STEM Teachers Program.

Photo courtesy of Midlands Mentoring Partnership

MENTEE TRAINING

Mentees Need Training Specific to STEM Activities and Careers to be Safe, Credible, and Effective in the Lab, Workplace, or Program

The fourth Training Enhancement **(E.3.4)** suggests that it is also important to provide pre-match training to mentees. In the case of STEM mentoring programs, there are specific topics related to STEM careers or professions that are important in helping to establish a positive relationship with a STEM mentor. Many STEM mentoring programs have discussed the importance of training of mentees and in fact, one review paper discussed a variety of different training models to use with high school STEM mentees including workshops or even weekly instruction[89]. One precollege, summer mentoring program for 11th and 12th grade high school students interested in electrical engineering included mentee training on professional ethics, societies, licensing, and written communication skills[90]. In another example involving a medical mentoring program for high school students focused on exposure to the healthcare profession, they conducted parallel mentor-mentee training in an academic hospital setting[91] on topics such as prerequisite classes needed for attending medical school and career opportunities in healthcare.

The following examples from our literature review provide further ideas around the types of mentee training topics that practitioners in STEM mentoring contexts may consider:

- An intensive, small summer program for disadvantaged high school students interested in STEM involved working in research labs with a doctoral or postdoctoral mentor[92]. In order to be prepared to work with mentors in an authentic research setting, mentees received extensive training on the professional attitudes, skills, and behaviors essential for being successful in a research lab, such as the importance of organization, time management, meeting deadlines, following directions, problem-solving, interpersonal communication, and teamwork. Training also included learning about the science behind the research projects in the lab. More importantly, students received training in how to think critically as well as how to design and conduct experiments. Students in this program performing significantly below grade level in reading and math at the inception of the program; hence, there was extensive academic training in writing and math to help the students function adequately in the lab. Given the small size of the program, a formal, empirical evaluation was not conducted; however, the majority of the students improved their scientific writing skills and all students reported feeling more confident and competent in writing, a key skill for the STEM workplace. Follow-up results indicated that all of the students are attending college or planning to attend college, and 60 percent are planning to major in a STEM field.

- A residential summer science program for high school girls offering engagement in faculty-mentored research projects includes training in career exploration and college admissions counseling[93]. Training topics in the research immersion experience cover scientific methods, how to do literature reviews, experimental techniques, data analysis, statistics, and presentation skills. Topics in the career exploration training include exposure to a wide range of STEM careers. Training in the college admissions process included information on required coursework, standardized testing, how to search and apply to colleges, essay writing, and mock interviews.

- Another mentee training curriculum was developed for the PROmoting Geoscience Research, Education, and SuccesS (PROGRESS) mentoring program[94], based on workshops developed for the Earth Science Women's Network (ESWN)[95,96]. Weekend workshops were held for undergraduate women STEM majors who were mentees in the PROGRESS program. In this curriculum, mentees were trained in taking a larger role in establishing their own natural mentoring relationships in addition to the assigned mentors they received as part of the program. This perspective is consistent with the idea that science is a collaborative endeavor and that mentees have diverse needs that can best be met by information relationships with a community of mentors[97]. Topics included assessing their networks of mentoring relationships; developing skills in initiating and maintaining relationships with mentors, such as clarifying and managing expectations; and common challenges that women face in STEM undergraduate education to help them cope with gender bias. In addition, students were provided access to a network of potential mentors who were both on and off campus including female role models who had diverse careers in the earth and environmental sciences. Although the training curriculum was not evaluated independent of the mentoring program, the mentoring program was evaluated using a design that included propensity score matching of the intervention group with a similar sample of female STEM students who did not participate in the mentoring program. Among many positive outcomes associated with participation in the program including increased scientific identity, persistence intentions, and deep interest in earth and environmental sciences, mentored students in the program reported having more mentors than students who were not in the program, suggesting that this training approach enhanced students' social capital.

- High school graduates who attended a summer bridge STEM mentoring program participated in a hands-on research internship where they attended an orientation meeting introducing them to the program, followed by supplemental group learning activities on topics such as the responsible conduct of research, how to conduct scientific literature reviews, preparing oral and poster presentations, careers in STEM, and networking skills[98].

- Another mentee training program, *Entering Research*, developed at the University of Wisconsin, helped undergraduate and graduate STEM students prepare for participating in effective mentoring relationships[99,100] and taught them how to take a more active role in their relationships with mentors[101]. Topics included in the training mirror those developed for general mentor training, including communication skills, the importance of aligning expectations, assessing understanding, addressing diversity, fostering independence, promoting professional development, and articulating a mentoring philosophy and plan. Students completed self-ratings of how their scientific confidence, skill, and knowledge increased from completing the training and mentored research experience, and more importantly, reported that the seminar guided them through the process and helped them to find mentors[102].

Mentees Also Need Training to be Safe in Executing STEM Activities or Being in STEM Settings

The fifth Training Enhancement **(E.3.5)** suggests STEM mentoring programs that involve mentees completing STEM activities or conducting research in a STEM laboratory need to provide mentees with training on lab safety. For example, in a summer STEM mentoring program in basic science departments at a medical school, students completed a biosafety training course to be aware of laboratory hazards and how to stay safe in that setting[103].

PARENT OR GUARDIAN TRAINING

Parents or Guardians Need Training to Support the Mission and Goals of the STEM Program

The sixth Training Enhancement **(E.3.6)** suggests that STEM mentoring programs should provide orientation or training to parent(s) or guardian(s) of children participating in the program. Parental emotional and instrumental support, as well as parental encouragement are considered to be critical for sustaining students' interest and commitment to a STEM career. Because of the central role of parents in supporting mentoring relationships, as well as their critical role related to sustaining interest in STEM, parent engagement and training may enhance the short- and long-term impacts of STEM mentoring programs[104]. Sometimes engagement involves direct parent training focused more on the instrumental aspects of the program or having parents attend capstone events. For example, in one program, parents were engaged as both stakeholders and judges giving constructive feedback in a closing ceremony at a precollege summer mentoring program for 11th and 12th grade high school students interested in electrical engineering[105]. In other programs, parental engagement may focus on how parents can support the mentoring relationship or further enhance STEM learning by their child.

A key theme in a STEM mentoring program with high school students with a disability was parent involvement[106]. Parents reported that the mentoring experience benefited their children in many ways including increasing students' knowledge of STEM careers; goals for and confidence in pursuing STEM; and involvement in career development activities. Interviews with parents, mentors, and mentees revealed the active role that parents played in supporting their children in the mentoring program from helping with STEM activities to debriefing with matches after activities were completed. In fact, many parents were motivated to do more and wanted to support their teens in both the skills they were learning and in their career planning. By having parents openly demonstrate appreciation for the mentor's role in their child's life, both mentors and mentees were more engaged and felt more supported in their matches.

Parents or Guardians Need to be Aware of Risks and Strategies for Keeping Their Children Safe in Executing STEM Activities or Being in STEM Settings

The seventh Training Enhancement **(E.3.7)** suggests that STEM mentoring programs that involve mentees completing STEM activities or conducting research in a STEM laboratory should provide parents or guardians with training on the risks associated with their child participating in the STEM activities. In addition, if parents receive training on lab safety procedures, they can reinforce and support safety policies and procedures with their children.

References

1 Bowling, B., Doyle, M., Taylor, J., & Antes, A. (2015). Professionalizing the role of peer leaders in stem. *Journal of STEM Education, 16*(2), 30–39.

2 Barker, B. S., Grandgenett, N., & Nugent, G. (2009). A new model of 4-H volunteer development in science, engineering, and technology programs. *Journal of Extension, 47*(2), 1–5.

3 Beech, B. M., Calles-Escandon, J., Hairston, K. G., Langdon, M. S. E., Latham-Sadler, B. A., & Bell, R. A. (2013). Mentoring programs for underrepresented minority faculty in academic medical centers: a systematic review of the literature. *Academic medicine: Journal of the Association of American Medical Colleges, 88*(4).

4 Bystydzienski, J. M., Eisenhart, M., & Bruning, M. (2015). High school is not too late: Developing girls' interest and engagement in engineering careers. *The Career Development Quarterly, 63*(1), 88–95. doi:10.1002/j.2161-0045.2015.00097.x

5 Chemers, M. M., Zurbriggen, E. L., Syed, M., Goza, B. K., & Bearman, S. (2011). The role of efficacy and identity in science career commitment among underrepresented minority students. *Journal of Social Issues, 67*(3), 469–491.

6 Thiry, H., Laursen, S. L., & Hunter, A.-B. (2011). What experiences help students become scientists?: A comparative study of research and other sources of personal and professional gains for STEM undergraduates. *The Journal of Higher Education, 82*(4), 357–388. doi:10.1353/jhe.2011.0023

7 Hunter, A. B., Laursen, S. L., & Seymour, E. (2007). Becoming a scientist: The role of undergraduate research in students' cognitive, personal, and professional development. *Science Education, 91*(1), 36–74.

8 Ibarra, H., Carter, N., & Silva, C. (2010). Why men still get more promotions. *Harvard Business Review, 88*, 80–126.

9 Brown, E. (2010). GO GIRL Response. *Educational Horizons*, *89*(1), 93–98.

10 Chemers, et al., 2011.

11 Dolan, E., & Johnson, D. (2009). Toward a holistic view of undergraduate research experiences: An exploratory study of impact on graduate/postdoctoral mentors. *Journal of Science Education and Technology, 18*(6), 487.

12 Thiry, et al., 2011.

13 Hurtado, S., Cabrera, N. L., Lin, M. H., Arellano, L., & Espinosa, L. L. (2009). Diversifying science: Underrepresented student experiences in structured research programs. *Research in Higher Education, 50*(2), 189–214.

14 Hunter, et al., 2007.

15 Anaya, G., & Cole, D. G. (2001). Latina/o student achievement: Exploring the influence of student-faculty interactions on college grades. *Journal of College Student Development, 42*(1), 3–14.

16 Salto, L. M., Riggs, M. L., Delgado De Leon, D., Casiano, C. A., & De Leon, M. (2014). Underrepresented minority high school and college students report STEM-pipeline sustaining gains after participating in the Loma Linda University summer health disparities research program. *PLoS One, 9*(9). doi:10.1371/

17 Sowers, J. A., Powers, L., Schmidt, J., Keller, T. E., Turner, A., Salazar, A., & Swank, P. R. (2017). A randomized trial of a science, technology, engineering, and mathematics mentoring program. *Career Development and Transition for Exceptional Individuals, 40*(4), 196–204. doi:10.1177/2165143416633426

18 Diekman, A. B., Brown, E. R., Johnston, A. M., & Clark, E. K. (2010). Seeking congruity between goals and roles: A new look at why women opt out of science, technology,engineering, and mathematics careers. *Psychological Science, 21*(8), 1051–1057.

19 Diekman, A. B., Clark, E. K., Johnston, A. M., Brown, E. R., & Steinberg, M. (2011). Malleability in communal goals and beliefs influence attraction to stem careers: Evidence for a goal congruity perspective. *Journal of Personality and Social Psychology, 101*(5), 902–918. doi:10.1037/a0025199

20 Diekman, A. B., & Steinberg, M. (2013). Navigating social roles in pursuit of important goals: A communal goal congruity account of STEM pursuits. *Social and Personality Psychology Compass, 7*(7), 487–501.

21 Diekman, A. B., Weisgram, E. S., & Belanger, A. L. (2015). New routes to recruiting and retaining women in STEM: Policy implications of a communal goal congruity perspective. *Social Issues and Policy Review, 9*(1), 52–88.

22 Smith, J. L., Cech, E., Metz, A., Huntoon, M., & Moyer, C. (2014). Giving back or giving up: Native American student experiences in science and engineering. *Cultural Diversity & Ethnic Minority Psychology, 20*(3), 413–429. doi:10.1037/a0036945

23 Thoman, D. B., Brown, E. R., Mason, A. Z., Harmsen, A. G., & Smith, J. L. (2015). The role of altruistic values in motivating underrepresented minority students for biomedicine. *BioScience, 65*(2), 183–188.

24 Kraus, M. W., & Stephens, N. M. (2012). A road map for an emerging psychology of social class. *Social and Personality Psychology Compass, 6*(9), 642–656.

25 Stephens, N. M., Fryberg, S. A., Markus, H. R., Johnson, C. S., & Covarrubias, R. (2012). Unseen disadvantage: How American universities' focus on independence undermines the academic performance of first-generation college students. *Journal of Personality and Social Psychology, 102*(6), 1178–1197.

26 Allen, J. M., Muragishi, G. A., Smith, J. L., Thoman, D. B., & Brown, E. R. (2015). To grab and to hold: Cultivating communal goals to overcome cultural and structural barriers in first-generation college students' science interest. *Translational Issues in Psychological Science, 1*(4), 331.

27 Momoh, J. A. (2014). Outreach program in electrical engineering: Pre-college for engineering systems (PCES). *IEEE Transactions on Power Systems, 29*(4), 1880–1887. doi:10.1109/tpwrs.2014.2320279

28 Powers, L. E., Schmidt, J., Sowers, J.-A., & McCracken, K. (2014). Qualitative investigation of the influence of STEM mentors on youth with disabilities. *Career Development and Transition for Exceptional Individuals, 38*(1), 25–38. doi:10.1177/2165143413518234

29 Foor, C. E., Walden, S. E., & Trytten, D. A. (2007). "I wish that I belonged more in this whole engineering group:" Achieving individual diversity. *Journal of Engineering Education, 96*(2), 103–115.

30 Byars-Winston, A. M., Branchaw, J., Pfund, C., Leverett, P., & Newton, J. (2015). Culturally diverse undergraduate researchers' academic outcomes and perceptions of their research mentoring relationships. *International Journal of Science Education, 37*(15), 2533–2554. doi:10.1080/09500693.2015.1085133

31 Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching, 44*(8), 1187–1218.

32 Hurtado, S., Cabrera, N. L., Lin, M. H., Arellano, L., & Espinosa, L. L. (2009). Diversifying science: Underrepresented student experiences in structured research programs. *Research in Higher Education, 50*(2), 189–214.

33 Larose, S., Cyrenne, D., Garceau, O., Brodeur, P., & Tarabulsy, G. M. (2010). The structure of effective academic mentoring in late adolescence. *New Direction in Youth Development, 2010*(126), 123–140. doi:10.1002/yd.353

34 Pfund, C., House, S., Spencer, K., Asquith, P., Carney, P., Masters, K. S., . . . Fleming, M. (2013). A research mentor training curriculum for clinical and translational researchers. *Clinical and Translational Science, 6*(1), 26–33.

35 Pfund, C., House, S. C., Asquith, P., Fleming, M. F., Buhr, K. A., Burnham, E. L., . . . Schurr, K. (2014). Training mentors of clinical and translational research scholars: a randomized controlled trial. *Academic medicine: Journal of the Association of American Medical Colleges, 89*(5), 774.

36 Pfund, C., Pribbenow, C. M., Branchaw, J., Lauffer, S. M., & Handelsman, J. (2006). The merits of training mentors. *Science, 311*(5760), 473.

37 Byars-Winston et al., 2015.

38 Syed, M., Goza, B. K., Chemers, M. M., & Zurbriggen, E. L. (2012). Individual differences in preferences for matched-ethnic mentors among high-achieving ethnically diverse adolescents in STEM. *Child Development, 83*(3), 896–910. doi:10.1111/j.1467-8624.2012.01744.x

39 Seymour, E., Hunter, A. B., Laursen, S. L., & DeAntoni, T. (2004). Establishing the benefits of research experiences for undergraduates in the sciences: First findings from a three-year study. *Science Education, 88*(4), 493–534.

40 Byars-Winston et al., 2015.

41 Chen, X., & Soldner, M. (2013). *STEM attrition: College students' paths into and out of STEM fields. (NCES 2014-001).* Washington, DC: U. S. Department of Education.

42 Steele, C. M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans. *Journal of Personality and Social Psychology, 69*(5), 797.

43 Hurtado, et al., 2009.

44 Pfund, et al., 2013.

45 Pfund, et al., 2014.

46 Pfund, et al., 2006.

47 McCoy, D. L., Winkle-Wagner, R., & Luedke, C. L. (2015). Colorblind mentoring? Exploring white faculty mentoring of students of color. *Journal of Diversity in Higher Education, 8*(4), 225–242. doi:10.1037/a0038676

[48] Powers, et al., 2014.

[49] Muller, C., Blake-Beard, S., Barsion, S. J., & Wotipka, C. M. (2012). Learning from the experiences of women of color in MENTORNET's one-on-one program. *Journal of Women and Minorities in Science and Engineering, 18*(4).

[50] Banks, K. H. (2010). A qualitative investigation of mentor experiences in a service learning course. *Educational Horizons*, 68–79.

[51] Brown, 2010.

[52] Sue, D. W., Capodilupo, C. M., Torino, G. C., Bucceri, J. M., Holder, A., Nadal, K. L., & Esquilin, M. (2007). Racial microaggressions in everyday life: implications for clinical practice. *American Psychologist, 62*(4), 271.

[53] Solorzano, D., Ceja, M., & Yosso, T. (2000). Critical race theory, racial microaggressions, and campus racial climate: The experiences of African American college students. *Journal of Negro Education*, 60–73.

[54] Kessler, R. C., Mickelson, K. D., & Williams, D. R. (1999). The prevalence, distribution, and mental health correlates of perceived discrimination in the United States. *Journal of Health and Social Behavior*, 208–230.

[55] Pascoe, E. A., & Smart Richman, L. (2009). Perceived discrimination and health: a meta-analytic review. *Psychological Bulletin, 135*(4), 531.

[56] Schmitt, M. T., Branscombe, N. R., Postmes, T., & Garcia, A. (2014). The consequences of perceived discrimination for psychological well-being: a meta-analytic review. *Psychological Bulletin, 140*(4), 921.

[57] Solorzano, et al., 2000.

[58] Ross, H. (2008). Proven strategies for addressing unconscious bias in the workplace. *CDO Insights, 2*(5), 1–18.

[59] Steele, C. M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist, 52*(6), 613.

[60] Estrada, M., Eroy□Reveles, A., & Matsui, J. (2018). The influence of affirming kindness and community on broadening participation in STEM career pathways. *Social Issues and Policy Review, 12*(1), 258-297.

[61] Powell, C., Demetriou, C., & Fisher, A. (2013). Microaffirmations in academic advising: Small acts, big impact. *Mentor: An Academic Advising Journal*.

[62] Morrell, C., & Parker, C. (2013). Adjusting micromessages to improve equity in STEM. *Diversity & Democracy, 15*(2).

[63] Kupersmidt, J. B., & Rhodes, J. E. (2014). Mentor training. In D. L. DuBois & M. J. Karcher (Eds.), *Handbook of Youth Mentoring, Second Edition* (pp. 439–456). Thousand Oaks, CA: Sage Publications.

[64] Kupersmidt, J. B., Stelter, R. L., Rhodes, J. E., & Stump, K. N. (2017). Enhancing mentor efficacy and preparedness through web-based pre-match training. *The Journal of Nonprofit Education and Leadership, 7*(3).

[65] Ream, R. K., Lewis, J. L., Echeverria, B., & Page, R. N. (2014). Trust matters: Distinction and diversity in undergraduate science education. *Teachers College Record, 116*(5), 1–50.

[66] Anaya & Cole, 2001.

[67] Momoh, 2014.

[68] Bowling, et al., 2015.

[69] Day, D. V. (2001). Leadership development:: A review in context. *The Leadership Quarterly, 11*(4), 581–613.

[70] Tuckman, B. W., & Jensen, M. A. C. (1977). Stages of small group development revisited. *Group & Organizational Studies, 2*(4), 419–427.

[71] Dodge, K. A., Dishion, T. J., & Lansford, J. E. (2006). Deviant peer influences in intervention and public policy for youth. *Social Policy Report, 20*(1).

[72] Dodge, et al., 2006.

[73] Handelsman, J., Pfund, C., Lauffer, S. M., & Pribbenow, C. M. (2005). Entering Mentoring. *Madison: The Wisconsin Program for Scientific Teaching*.

[74] Pfund, et al., 2006.

[75] Pfund, et al., 2006.

[76] Pfund, et al., 2006.

[77] Pfund, et al., 2006.

[78] Pfund, et al., 2013.

[79] Pfund, et al., 2014.

[80] Huskins, W. C., Silet, K., Weber□Main, A. M., Begg, M. D., Fowler Jr, V. G., Hamilton, J., & Fleming, M. (2011). Identifying and aligning expectations in a mentoring relationship. *Clinical and Translational Science, 4*(6), 439–447.

[81] Stevens, S., Andrade, R., & Page, M. (2016). Motivating young Native American students to pursue STEM learning through a culturally relevant science program. *Journal of Science Education and Technology, 25*(6), 947–960. doi:10.1007/s10956-016-9629-1

[82] Gandhi, M., & Johnson, M. (2016). Creating more effective mentors: mentoring the mentor. *AIDS and Behavior, 20*(2), 294–303.

[83] Bowling, et al., 2015.

[84] Brainard, S. G. (1998). *A curriculum for training mentors and mentees*. Paper presented at the WEPAN National Conference.

[85] Culp, K., McKee, R. K., & Nestor, P. (2007). Identifying volunteer core competencies: Regional differences. *Journal of Extension, 45*(6).

[86] Barker, et al., 2009.

[87] Banks, 2010.

[88] Momoh, 2014.

[89] Manson, S. M., Martinez, D. F., Buchwald, D. S., Rubio, D. M., & Moss, M. (2015). Vision, identity, and career in the clinical and translational sciences: Building upon the formative years. *Clinical Translational Science, 8*(5), 568–572. doi:10.1111/cts.12316

[90] Momoh, 2014.

[91] Danner, O. K., Lokko, C., Mobley, F., Dansby, M., Maze, M., Bradley, B., . . . Childs, E. (2017). Hospital-based, multidisciplinary, youth mentoring and medical exposure program positively influences and reinforces health care career choice: "The Reach One Each One Program Early Experience". *American Journal of Surgery, 213*(4), 611–616. doi:10.1016/j.amjsurg.2016.12.002

[92] Kabacoff, C., Srivastava, V., & Robinson, D. N. (2013). A summer academic research experience for disadvantaged youth. *CBE Life Sciences Education, 12*(3), 410–418. doi:10.1187/cbe.12-12-0206

[93] Phelan, S., Harding, S., & Harper-Leatherman, A. (2017). BASE (Broadening Access to Science Education): A research and mentoring focused summer STEM camp serving underrepresented high school girls. *Journal of STEM Education, 18*(1), 65-72.

[94] Hernandez, P. R., Bloodhart, B., Barnes, R. T., Adams, A. S., Clinton, S. M., Pollack, I., . . . Fischer, E. V. (2017). Promoting professional identity, motivation, and persistence: Benefits of an informal mentoring program for female undergraduate students. *PLoS One, 12*(11), e0187531. doi:10.1371/journal.pone.0187531

[95] Adams, A. S., Steiner, A. L., & Wiedinmyer, C. (2016). The earth science women's network (ESWN): Community-driven mentoring for women in the atmospheric sciences. *Bulletin of the American Meteorological Society, 97*(3), 345–354.

[96] Glessmer, M., Wang, Y., & Kontak, R. (2012). Networking as a tool for Earth science women to build community and succeed. *Eos, Transactions American Geophysical Union, 93*(41), 406–407.

[97] Kobulnicky, H. A., & Dale, D. A. (2016). A community mentoring model for STEM undergraduate research experiences. *Journal of College Science Teaching, 45*(6), 17.

[98] Salto, et al., 2014.

[99] Balster, N., Pfund, C., Rediske, R., & Branchaw, J. (2010). Entering research: a course that creates community and structure for beginning undergraduate researchers in the STEM disciplines. *CBE-Life Sciences Education, 9*(2), 108–118.

[100] Stamp, N., Tan-Wilson, A., & Silva, A. (2015). Preparing graduate students and undergraduates for interdisciplinary research. *BioScience, 65*(4), 431–439.

[101] Lee, S. P., McGee, R., Pfund, C., & Branchaw, J. (2015). Mentoring up: learning to manage your mentoring relationships. *The Mentoring Continuum: From Graduate School Through Tenure. Syracuse: The Graduate School Press of Syracuse University*.

[102] Balster, et al., 2010.

[103] Kabacoff, et al., 2013,

[104] Manson, et al., 2015.

[105] Momoh, 2014.

[106] Powers, et al., 2014.

MATCHING AND INITIATION

Program considers the characteristics of the mentor(s) and mentee(s) (e.g., interests, proximity; availability; age; gender; race; ethnicity; personality; expressed preferences of mentor, mentee, and parent or guardian; goals; strengths; previous experiences) when making matches. (B.4.1)

▶ **STEM RECOMMENDATION**

Based on the goals and target population of the mentoring program, the STEM-specific interests, STEM knowledge, and STEM backgrounds of both mentors and mentees should be taken into consideration when making matches.

▶ **STEM RECOMMENDATION**

- Mentoring programs that involve matches working together on long-term or technical projects should prioritize the expressed preferences of the mentor or mentee when making matches.
- Mentoring programs that create mentoring relationships involving one or more mentors and multiple mentees should take into consideration the group dynamics when making matches. (B.4.5 STEM)
- Mentoring programs that create mentoring relationships involving one or more mentors and multiple mentees should consider having a trial period for all group matches that allows for the opportunity to make changes to the group membership, as needed. (E.4.7 STEM)

Justification

Formally matching mentors and mentees is often considered more art than science, with mentoring program practitioners relying on their intuition, as well as logistical, and background characteristics of the mentor and mentee to guide the matching process. This is due, in part, to the overall lack of research examining the matching process in the mentoring field. Similarly, there is a lack of empirical research focused on STEM mentoring programs to guide recommendations for specific practices for creating matches. Thus, the following recommendations are extensions of practices important for all mentoring programs included in the Elements of Effective Practice for Mentoring, 4th edition, as well as some additional considerations for matching when the program utilizes a group mentoring approach.

Characteristics to Consider When Making Matches

Perceived similarity between mentor and mentee, which could include dimensions such as demographics, background, personality, as well as interests, has been associated with perceptions of mentoring relationship quality[1,2] and thus these characteristics should be considered when making matches between mentors and mentees. Matching based on common interests, including STEM-specific interests, has been recommended for STEM mentoring programs based on findings suggesting that when mentoring programs match mentors and mentees with similar interests, the programs have a stronger impact on youth outcomes[3]. This is also common practice among mentoring programs, generally[4].

There are many dimensions of interests that can be considered when making matches, including hobbies, sports, movies, school subjects, movies, and music. STEM-specific interests may include interests regarding a specific STEM field (e.g., biology, climate science, astronomy, chemistry) or interest in learning specific STEM skills (e.g., computer programming, robotics, laboratory skills). There are no empirical studies that have specifically examined the impact of matching on STEM interests on mentoring relationship quality or youth outcomes, but this practice is mentioned as a matching criteria in evaluation studies of individual mentoring programs[5]. The prioritization of a mentee's STEM interests, STEM knowledge, and STEM background when making matches will depend on the goals and target population of the program. For instance, the prioritization of STEM specific interests may be more important for older mentees who have thought about their career goals and are beginning to prepare for post-secondary education. In addition to STEM specific interests, STEM knowledge and background may be particularly relevant when making matches in programs where mentors and mentees will be working together on projects that require specific skills. For example, matching a mentee with a mentor who will be working together on a biology project may require that the mentee have knowledge and proficiency in how to use a microscope in order to meaningfully contribute to the shared project.

Alternatively, some programs may intentionally match youth across different areas of STEM interest—such as pairing a student who is interested in chemistry with an engineer—to broaden the youth's exposure to other scientific disciplines they may not have considered. This may be particularly important for girls as they often steer away from male-dominated fields such as engineering or computer science, but may be encouraged to consider those fields based on exposure to mentors. Regardless of whether a program does same- or cross-discipline matching, information about mentees' STEM specific interests, knowledge, and background should be obtained during the screening process so this information can inform matching decisions (see the "Screening" section for a more detailed discussion of how to screen for the requisite skills in STEM mentoring programs).

Considering mentee and mentor demographic characteristics such as gender, race, ethnicity, and disability status when making matches is included in Benchmark practice **B.4.1**. of the *Elements of Effective Practice for Mentoring*, 4th edition. Research comparing mentoring relationship and mentee outcomes for same gender, race, or ethnicity matches vs. cross-gender, race, or ethnicity matches has found few, if any differences between these matches[6,7,8]. Similar effects have been noted in research on STEM mentoring programs. For example, when comparing STEM outcomes (e.g., STEM-related knowledge, engagement, confidence, and career planning) following participation in a STEM mentoring program for high school students with disabilities, there were no differences in outcomes when comparing mentees who had a mentor with a disability and mentees whose mentor did not have a disability[9]. In another evaluation of a STEM mentoring program for African-American STEM undergraduates, mentee-perceived similarity with their mentor was more important for perceptions of mentoring relationship quality than gender or racial similarity[10]. Relationship quality was, in turn, associated with greater feelings of commitment to a STEM-career by mentees[11]. These findings suggest that factors other than matching on demographic characteristics alone may be more important for creating close, effective mentoring relationships in STEM mentoring programs.

While matching based on demographics may not be necessary for many STEM mentoring programs, the prioritization of demographic characteristics when matching could be important based on the goals and target population of the program. For example, if a mentoring program has a specific goal of providing mentees who are traditionally underrepresented in STEM fields with a mentor who can help the mentee prepare for and navigate the potential challenges of pursuing a STEM career that are associated with their demographic characteristics, then relevant characteristics should be given greater weight when making matching decisions. Anecdotally, Black doctoral engineering students reported that having faculty and administrators who are similar to them serves as an example of what they could achieve and that having a faculty mentor with a similar racial identity enhanced the mentoring relationship[12]. Additionally, mentees in a STEM mentoring program for high school students with a disability reported that having a mentor with a similar disability was important to them and was more likely to lead to discussions with their mentor about navigating the additional challenges associated with having a disability when pursuing STEM careers and education[13].

PREFERENCES OF MENTEES AND MENTORS

In addition to the goals and target population of the STEM mentoring program, the expressed preferences of mentees regarding the background and characteristics of their mentor appears to be an important factor for determining how much weight to give characteristics such as race, ethnicity, gender, or social class when making matches. For example, college students in an online STEM mentoring program reported that it was important to them to have a mentor who was similar to them in terms of gender and race, this was especially true for women and students of color[14]. When students had a mentor similar to them in terms of race or gender, they reported that they received more help; however, mentees matched with a mentor of similar gender or race did not have better academic outcomes when compared to mentees whose mentor was not similar to them in race or gender[15]. In another study, mentees in a STEM mentoring program who reported that it was important to them to have a mentor with a similar background (i.e., similar ethnicity, gender, or social class) and reported they received mentoring through the program from one or more mentors who shared their background, demonstrated increased feelings of belonging and identity as a science student[16].

Mentor preferences may be particularly important to consider in programs in which matches work together on a specific research project. Mentors who will be formally supervising mentees in

STEM MENTORING IN ACTION:

New York City Science Mentoring Consortium

THE NEW YORK CITY SCIENCE RESEARCH MENTORING CONSORTIUM is a group of academic, research, and cultural institutions that place NYC high school students in laboratories and other authentic STEM environments for mentored research experiences. Mentees are embedded in the mentor's workplace and contribute to real research projects, so it's especially important that matches are made with care and finesse. Mentors must feel confident in how a mentee's work ethic, strengths, and personality will integrate into the already-existing team dynamic, and mentees must feel comfortable with the research they'll be contributing to and the lab environment they'll be entering.

Many programs within the Consortium facilitate a pre-match meeting so that mentors and mentees can familiarize themselves with each other and help inform the matching process. Programs do this in a variety of ways—some programs host a casual networking event, where mentors and mentees can mingle to learn about each other's work and interests. Other programs host a more structured event—especially when it's a larger program with many students and labs—where mentees receive descriptions of each lab beforehand and identify several they'd like to meet during the event. The mentees rotate around the room and briefly meet mentors from each of their selections. Mentors and mentees use these events to consider who they'd like to be matched with. Mentors' notes may include reflections about whether the mentee expressed interest in a specific research project, whether the mentee would fit into the lab's culture (e.g., a loquacious student may not fit in well with a quiet lab), and whether the mentee seemed to understand the lab's project. Mentees are occasionally asked to continue working in the lab after the program concludes, so mentors want to select and invest in mentees who have the potential to contribute to the lab long-term. This initial meeting also gives mentors an opportunity to set realistic expectations for the mentoring experience. Science sometimes requires repetitive work, and mentors want to accurately convey the internship experience so mentees don't select opportunities they're not truly interested in.

After mentors and mentees meet, both share their notes and preferences with the Program Coordinator. The Program Coordinator considers this input, along with applications, interviews, and required coursework, when making the match.

completing a project may even specify a set of criteria for type of mentee who would be best suited to work on the project, or they may be involved in the matching process by reviewing potential mentees and ranking their preferences based on information about the mentee provided by the mentoring program (e.g., STEM interests, knowledge, and skills).

For a real-life example of a STEM mentoring program that gives mentors and mentees a chance to meet each other and see if there is alignment of interests and personalities, see the previous page about the work of the New York City Science Research Mentoring Consortium.

Whether mentoring programs decide to prioritize matching based on interests, demographics, expressed preferences, or other similarities, the goals and target population of the program should inform these decisions and matching must be done in a thoughtful, intentional manner, following established procedures, and informed by information gathered during the screening process.

GROUP MENTORING RELATIONSHIPS

The consideration of mentoring relationships among one or more mentors and multiple mentees, referred to as group mentoring, has not been included in the previous version of the Elements and thus there are currently no benchmarks or enhancements specific to this type of mentoring. Based on a review of the literature[17,18,19] and consultation with the Working Group of STEM practitioners, it is clear that group mentoring is frequently utilized in STEM mentoring programs. There are currently no empirical studies examining specific matching practices for group mentoring programs; however, the concept of group cohesion has been proposed as an important factor in contributing to the success of group mentoring relationships[20]. For group mentoring programs, the complimentary and competing personalities, interests, backgrounds, goals, skills, knowledge, strengths, and previous experiences of the individuals within the group create additional layers of complexity when making matches. Program staff must take into consideration mentor-to-group, mentee-to-mentee, and possibly mentor-to-mentor dynamics.

Within the child and adolescent group psychotherapy literatures, one concern has been the possibility that grouping individuals with behavioral problems together can contribute to even more deviant behavior[21]—meaning programs that utilize a group mentoring approach and that work with youth who have behavioral problems should carefully consider how to group these individuals together when making matches. For instance, limiting the number of individuals within a group with externalizing behavior problems can reduce the likelihood of contributing to negative outcomes among group members[22]. The skills, training, and experience of the mentor in managing group dynamics will also be important when making group matches, particularly if the group includes mentees with known behavioral challenges. *See the "Training" section for additional details.*

Finally, given the complexity of making group matches, it has been suggested that mentoring programs using a group approach should consider having a brief trial period at the beginning of the program during which mentoring program leaders can observe the groups, obtain feedback from group members, and make adjustments in order create the most optimal group composition. If programs choose to take this approach, it must be done thoughtfully. Before making groups, it must be communicated to all program participants that there will be a set amount of time at the beginning of the program that will allow for everyone to get to know one another and that changes to the groups might be made based on expressed preferences and interests of the participants. Both mentors and mentees should be privately asked about their feelings of comfort with their group and whether their group assignment is meeting their needs and goals. If group assignments are modified at the beginning of the program, program staff must ensure that this is done in a way that is sensitive to the feelings of all the group members in order to avoid feelings of shame at being singled out and moved to a different group, regardless of the reasons for this decision. For a real-life example of this kind of "trial run" group matching in action, please see the case study on the next page on the approach of Sea Research Foundation.

Creating matches in STEM mentoring programs requires a few additional considerations and the extent to which these recommendations are relevant to a specific program will depend, in part, on the goals and target population. Following these evidence- and practice-based recommendations for matching are expected to help improve the likelihood of creating close and enduring mentoring relationships.

Photo courtesy of Sea Research Foundation

STEM MENTORING IN ACTION: **Sea Research Foundation**

STEM MENTORING is a group mentoring program that matches mentors with four mentees each. In the first years of the program, Program Coordinators occasionally reported having difficulty creating flourishing and long-lasting matches that engaged all participants; sometimes the five different personalities wouldn't complement each other as intended, but rather would create unexpected group dynamics that left mentees feeling more frustrated than excited. Program Coordinators would do their best to use the STEM Mentoring applications, interviews, and their own intuition to create groups that worked on paper, but they didn't always translate well to real life. Once groups were established, mentors and mentees would complete three modules together that each lasted 8–12 weeks. Program Coordinators were often reluctant to modify groups midway through the program because putting mentees into new groups could disrupt the dynamics, relationships, and routine of multiple groups—that is, any groups that mentees moved from along with the groups they moved to would have to reestablish group norms.

For the reasons above, STEM Mentoring decided to develop a new curriculum to assist Program Coordinators in "testing the matches" before solidifying groups for the program's duration. The curriculum consists of a four-week mini-module that takes place before the first full-length module begins. Program Coordinators create groups for this mini-module with the expectation that participants may shift and reconfigure before the formal program begins. If groups work well, they can remain together for the remaining three modules; however, if negative group dynamics distract participants from the STEM activities and/or impede positive relationship building among mentees and their mentors, the Program Coordinator can reconfigure the groups before the first full-length module begins. The mini-module is long enough that groups have a good chance to work through issues and find their momentum, but not so long that group members have to spend too much time in matches that may not be ideal.

After the mini-module concludes, Program Coordinators assess how the groups collaborated and have the opportunity to reconfigure the groups, if necessary. Program Coordinators may find that a mentor needs to be reassigned to a less rambunctious group, or that a mentee needs to be with a group that challenges her more. STEM Mentoring hopes that having a designated time to make these changes will set appropriate expectations for the groups' duration and prepare mentors and mentees for successful long-term matches.

References

1 Ensher, E. A., & Murphy, S. E. (1997). Effects of race, gender, perceived similarity, and contact on mentor relationships. *Journal of Vocational Behavior, 50*, 460–481.

2 Hernandez, P. R., Estrada, M., Woodcock, A., & Schultz, P. W. (2017). Protégé perceptions of high mentorship quality depend on shared values more than on demographic match. *The Journal of Experimental Education, 85*(3), 450–468. doi:10.1080/00220973.2016.1246405

3 DuBois, D. L., Portillo, N., Rhodes, J. E., Silverthorn, N., & Valentine, J. C. (2011). How effective are mentoring programs for youth? A systematic assessment of the evidence. *Psychological Science in the Public Interest, 12*(2), 57–91. doi:10.1177/1529100611414806

4 Kupersmidt, J. B., Stump, K. N., Stelter, R. L., & Rhodes, J. E. (2017). Mentoring program practices as predictors of match longevity. *Journal of Community Psychology, 45*(5), 630–645. doi:10.1002/jcop.21883

5 Tyler-Wood, T., Ellison, A., Lim, O., & Periathiruvadi, S. (2012). Bringing up girls in science (BUGS): The effectiveness of an afterschool environmental science program for increasing female students' interest in science careers. *Journal of Science Education and Technology*, *21*(1), 46–55.

6 Kanchewa, S. S., Rhodes, J. E., Schwartz, S. E. O., & Olsho, L. E. W. (2014). An investigation of same- versus cross-gender matching for boys in formal school-based mentoring programs. Applied Developmental Science*, 18*(1), 31–45. doi:10.1080/10888691.2014.876251

7 Park, H., Yoon, J., & Crosby, S. D. (2016). A pilot study of big brothers big sisters programs and youth development: An application of critical race theory. *Children and Youth Services Review, 61,* 83–89. doi:10.1016/j.childyouth.2015.12.010

8 Rhodes, J., Reedy, R., Grossman, J. B., & Lee, J. M. (2002). Volunteer mentoring relationships with minority youth: An analysis of same- versus cross-race matches. *Journal of Applied Social Psychology, 32*(10), 2114–2133.

9 Sowers, J. A., Powers, L., Schmidt, J., Keller, T. E., Turner, A., Salazar, A., & Swank, P. R. (2017). A randomized trial of a science, technology, engineering, and mathematics mentoring program. *Career Development and Transition for Exceptional Individuals, 40*(4), 196–204. doi:10.1177/2165143416633426

10 Hernandez, et al., 2017

11 Hernandez, et al., 2017

12 McGee, E. O., White, D.T., Jenkins, A. T., Houston, S., Bentley, L. C., Smith, W. J., Robinson, D. H. (2016). Black engineering students' motivation for PhD attainment: Passion plus purpose. *Journal for Multicultural Education, 10*(2), 167–193.

13 Powers, L. E., Schmidt, J., Sowers, J. A., & McCracken, K. (2014). Qualitative investigation of the influence of STEM mentors on youth with disabilities. *Career Development and Transition for Exceptional Individuals, 38*(1), 25–38. doi:10.1177/2165143413518234

14 Blake-Beard, S., Bayne, M. L., Crosby, F. J., & Muller, C. B. (2011). Matching by race and gender in mentoring relationships: Keeping our eyes on the prize. *Journal of Social issues, 67*(3), 622–643.

15 Blake-Beard, et al., 2011

16 Syed, M., Goza, B. K., Chemers, M. M., & Zurbriggen, E. L. (2012). Individual differences in preferences for matched-ethnic mentors among high-achieving ethnically diverse adolescents in STEM. *Child Dev, 83*(3), 896–910. doi:10.1111/j.1467-8624.2012.01744.x

17 Cutucache, C. E., Luhr, J. L., Nelson, K. L., Grandgenett, N. F., & Tapprich, W. E. (2016). NE STEM 4U: An out-of-school time academic program to improve achievement of socioeconomically disadvantaged youth in STEM areas. *International Journal of STEM Education, 3*(1), 1–7. doi:10.1186/s40594-016-0037-0

18 Martin, F. G., Scribner-MacLean, M., Christy, S., Rudnicki, I., Londhe, R., Manning, C., & Goodman, I. F. (2011). Reflections on iCODE: Using web technology and hands-on projects to engage urban youth in computer science and engineering. *Autonomous Robots, 30*(3), 265–280. doi:10.1007/s10514-011-9218-3

19 Syed, et al., 2012

20 Kuperminc, G. P., & Thomason, J. D. (2013). Group mentoring. in *Handbook of Youth Mentoring*, 273–289.

21 Dodge, K. A., Dishion, T. J., & Lansford, J. E. (2006). Deviant peer influences in intervention and public policy for youth. Social Policy Report, 20(1).

22 Dodge, et al., 2006

2 STANDARDS OF PRACTICE FOR STEM MENTORING PROGRAMS

MONITORING AND SUPPORT

MONITORING AND SUPPORT

At each mentor monitoring contact, program staff should ask mentors about mentoring activities, mentee outcomes, child safety issues, the quality of the mentoring relationship, and the impact of mentoring on the mentor and mentee using a standardized procedure. (B.5.2)

▶ **STEM RECOMMENDATION**
When the mentoring program includes structured STEM activities, program staff should ask about the mentor's experience in completing the activities with his or her mentee(s) during the mentor monitoring contact.

▶ **STEM RECOMMENDATION**
When the mentoring program has goals that include influencing mentees' attitudes, beliefs, skills, and plans regarding STEM, mentoring program staff should ask mentors about these outcomes during the mentor monitoring contact.

At each mentee monitoring contact, program staff should ask mentees about mentoring activities, mentee outcomes, child safety issues, the quality of the mentoring relationship, and the impact of mentoring on the mentor and mentee using a standardized procedure. (B.5.3)

▶ **STEM RECOMMENDATION**
When the mentoring program includes structured STEM activities, program staff should ask about the mentee's experience in completing the activities with his or her mentor(s) during the mentee monitoring contact.

▶ **STEM RECOMMENDATION**
When the mentoring program has goals that include influencing mentees' attitudes, beliefs, skills, and plans regarding STEM, mentoring program staff should ask mentees about these outcomes during the mentee monitoring contact.

At each monitoring contact with a responsible adult in the mentee's life, program asks about mentoring activities, mentee outcomes, child safety issues, the quality of the mentoring relationship, and the impact of mentoring on the mentor and mentee using a standardized procedure. (B.5.6)

▶ **STEM RECOMMENDATION**
When the mentoring program has goals that include influencing mentees' attitudes, beliefs, skills, and plans regarding STEM, mentoring program staff should ask the responsible adult about these outcomes during the monitoring contact.

Program provides mentors with access to relevant resources (e.g., expert advice from program staff or others, publications, Web-based resources, experienced mentors) to help mentors address challenges in their mentoring relationships as they arise. (B.5.9)

▶ **STEM RECOMMENDATION**
When the program includes structured STEM activities, mentors should be given access to resources that will help them complete these activities with their mentee(s) and deepen their knowledge about these activities.

▶ **STEM RECOMMENDATION**
Mentors should be given access to resources to help foster mentees' identity as a STEM student or employee, and sense of belonging in a STEM field.

Program provides mentees and parents or guardians with access or referrals to relevant resources (e.g., expert advice from program staff or others, publications, Web-based resources, available social service referrals) to help families address needs and challenges as they arise. (B.5.10)

▶ **STEM RECOMMENDATION**
Programs should provide access to STEM-related resources and referrals for needs and challenges of mentees and families that are beyond the scope and services of the mentoring program.

Program provides one or more opportunities per year for post-match mentor training. (B.5.11)

▶ **STEM RECOMMENDATION**
Mentors should receive training on how to help foster mentees' STEM-related self-efficacy, identity, and belonging.

▶ **STEM RECOMMENDATION**
Mentors should receive ongoing training on how to help mentees prepare for marginalizing experiences they may face in pursuing STEM education and careers.

When mentoring activities take place in the presence of mentoring program staff, program staff should provide real-time monitoring and support of mentoring activities and group dynamics to help support mentors and mentees in completing STEM activities and help mentors manage the dynamics of their mentoring relationship(s). (B.5.13 STEM)

Justification

Once matches are created and established, the main task of mentoring program staff becomes monitoring and supporting matches as they begin the process of getting to know one another and developing their relationship. High-quality monitoring and support practices help prevent premature closure of mentoring relationships and promote higher quality mentoring relationships. STEM mentoring programs should adhere to all of the monitoring and support practices outlined in the *Elements of Effective Practice for Mentoring*, 4th edition, when applicable. In addition, STEM mentoring programs have some additional considerations related to these practices, including one new Benchmark practice detailed later in the chapter (B.5.13). Because there is very little research within the area of STEM mentoring, most of the following recommendations are based on practices suggested by this project's Working Group.

Match Contacts

STEM mentoring programs frequently incorporate structured STEM experiments and learning opportunities into the mentoring relationship as the primary activities that mentors and mentees engage in when they are together for their mentoring meetings[1,2,3,4]. These activities may include a specific curriculum or activities created by program staff that are responsive to the interests and goals of program participants as well as long-term STEM-related projects that take more than one session to complete. Regardless of what form the activities take, if mentors and mentees are expected to engage in structured STEM activities, mentoring program staff should take time at each check-in **(B.5.2, B.5.3, B.5.6)** to ask mentors and mentees about their experiences in engaging in these activities together. These check-ins should include asking about their successes, challenges, and lessons learned from the activities. Program staff may consider asking mentors about what they observed their mentee learning from the activity, mentee level of engagement with the activity, and whether the activity highlighted any specific strengths or areas that need improvement.

For a real-life example of how mentor check-ins can boost the quality of a program's implementation, see the sidebar on the next page on Genentech's mentor check-in procedures and the value they bring to their work.

An additional set of topics that should be addressed during match monitoring contacts is assessing mentees' attitudes, beliefs, skills, and plans regarding STEM, particularly if a goal of the mentoring program is to influence these outcomes in mentees. Evaluations of STEM mentoring programs have demonstrated impacts on these types of outcomes for mentees who participate in the program[5,6,7]. Attitudes may include topics such as how excited the mentee is about STEM, beliefs are topics such as the mentee's feelings of belonging in STEM, skills include their actual abilities in completing STEM activities or feelings of confidence in specific STEM skills, and plans regarding STEM refers to the mentee's intentions to pursue STEM coursework or career. Mentors, mentees, and the responsible adult contact should all be asked to comment on these areas.

Not all of these topics must be assessed during each monitoring contact but they should be assessed regularly and in a systematic way. For example, standardized questions or brief surveys can be utilized to assess these ideas from the perspective of each person involved in the match. The information gathered through the match monitoring contacts should inform the additional support and resources provided by the program to mentees and mentors.

Provision of Stem-Related Resources and Referrals

In addition to providing mentees and parents or guardians with support through access to resources or referrals, STEM mentoring programs should also be able to provide additional STEM-related resources or make STEM-related referrals to extend support to mentees and their parents or caregivers beyond the context of the mentoring program. For example, tutoring in STEM subject areas is often beyond the scope of most STEM mentoring programs. If the mentee, parent or guardian, mentor, or mentoring program staff recognize that a mentee needs supplemental instruction in a STEM topic in order to help the mentee achieve his or her potential, then the program should be aware of resources that are available and help connect mentees and their parents or guardians to these resources. As another example, mentees who are ready to apply for college and have an interest in a STEM career may need additional support in determining where to apply and how to obtain financial and social support[8]. This expertise is likely beyond the abilities of most mentors and mentoring programs and thus programs that serve this population should be prepared to make referrals to other individuals or programs who can assist mentees with this and other similar areas of need.

Photo courtesy of Genentech

STEM MENTORING IN ACTION:

Genentech's Futurelab Initiative

GENENTECH'S FUTURELAB program keeps mentors engaged and informed through regular and ongoing email communication. Every few weeks, Futurelab's volunteer management team (comprised of employee volunteers) and team captains create and distribute a different newsletter for each of Futurelab's three distinct programs. Some newsletters provide a preview of the next week's lesson to help mentors feel prepared for the upcoming activity. Other newsletters focus on relationship development and explore strategies to foster a connection in the context of the program; for example, asking students how their day was before jumping right into homework or a STEM activity.

These communications are especially important for Futurelab's mentors who are embedded in a South San Francisco classroom. Teachers don't always have time to provide comprehensive instructions for how mentors can contribute to the classroom, so newsletters can prepare mentors by describing the activity and the mentor's role and responsibilities. If the next week's activity is an egg drop, the newsletter may contain information about how the mentor can assist the teacher in scoring the competition. After reading these newsletters, mentors are better equipped to contribute to the classroom and feel more confident about their role supporting students and teachers.

Regular communications to volunteers ensures that they're working effectively and have the support they need. Team Captains are also expected to check in with their members through face-to-face meetups and report back to program staff on volunteer morale, attendance, and engagement. Volunteers are given a sense of community as they share the responsibility and the reward of being a Futurelab mentor. Volunteers can check in with each other and help one another.

Ongoing Training Topics

As described previously, STEM mentors often have an additional task promoting mentees' self-efficacy, identity, and feelings of belonging in STEM pursuits as these attitudes and beliefs are thought to underlie an individual's intentions and behaviors in the pursuit of STEM education and career goals [9,10,11]. Mentors should receive ongoing training **(B.5.11)** in how to address these outcomes within the context of a mentoring relationship, particularly if information gathered during the match monitoring contacts indicate that this is an issue in the mentoring relationship. In addition, many STEM mentoring programs aim to target youth who are traditionally underrepresented in STEM fields and thus mentors may need additional ongoing training in how to help mentees prepare for challenges they face in pursuing a STEM education or career.

Real-time Monitoring and Support

Site-based STEM mentoring programs have a unique opportunity to observe in real-time the interactions of mentors and mentees and should take advantage of this opportunity to provide immediate monitoring and support, as needed **(new Benchmark 5.13)**. This includes supporting matches who are working together on STEM activities and supporting matches in navigating the dynamics of their relationship. Real-time monitoring in STEM mentoring programs helps ensure that critical messages or lessons are delivered accurately by mentors in programs that include structured STEM activities. In order to provide the most effective monitoring, program staff should be familiar with the principles of cooperative learning and play an active role while the groups work together on an activity or engage in their mentoring relationship, by moving throughout the room, using reflective listening, and giving constructive feedback[12]. Asking questions of the group, as well as privately asking questions of individuals within the group, can give program staff information about how things are going in regards to both the planned activities and the mentoring relationship or group dynamics.

In addition, there are many dimensions of group dynamics that program staff should be aware of in order to effectively observe and supervise group mentoring relationships, including group cohesion, power dynamics, engagement of individuals in the group, feelings of emotional safety, and trust within the group. Group development is theorized to include distinct stages: forming, storming, norming, performing, and adjourning[13]. Mentoring program staff who are aware of these normal group processes and know what to look for can help prepare mentors and mentees for the expected changes and challenges within the group. Based on the information gathered during their observations of the activities and interactions of mentors and mentees, program staff should provide additional support or resources to address any challenges associated with the mentoring activities as well as the match or group dynamics.

For a great real-life example of how one STEM mentoring program does this kind of real-time monitoring and support of matches, please see the case study on the next page on the work of Science Club. STEM Mentoring in Action: Science Club

References

1 Cutucache, C. E., Luhr, J. L., Nelson, K. L., Grandgenett, N. F., & Tapprich, W. E. (2016). NE STEM 4U: An out-of-school time academic program to improve achievement of socioeconomically disadvantaged youth in STEM areas. *International Journal of STEM Education, 3*(1), 1–7. doi:10.1186/s40594-016-0037-0

2 Gilliam, M., Jagoda, P., Fabiyi, C., Lyman, P., Wilson, C., Hill, B., & Bouris, A. (2017). Alternate reality games as an informal learning tool for generating STEM engagement among underrepresented youth: A qualitative evaluation of the source. *Journal of Science Education and Technology, 26*(3), 295–308. doi:10.1007/s10956-016-9679-4

3 Gregg, N., Wolfe, G., Jones, S., Todd, R., Moon, N., & Langston, C. (2016). STEM e-mentoring and community college students with disabilities. *Journal of Postsecondary Education and Disability, 29*(1), 47–63.

4 Ilori, O., & Watchorn, A. (2016). Inspiring next generation of engineers through service-learning robotics outreach and mentorship programme. *International Journal of Advanced Robotic Systems, 13*(5), 1–7. doi:10.1177/1729881416663372

5 Huziak-Clark, T., van Staaden, M., Bullerjahn, A., Sondergeld, T., & Knaggs, C. (2015). Assessing the impact of a research-based STEM program on STEM majors' attitudes and beliefs. *School Science and Mathematics, 115*(5), 226–236.

6 Martin, F. G., Scribner-MacLean, M., Christy, S., Rudnicki, I., Londhe, R., Manning, C., & Goodman, I. F. (2011). Reflections on iCODE: Using web technology and hands-on projects to engage urban youth in computer science and engineering. *Autonomous Robots, 30*(3), 265–280. doi:10.1007/s10514-011-9218-3

7 Stoeger, H., Duan, X., Schirner, S., Greindl, T., & Ziegler, A. (2013). The effectiveness of a one-year online mentoring program for girls in STEM. *Computers & Education, 69*, 408–418. doi:10.1016/j.compedu.2013.07.032

8 Bystydzienski, J. M., Eisenhart, M., & Bruning, M. (2015). High school is not too late: Developing girls' interest and engagement in engineering careers. *The Career Development Quarterly*, *63*(1), 88–95. doi:10.1002/j.2161-0045.2015.00097.x

9 Callahan, C. N., Libarkin, J. C., McCallum, C. M., & Atchison, C. L. (2015). Using the lens of social capital to understand diversity in the earth system sciences workforce. *Journal of Geoscience Education*, *63*(2), 98–104. doi:10.5408/15-083.1

10 Manson, S. M., Martinez, D. F., Buchwald, D. S., Rubio, D. M., & Moss, M. (2015). Vision, identity, and career in the clinical and translational sciences: Building upon the formative years. *Clinical Translational Science*, *8*(5), 568–572. doi:10.1111/cts.12316

11 Phelan, S., Harding, S., & Harper-Leatherman, A. (2017). BASE (Broadening Access to Science Education): A research and mentoring focused summer STEM camp serving underrepresented high school girls. *Journal of STEM Education, 18*(1), 65–72.

12 Stein, R. F., & Hurd, S. (2000). Using student teams in the classroom: A faculty guide: Anker Publishing Company Bolton, MA.

13 Tuckman, B. W., & Jensen, M. A. C. (1977). Stages of small group development revisited. *Group & Organizational Studies, 2*(4), 419–427.

For a great real-life example of how one STEM mentoring program does this kind of real-time monitoring and support of matches, please see the case study on the next page on the work of Science Club.

Photo Courtesy of Northwestern/Science in Society

STEM MENTORING IN ACTION: SCIENCE CLUB

SCIENCE CLUB, an after-school STEM mentoring program for middle school students, has found that providing groups with real-time, in-person monitoring and support is critical to fostering long-lasting mentoring relationships, youth STEM competencies, and mentor skills.

For most Science Club mentors, this is their first experience working with middle school youth at a community site. The group- and STEM-discipline-based nature of Science Club presents extra challenges, compared to a one-to-one mentoring program. These include managing group dynamics/behavior, safety, flexibility in allowing students to work semi-independently, and ensuring enough time for one-on-one conversations with youth about issues of interest or concern.

Science Club's Program Coordinator plays a central role in this support. This person's professional background includes experience with youth development and STEM education. During each Science Club session, the program coordinator actively monitors the groups and moves throughout the room as conditions dictate. If the staff member sees a group that seems offtrack, or a mentor signals for support, the program coordinator will approach the table to check in and help navigate the situation.

Because staff members are more seasoned with informal STEM pedagogy, they can model productive discussions on how to unpack students' passions and empower them to pursue projects in a way that is safe, aligned with their abilities, and grounded in their own interests. This extra support, often just a light touch, allows groups to quickly resolve small issues, with mentors receiving real-time support in how to manage particular situations without halting their groups to problem-solve every time they encounter a challenge. Post-club debriefs may also take place, depending on mentor needs.

Having a staff member in the room also allows Science Club to more accurately assess which groups are doing well and which are in need of extra support. Some mentors join the program with high expectations of what they'll accomplish and the relationships they'll develop in a short amount of time; the mentoring experience is often more difficult than mentors anticipated, however, and it can take longer for relationships to become established. Because the program coordinator monitors each group on a regular basis, it is easier to pick up on subtle cues that a mentor is having an impact. For example, the staff member might notice that a student makes eye contact more than he did previously, or that a student goes straight to her mentor upon entering the room instead of chatting with other students. Staff can communicate these observations and reassure mentors of their progress in building relationships, which motivates mentors to persist during the often-challenging first six months.

2 STANDARDS OF PRACTICE FOR STEM MENTORING PROGRAMS

CLOSURE

At the conclusion of the agreed upon time period of the mentoring relationship, program explores the opportunity with mentors, mentees, and (when relevant) parents or guardians to continue the match for an additional period of time. (E.6.1)

▶ **STEM RECOMMENDATION**

Based upon mentees' ages, parent permission, program goals, and company rules (for workplace or work-sponsored mentoring programs), mentoring relationships may continue after the conclusion of the program.

Program hosts a final celebration meeting or event for mentors and mentees, when relevant, to mark progress and transition or acknowledge change in the mentoring relationship. (E.6.2)

▶ **STEM RECOMMENDATION**

STEM mentoring programs that include completing long-term projects such as scientific experiments could host a final celebration that provides a forum for mentees to showcase their work or findings. This final event could mirror a scientific conference or presentation that provides mentees with an authentic mastery experience that is directly related to being in a STEM career.

Program staff members provide training and support to mentees and mentors, as well as, when relevant, to parents or guardians, about how mentees can identify and connect with natural mentors in their lives. (E.6.3)

▶ **STEM RECOMMENDATION**

If one of the program goals is to help mentees build a network of STEM professionals, the program and mentor may introduce or connect (either in person or virtually) mentees to other potential helpers and mentors who are STEM professionals.

▶ **STEM RECOMMENDATION**

Time-limited STEM mentoring programs may consider networking with other mentoring programs, so that when the program ends, mentees will be able to continue to receive additional mentoring services. In addition, prior to relationship closure, STEM mentoring programs should consider training mentees in the lifelong skills of being able to locate, identify, initiate, and maintain new mentoring relationships with caring adults in their lives to address the ongoing needs for support as youth enter a STEM education or STEM career.

Justification

All mentoring programs need to have policies and procedures in place for handling mentoring relationship closure. Benchmark practices for match closure described in the *Elements of Effective Practice for Mentoring* suggest that these should be designed and consistently implemented for handling both anticipated and unanticipated relationship closures. The recommendations included in this STEM supplement speak primarily to recommendations for handling anticipated match closures. There were no supplemental recommendations for how programs might manage unanticipated match closures over and above those currently described in the *Elements.*

Despite the importance of closure for mentee outcomes, even the broader literature on youth mentoring provides little guidance about specific practices for effectively managing the relationship closure process. The literature on STEM mentoring programs is no exception and there were few studies that we located which discussed a program's relationship closure practices at all—and no studies that actually tested the effectiveness of any specific closure practices.

The lack of discussion of closure practices in the literature on STEM mentoring may be because STEM mentoring programs may not realize the importance of having closure procedures in place and the potential deleterious effects of both premature relationship closure or the use of ineffective closure procedures. Some possible explanations are described below.

- A small percentage of mentoring programs are located in **workplace settings** (i.e., where youth come to the worksite during the school day or after school)—about 6 percent of all mentoring programs based on one national survey[1]. Many STEM companies and institutions of higher education sponsor STEM mentoring programs for youth because of their interest in contributing to the growth of the workforce, particularly of underrepresented groups. Notably, mentoring relationships located in workplace settings may have lower rates of premature closure than mentoring that occurs in other locations[2] suggesting that these types of programs and locations may have increased promise for positive outcomes. Staff members may not perceive premature relationship closure as a problem, because premature closure is relatively less common in workplace mentoring programs than in other settings. Workplace STEM mentoring programs tend to be more structured and less demanding in terms of their duration, frequency, and length, which may result in these lower rates of premature closure[3]. Even though rates of premature closure may be lower in workplace settings, they still need closure procedures to handle the variety of reasons matches may end early.

- Many STEM mentoring programs are **curriculum- or project-based**. In these types of programs, relationships often are designed to close when the curriculum ends or a project is completed unlike open-ended, one-to-one, community-based mentoring relationships. Because the STEM program has pre-defined the ending of the relationship, staff may believe that relationship closure has implicitly been handled. However, even in this context, there needs to be procedures in place to support healthy and productive match closures—for example, in programs using a curriculum that has a match where one member ends the relationship prematurely. In this case, the mentee would probably not have completed the curriculum or project. Having an incomplete experience could also have an adverse effect on the mentee's feelings of competence and efficacy, in addition to the generally negative outcomes associated with premature relationship closure (e.g., feelings of abandonment, rejection, anxiety, anger, confusion, sadness)[4,5,6]. Programs need to consider a variety of options for how they will handle this type of closure such as whether they would re-match the mentee with a new mentor or even a staff member so the mentee can complete the curriculum or finish the project. Note that findings on the impact of re-matching are mixed suggesting it can have negative effects on youth[7] unless the new relationship becomes close relatively quickly, which appears to mitigate against the negative effects of re-matching[8].

- Because many STEM mentoring programs are **group-based**, the end of the program may be well-defined or time-limited (e.g., summer camp, academic school). Yet despite there being both a clear beginning and end date to the relationship, additional closure procedures are still needed for these groups. For example, if one mentee stops coming to the group meetings, the situation may not feel like closure, because there are still ongoing relationships between the mentor and other mentees in the group. However, this situation still constitutes closure for the specific mentee, their mentor, and for the other group members so they can say goodbye to the departing youth. The program needs to have procedures in place for directly addressing this type of premature termination to manage its impact on everyone in the group.

Thus, well-developed relationship closure policies aligned with the *Elements* benchmarks are needed and core to the effective functioning of all mentoring programs. Notably, unlike the empirical research reported on premature closure rates in general mentoring programs that are as high as 38 percent of relationships[9], research on the prevalence of premature closure in STEM mentoring programs is largely absent from the literature. In addition, research on the predictors, prevention, and treatment of premature relationship closure in STEM mentoring programs is also not reported. These are all important directions for future research to inform the development of STEM program practices and policies. Nonetheless, practice experience and related literatures provide some guidance for recommendations for managing anticipated closure practices in STEM mentoring programs that may enhance the impact of the program on participating mentees and these recommendations are described on the next page.

Relationship Continuation

The program **Enhancement 6.1** suggests that as the agreed upon time period of the mentoring relationship comes to a close, the mentoring program could explore the possibility with mentors, mentees, and (when relevant) parents or guardians for the match to continue. This enhancement was originally introduced to the *Elements* in order to provide recommendations to mentoring programs that have a defined end date or end when mentees turn 18, but where the match members would like to continue their mentoring relationship.

Because of the long-term needs for advice and support for successful integration into a STEM career, one program recommendation is that STEM mentoring programs consider allowing their matches **to continue contact** with one another after the program ends. This decision should be informed by several factors described below.

- First, the **age** of the mentees is important to consider. For mentees who are under 18 or who may have an intellectual disability, or some other characteristic that could impair making an informed decision or protecting their own safety, receipt of **parent permission** in advance is critical regarding allowing ongoing contact between match members.
- The **goals of the program** should also be considered:
  - *Initial recruitment into STEM*: For example, for programs designed to recruit young mentees into a STEM field and that are mostly focused on designing fun and engaging STEM activities with a mentor who is acting as a positive role model and friend, ongoing contact may be less important. This type of program may meet its goals if it has piqued the interest of its mentees and then, subsequent STEM programs might focus on developing deeper mentoring relationships.
  - *Retention in STEM*: For programs designed to recruit or retain older mentees who have already expressed interest in a STEM field, a more enduring relationship with a STEM mentor may be more relevant to facilitate to help sustain mentees' interests over time and help mentees cope with educational and career challenges, open opportunities, and inform decision-making.
- Because many STEM programs are sponsored by STEM companies or academic STEM departments located in institutions of higher education, the **rules** for employees, faculty, or postdoctoral, graduate, or undergraduate students for that workplace should be considered. These policies may permit or prohibit contact with mentees outside of the program structure.

There are a few STEM mentoring programs that have reported their strategies for encouraging or supporting relationship continuation. For example, one summer camp STEM program for high school students using faculty and near-peer mentors reported that the program continued contact with mentees after the camp ended through email correspondence[10]. The program reported they regularly updated their website to add notices of related resources for mentees. In addition, some matches continued contact with one another, particularly using social media platforms to continue to build and strengthen their relationships. In a similar vein, some members of our Working Group noted that they encourage or help mentees to build a profile on LinkedIn. Furthermore, mentors and mentees were encouraged to connect with one another on LinkedIn, so that mentees could have ongoing educational- and career-related support from their mentors, while getting help building their professional networks.

Final Celebration and Participation in Authentic STEM-Related Events

Program **Enhancement 6.2** suggests that mentoring programs host a final celebration meeting or event for mentors and mentees to mark progress, transition, or acknowledge change in the mentoring relationship. This enhancement is particularly relevant for most STEM mentoring programs, particularly those where mentees complete long-term projects such as conducting scientific experiments or building a product or piece of equipment. Relationships that end well can have far-reaching positive effects on youth[11]; furthermore, when mentees are engaged in the planning of the final celebration or graduation ceremony, it can help to give them some control over the closure process[12]. Thus, a strong recommendation is for STEM mentoring programs to construct a final celebration that is planned, at least in part, by mentees. The experience can provide mentees with a forum to showcase their work or findings, and an opportunity to end their mentoring relationship in a healthy and joyous way.

Because research suggests that STEM programs aimed at recruitment and retention that reflect **authentic STEM activities** have stronger outcomes[13], having a STEM program culminate in an event that mirrors what STEM professionals might do in their careers could provide an effective means of closing the program and the relationship. Activities that reflect the work actually done by STEM professions will vary based upon the discipline. Some examples we located include:

- Mentees might work as part of an existing team or lab on an ongoing research project[14].
- Mentees engaged with research scientists would likely learn the scientific method, and then, design and conduct empirical research projects[15,16,17].
- Mentees matched with engineers or applications developers might program a software application or design and build a device, such as in a robotics camp[18,19,20].

These types of final events may be designed for mentees to have an authentic mastery experience that is directly related to being in a particular kind of STEM career. Several STEM mentoring organizations have reported a variety of different ways that they have constructed this type of authentic scientific activity:

- Some report having participants present their research findings, products, or projects in local, national, or international **competitions** (we found examples involving K–12 students,[21,22] as well as college students, including in international contexts[23].
- Others utilize more of a mini-conference approach where mentees present their projects in a **poster** format (college)[24], or in **an oral report, demonstration, or game** presented to peers, mentors, or other experts in the field, or family members in both elementary[25] and high school programs[26].
- For programs that chose to include participation in competitions, particularly ones that may be expensive to attend because they involve entrance fees and travel, the mentors have often collaborated with their mentees on **fundraising activities**[27]. Fundraising can be considered an authentic STEM activity as well, since STEM professionals regularly have to engage in these types of entrepreneurial activities (e.g., apply to external funders for grants or contracts) to support their work. By presenting their projects to potential donors, mentees get opportunities to develop their communications skills, get practice in pitching their ideas to interested laypeople, and consequently, can further develop their self-confidence and sense of belonging in a STEM field.

For a great real-life example of how one program maximizes these “capstone” style presentations into a celebration event, see the case study on the next page on the work of Sea Research Foundation.

Connect mentees to others in STEM fields

What is remarkable in the STEM literature is that, unfortunately, STEM mentoring programs cannot “rest easy” after they have sparked an interest in STEM. Support of someone into a STEM career may be a lifelong journey particularly for supporting the career development of youth and adults from underrepresented groups. Interest is only the first step and needs to be reinforced, grown, nurtured, and supported across development. The choice to pursue a STEM major or career, particularly one at an expert level, requires attention and resources. Each organizational context will present STEM mentees with new challenges to overcome and mentoring can be a means of supporting this process. For these reasons, mentoring programs, regardless of the target age group, should consider forming a consortium of programs and services that support the development of a STEM professional across adolescence and well into adulthood.

Program **Enhancement 6.3** suggests that mentoring program staff members should provide training and support to mentees and mentors, as well as, when relevant, to parents or guardians, about how mentees can identify and connect with natural mentors in their lives.

This enhancement in the *Elements* was included based on a growing literature on the importance of natural mentors in people’s lives[28,29,30] and could provide a bridge to future types of support for mentees whose formal mentoring relationships were ending. There are three recommendations that build upon this general enhanced practice:

- ***Connect mentees to other STEM professionals***
  Given the ongoing need for mentoring for young people interested in entering a STEM major or career, a strong recommendation is to help mentees build a network of STEM professionals that can deepen and grow across time. Specifically, the mentoring program and the mentor may introduce or connect mentees to other potential helpers and mentors who are STEM professionals. These introductions can be conducted either in person or virtually with the idea of growing mentee’s social capital which is often underdeveloped in the networks of students in underrepresented groups. For example, using LinkedIn as a professional networking device both within the program and for connecting mentees to other STEM professionals for education or career advice or opportunities could be an effective strategy to help achieve this goal.

- ***Network your STEM mentoring program with other STEM mentoring programs***
  An additional recommendation for STEM programs, particularly those that are time-limited, is for the program itself to network with other STEM mentoring programs. That way, when the program ends, mentees will still be able to receive mentoring services and/or participate in more advanced or ongoing STEM programs.

Photo courtesy of Sea Research Foundation

STEM MENTORING IN ACTION:
Sea Research Foundation

SEA RESEARCH FOUNDATION'S STEM MENTORING PROGRAM CONCLUDES EACH YEAR WITH A GRADUATION event that brings mentees, mentors, program staff, and family members together to celebrate the year. Everyone is invited to the program site, where participants share what they've learned and watch a slideshow of photos. The graduation takes place after all the curriculum modules have been completed, so sites are able to put mentees' STEM projects from various curricula on display to demonstrate what they've created. The graduation event is sometimes the first opportunity families get to see what mentees and mentors have worked on, and mentees are often quite proud to share what they've accomplished.

The graduation event also signals the end of the program, so sites use this opportunity to close matches. Even continuing sites may not have the same mentors and mentees from year to year, so it's important for sites to communicate that matches are officially over after this event and give mentors and mentees a chance to say goodbye. Mentees present mentors with certificates of appreciation and everyone receives a group photograph and a magnetic picture frame to commemorate the experience.

▶ ***Train mentees in youth-initiated mentoring skills***

Low-income youth often have reduced access to naturally occurring mentors and these relationships tend to be with family and friends, rather than with nonfamilial adults which can limit their economic, educational, and career opportunities[31]. Prior to relationship closure, STEM mentoring programs might consider training mentees in the lifelong skills of being able to locate, identify, initiate, and maintain new mentoring relationships with caring adults in their lives to address the ongoing needs for support as youth enter a STEM education or STEM career. This new youth-initiated mentoring approach has been undergoing development in various forms and with diverse populations, and piloted in small pilot studies, suggesting it is a promising approach[32,33,34]. The results of these studies suggest that students who are trained in youth-initiated mentoring approaches report a reduction in help-seeking avoidance, particularly in students from underrepresented groups, while improving the interpersonal skills students need to increase their social capital. These skills will serve STEM-interested mentees well along their journey toward a career in a STEM field.

References

1 Garringer, M., McQuillin, S., & McDaniel, H. (2017). *Examining youth mentoring services across America: Findings from the 2016 National Mentoring Program Survey*. Boston, MA: MENTOR: The National Mentoring Partnership.

2 Kupersmidt, J. B., Stump, K. N., Stelter, R. L., & Rhodes, J. E. (2017). Predictors of premature match closure in youth mentoring relationships. *American Journal of Community Psychology, 59*(1–2), 25–35.

3 Spencer, R., & Basualdo-Delmonico, A. (2014). Termination and closure of mentoring relationships. In D. L. DuBois & M. J. Karcher (Eds.), *Handbook of Youth Mentoring, Second Edition* (pp. 469–480). Thousand Oaks, CA: Sage Publications.

4 Grossman, J. B., & Rhodes, J. E. (2002). The test of time: Predictors and effects of duration in youth mentoring relationships. *American Journal of Community Psychology, 30*(2), 199–219.

5 Spencer, R., Basualdo-Delmonico, A., Walsh, J., & Drew, A. L. (2017). Breaking up is hard to do: A qualitative interview study of how and why youth mentoring relationships end. *Youth & Society, 49*(4), 438–460.

6 Zilberstein, K., & Spencer, R. (2017). Breaking bad: An attachment perspective on youth mentoring relationship closures. *Child and Family Social Work, 22*(1), 67–76.

7 Grossman, J. B., Chan, C. S., Schwartz, S. E., & Rhodes, J. E. (2012). The test of time in school□based mentoring: The role of relationship duration and re-matching on academic outcomes. *American Journal of Community Psychology, 49*(1–2), 43–54.

8 Bayer, A., Grossman, J. B., & DuBois, D. L. (2015). Using volunteer mentors to improve the academic outcomes of underserved students: the role of relationships. *Journal of Community Psychology, 43*(4), 408–429.

9 Kupersmidt, et al., 2017.

10 Phelan, S., Harding, S., & Harper-Leatherman, A. (2017). BASE (Broadening Access to Science Education): A research and mentoring focused summer STEM camp serving underrepresented high school girls. *Journal of STEM Education, 18*(1), 65–72.

11 Zilberstein & Spencer, 2017.

12 Zilberstein, K. (2008). Au revoir: An attachment and loss perspective on termination. *Clinical Social Work Journal, 36*(3), 301–311.

13 Seymour, E., Hunter, A. B., Laursen, S. L., & DeAntoni, T. (2004). Establishing the benefits of research experiences for undergraduates in the sciences: First findings from a three-year study. *Science Education, 88(4), 493–534.*

14 Bowling, B., Bullen, H., Doyle, M., & Filaseta, J. (2013). *Retention of STEM majors using early undergraduate research experiences.* Paper presented at the Proceeding of the 44th ACM Technical Symposium on Computer Science Education.

15 Byars-Winston, A. M., Branchaw, J., Pfund, C., Leverett, P., & Newton, J. (2015). Culturally diverse undergraduate researchers' academic outcomes and perceptions of their research mentoring relationships. *International Journal of Science Education, 37*(15), 2533–2554. doi:10.1080/09500693.2015.1085133

16 Nagda, B. A., Gregerman, S. R., Jonides, J., Von Hippel, W., & Lerner, J. S. (1998). Undergraduate student-faculty research partnerships affect student retention. *The Review of Higher Education, 22*(1), 55–72.

17 Seymour, et al., 2004.

18 Ilori, O., & Watchorn, A. (2016). Inspiring next generation of engineers through service-learning robotics outreach and mentorship programme. *International Journal of Advanced Robotic Systems, 13*(5). doi:10.1177/1729881416663372

19 Karp, T., Gale, R., Tan, M. G., & Burnham, G. (2014). Hosting a pipeline of K–12 robotics competitions at a College of Engineering-A review of benefits and challenges. *International Journal for Service Learning in Engineering, 9*.

20 Martin, F. G., Scribner-MacLean, M., Christy, S., Rudnicki, I., Londhe, R., Manning, C., & Goodman, I. F. (2011). Reflections on iCODE: Using web technology and hands-on projects to engage urban youth in computer science and engineering. *Autonomous Robots, 30*(3), 265–280. doi:10.1007/s10514-011-9218-3

21 Howell, W. L., McCaffrey, E. J., & Murphy, R. R. (2003). *University mentoring for first Lego league.* Paper presented at the 33rd Annual Frontiers in Education Conference.

22 Karp, et al., 2014.

23 Ilori & Watchorn, 2016.

24 Bowling, et al., 2013.

25 Karp, T., Gale, R., Lowe, L. A., Medina, V., & Beutlich, E. (2010). Generation NXT: Building Young Engineers With LEGOs. *IEEE Transactions on Education, 53*(1), 80–87. doi:10.1109/te.2009.2024410

26 Phelan, et al., 2017.

27 Ilori & Watchorn, 2016.

28 Black, D. S., Grenard, J. L., Sussman, S., & Rohrbach, L. A. (2010). The influence of school-based natural mentoring relationships on school attachment and subsequent adolescent risk behaviors. *Health Education Research, 25*(5), 892–902.

29 DuBois, D. L., & Silverthorn, N. (2005). Natural mentoring relationships and adolescent health: Evidence from a national study. *American Journal of Public Health, 95*(3), 518–524.

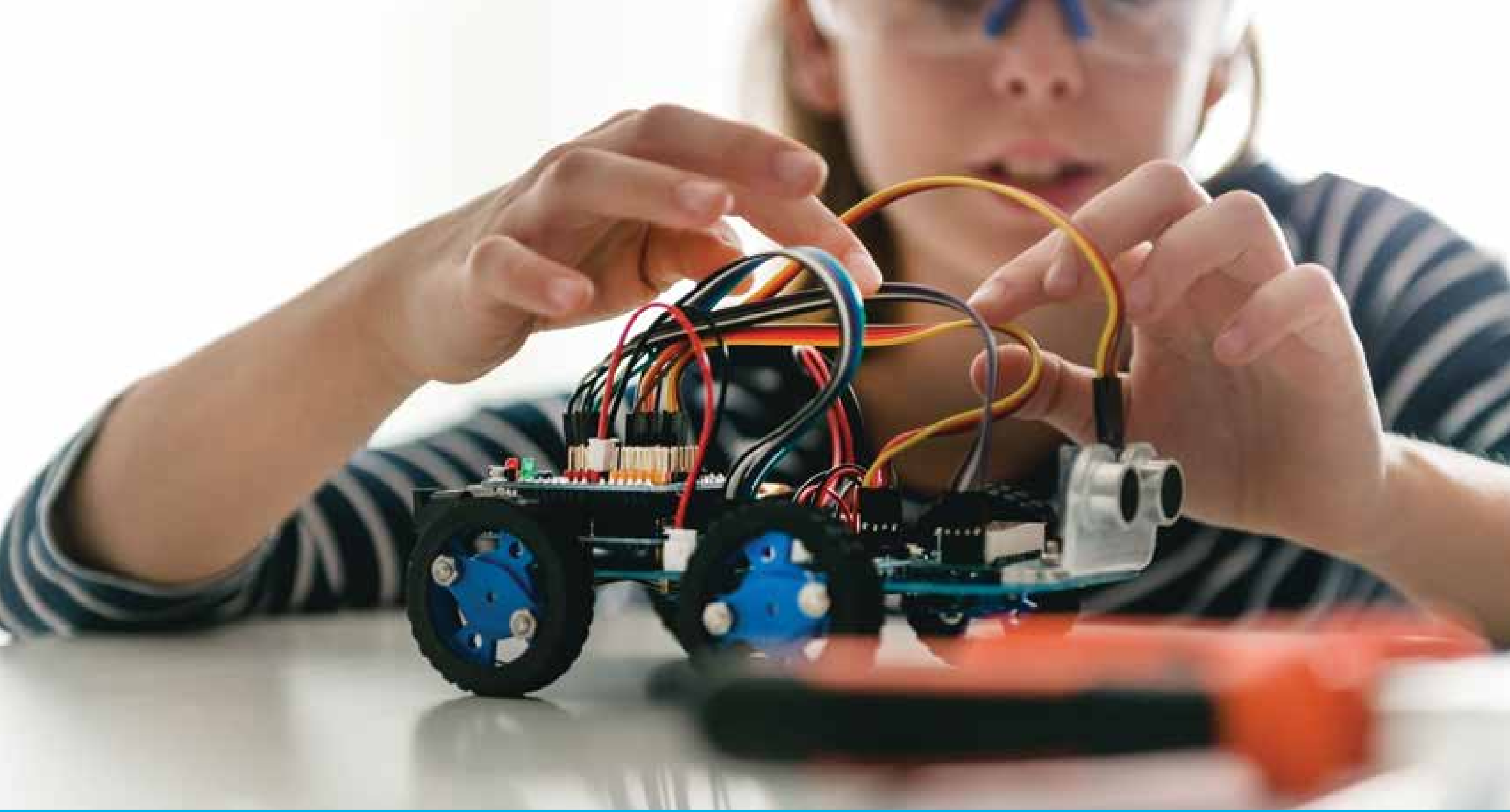
30 McDonald, S., & Lambert, J. (2014). The long arm of mentoring: A counterfactual analysis of natural youth mentoring and employment outcomes in early careers. *American Journal of Community Psychology, 54*(3–4), 262–273.

31 Raposa, E. B., Erickson, L. D., Hagler, M., & Rhodes, J. E. (2018). How economic disadvantage affects the availability and nature of mentoring relationships during the transition to adulthood. *American Journal of Community Psychology*.

32 Schwartz, S. E., Kanchewa, S. S., Rhodes, J. E., Cutler, E., & Cunningham, J. L. (2016). "I didn't know you could just ask:" Empowering underrepresented college-bound students to recruit academic and career mentors. *Children and Youth Services Review, 64*, 51–59.

33 Schwartz, S. E., & Rhodes, J. E. (2016). From treatment to empowerment: New approaches to youth mentoring. *American Journal of Community Psychology, 58*(1–2), 150–157.

34 Spencer, R., Tugenberg, T., Ocean, M., Schwartz, S. E., & Rhodes, J. E. (2016). "Somebody who was on my side," A qualitative examination of youth initiated mentoring. *Youth & Society, 48*(3), 402–424.



3 PROGRAM ELEVATION AND OUTCOME MEASUREMENT IN STEM MENTORING

One of the surprising findings of our literature review was the limited range of studies of STEM mentoring programs, and STEM education programs in general, which used strong evaluation or research designs. Only about one in ten of the research articles in our initial literature review utilized some form of a control or comparison group, with only three involving random assignment of participants to one group or another (others used a matched comparison group or other designs). We also found few examples of longer-term studies of program impact, with only a handful of evaluations using student records or other methods to track mentored and unmentored youth deep into their higher education and career experiences[1]. Other reviews of the STEM mentoring literature have found similar gaps in both experimental designs and examinations of long-term outcomes[2].

This lack of rigorous research design makes it very challenging to make causal claims about what "works" in STEM mentoring or to understand with certainty how STEM programs or mentors can use different approaches to maximize their impact. This is one of the many reasons the recommendations and tips provided in this supplement to the Elements also draws from related research in other fields and practitioner wisdom.

The vast majority of research and program evaluation in the STEM mentoring space consists of pre-post tracking of the types of outcomes discussed earlier in this guide: changes in STEM attitudes, beliefs, and plans; increased participation in STEM activities and classes; and gains in STEM knowledge and skills. This type of quantitative outcome monitoring (as distinct from comparative evaluation) was often accompanied by qualitative data collection about participant's experiences, their insights regarding what they considered to be impactful aspects of the program, and their suggestions for optimizing service delivery. We also noted some examples of studies based on analysis of existing data sets (e.g., multi-year longitudinal questionnaires or student records).

Given the emphasis on qualitative data and the participant experience in the evaluations we reviewed, it was interesting that few of the studies focused much on fidelity of implementation of the program model. Compared to the traditional mentoring literature, in which adherence to standards or practice by staff and participation in program activities (not just match meetings, but also required training and other participant obligations) are commonly included in studies as moderators of program outcomes[3,4], we found few examples of that type of data in the STEM mentoring literature. While some studies noted the number of times mentors and mentees met, or other data suggesting uptake of the program, issues of implementation were surprisingly absent in many studies. As a result, it was also challenging to find clear examples of how STEM mentoring programs could improve their service delivery.

Suggestions for improving the quality of program evaluation and research in STEM mentoring are provided at the end of this section.

REVIEW OF STEM MENTORING OUTCOMES

We thought it would be helpful to the STEM mentoring field to take stock of the full range of outcome areas and specific measures that were mentioned or used in our literature review. As noted in the General Program Design Principles section earlier in this guide—and detailed further in the Appendix—we did find that types of program outcomes tended to cluster around the age ranges of youth participants, with programs for younger mentees focused more on initial STEM interest and engagement and programs serving older adolescents or young adults emphasizing instrumental supports, professional skills, and assistance with key transitions along STEM pathways. Programs will want to select measures that speak clearly to the current STEM engagement of the mentees, the traits of those serving in the mentoring role, and the types of activities that mentors and youth engage in. In looking across the full literature review, we found programs emphasizing measures from the listing on the next page.

RECOMMENDATIONS FOR PROGRAM EVALUATION

STEM mentoring programs can help build the literature base for this type of programming, as well as inform program improvements, by designing evaluations with the following suggestions in mind:

- ***Focus on the proximal outcomes that speak most directly to the work of mentors and mentees***
  As noted earlier in this guide, STEM pathways from childhood through young adulthood have many transition points and barriers that can challenge the long-term engagement in STEM for even the most dedicated and driven students. And while every program wants to prove that their services are the key spark that propelled their mentees into STEM accomplishments and careers, it's important to remember that one STEM program, and one STEM mentor, likely plays a limited role in helping nudge that mentee along their path. Evaluations should focus on the piece of that long-term puzzle that your mentors provide to young people. Whether it's changing attitudes and building some STEM confidence or helping youth complete advanced research projects and present findings in adult settings, selecting outcomes that might be detectable "close to the action" of mentoring are most likely to show growth and impact for mentees. Programs should avoid designs that have the program searching or taking credit for distal outcomes that are beyond the control and scope of what the program provides.

- ***But, when possible, use accessible data to track participants into their STEM futures***
  Although programs are likely to see their strongest impacts on those short-term outcomes that are most relevant to their work, there is also value in seeing if the program did result in any longer term engagement in STEM participation. This is most commonly done by tracking students using K–12 and higher education records, although we have noted examples of long-term follow-up surveys of participants, and even the use of platforms like LinkedIn, to see if program participants (or their comparisons) eventually found their way into STEM academia or industries. While you might not be able to tie these long-term findings directly to what your mentors provided, you might find that the program have varying levels of success for subgroups of participants or gain valuable information about barriers that prevented youth from building on what your program provided as they got older. This can help programs be more intentional about giving advice to mentees about challenges they may face down the road or spur new partnerships so that promising STEM mentees can purposefully transition into their next STEM mentoring opportunity.

- ***Track implementation fidelity***
  As noted above, we did not find many discussions of levels of program participation or adherence to program procedures in the literature we reviewed. For STEM mentoring programs, it may be especially important to track indicators of program delivery, such as adherence to or completion of STEM curriculum or experiments, the volume of delivery of specific STEM messages and encouragements, or the completion of

COMMON STEM MENTORING PROGRAM OUTCOMES

STEM-RELATED KNOWLEDGE

- Knowledge about STEM subject matter
- Knowledge of STEM careers
- Knowledge of college application process and identification of college choices

STEM-RELATED ATTITUDES

- Attitudes about science (generally) or STEM subjects
- Anxiety about STEM subjects
- Interest in STEM careers
- STEM identity
- STEM sense of belonging

STEM-RELATED BEHAVIORS

- Direct STEM skills (e.g., conducting research, interpreting and reporting data, etc.)
- Skills beneficial in STEM work (e.g., teamwork, how to get information from other people, problem-solving, the scientific method, time management, and critical thinking skills)
- STEM-related confidence or self-efficacy (both in terms of schoolwork and career paths)
- Active planning for STEM careers
- Frequency and depth of engagement with STEM activities, books, media, etc.
- Affirmation of STEM career choice
- STEM-related grades or test scores
- Enrollment and/or persistence in post-secondary STEM courses

BEHAVIORAL FUNCTIONING (non-STEM-related per se)

- School attendance and behavior
- Afterschool problem behaviors
- Substance use

MENTORING AND NETWORKING ATTITUDES AND BEHAVIORS

- Help-seeking
- Number and types of STEM-related adults youth interact with
- Quality of STEM mentoring relationships (e.g., level of participation, activities engaged in, advice giving, fun interactions)

OTHER OUTCOMES

- Parent involvement in STEM activities or post-secondary planning
- Teacher perceptions of STEM engagement

training or monitoring activities. Of course, the volume and frequency of mentor-mentee interactions can also be a critical component of program success. Investigating these markers of implementation will help the program determine why it might be more effective for some participants than others, can point to weaknesses that the staff can address, and might provide an explanation when programs don't have the successful outcomes they expect. Low-quality implementation is often the culprit when impacts are small.

- ***Attempt to separate the value of mentoring relationships vs the program activities or other factors***

  Previous reviews of the STEM literature have noted that there is almost no research detailing the role that mentoring relationships with STEM experts play, compared to other program features, in achieving program outcomes[5]. Simply put, we don't know very much about what combination of STEM relationships (role modelling, identity development, etc.), hands-on activities and experiments, direct STEM teaching, and instrumental supports will achieve the optimal outcomes for youth participants. When designing evaluations, programs may want to consider qualitative methods that can be coupled with quantitative findings to explain the ways in which mentors compliment other program features and vice versa. This can inform mentor training, the selection of STEM activities, and the additional supports that a program provides.

- ***When emphasizing program improvement, test variations in practice and look for subgroup effects***

  Also lacking in the research literature were studies designed to compare different approaches to the same practice (e.g., testing different training curricula or mentoring activities within the same program) or examine mentoring outcomes for youth of different ages or backgrounds. Programs may find that they can make targeted improvements in implementation over time by systematically testing different ways of doing the work and seeing which is most effective or satisfying for participants. Programs may also find that some groups of youth are getting more out of the program than others, suggesting key improvements that can address issues and allow all mentees to get the most out of their mentoring relationships.

One example of a program that is taking their STEM mentoring evaluation to a new level can be found in the sidebar on the evaluation work of Genentech.

Photo courtesy of Genentech

STEM MENTORING IN ACTION: Genentech's Futurelab Initiative

Since the start of **FUTURELAB** in 2015, Genentech has partnered with a third-party evaluator to measure and monitor program outcomes that include surveys, focus groups, and one-to-one interviews with our Futurelab student participants and teachers and Genentech volunteers. Genentech plans to pursue a rigorous formal evaluation of their programs after the 2020 programming year and encourages other STEM mentoring programs to consider formal evaluation to add to the field's collective knowledge of high-quality STEM mentoring practices.

References

[1] Bowling, B., Doyle, M., Taylor, J., & Antes, A. (2015). Professionalizing the role of peer leaders in STEM. *Journal of STEM Education, 16*(2), 30–39.

[2] Gamse, B. C., Martinez, A., Bozzi, L., & Didriksen, H. (2014). *Defining a research agenda for STEM Corps: Working white paper.* Cambridge, MA: Abt Associates.

[3] DuBois, D. L., Holloway, B. E., Valentine, J. C., & Cooper, H. (2002). Effectiveness of mentoring programs for youth: A meta-analytic review. *American Journal of Community Psychology, 31*(2), 157–197.

[4] Kupersmidt, J. B., Stump, K. N., Stelter, R. L., Rhodes, J. E. (2017). Mentoring program practices as predictors of match longevity. *Journal of Community Psychology, 45,* 630–645. doi:10.1002/jcop.21883

[5] Gamse, et al., 2014.

MATRIX OF STEM MENTORING PROGRAM FEATURES IN ELEMENTARY SCHOOL

OVERARCHING GOALS	MENTORS (TYPICAL)	MENTORING MODEL	SETTING AND SUPPORT	MENTORING ACTIVITIES (TYPICAL)	OUTCOMES MEASURED (TYPICAL)
▶ Get young students interested and succeeding in STEM subjects in school	▶ Employees at STEM companies ▶ STEM undergrads ▶ High school students ▶ Nonprofit staff ▶ General public *For some programs, women, adults of color, and adults with disabilities are specifically recruited*	▶ 1:1 ▶ 1:many youth ▶ Group (in-person)	▶ Youths' school ▶ After-school program ▶ STEM companies ▶ Higher education campus *Common supports:* ▶ Parent engagement and do-at-home activities* ▶ Transportation for youth, if offsite ▶ Training for mentors on conducting experiments and being relational	▶ Adult-facilitated, hands-on science experiments ▶ Field trips to STEM museums ▶ Brief or day-long visits to STEM businesses ▶ Teaching of science concepts ▶ Tutoring for STEM school assignments ▶ Light information sharing about STEM careers ▶ Engagement with STEM media ▶ Fun, playful activities	▶ General interest in STEM subjects ▶ Performance in STEM subjects in school ▶ Attitudes about STEM subjects (general) ▶ Anxiety about STEM subjects ▶ Interest in STEM careers ▶ School attendance and behavior ▶ Frequency and depth of engagement in STEM activities

MATRIX OF STEM MENTORING PROGRAM FEATURES IN MIDDLE SCHOOL

OVERARCHING GOALS	MENTORS (TYPICAL)	MENTORING MODEL	SETTING AND SUPPORT	MENTORING ACTIVITIES (TYPICAL)	OUTCOMES MEASURED (TYPICAL)
▶ Build direct STEM skills and boost STEM classroom performance ▶ Nurture STEM identity and sense of belonging* ▶ Start building interest in specific STEM fields and careers and their associated higher education pathways	▶ Employees at STEM companies ▶ STEM undergrads or graduate students ▶ Nonprofit staff ▶ Women, minorities, or adults with disabilities working or studying in STEM fields*	▶ 1:1 ▶ 1:many youth ▶ Group (in-person)	▶ Youths' school ▶ After-school program ▶ STEM companies ▶ Higher education campus ▶ Summer "bridge" program *Common supports:* ▶ Parent engagement, often as end-of-program portfolio or project sharing ▶ Transportation for youth to off-site activities ▶ Training for mentors on conducting experiments and being relational ▶ Additional training on discussing intersection of gender, race/ethnicity, and disability with pursuit of STEM careers*	▶ Youth-led, hands-on science experiments ▶ Deeper teaching of science concepts ▶ Multi-day visits to STEM companies ▶ Deeper discussion of STEM careers and related higher education pathways ▶ Remedial instruction for youth behind grade level in STEM subjects ▶ Some exploration of the role of gender, race/ethnicity, and disability in STEM participation and careers*	▶ General interest in STEM subjects ▶ Performance in STEM subjects in school ▶ Attitudes about STEM subjects (general) ▶ STEM self-efficacy or confidence ▶ Anxiety about STEM subjects ▶ STEM identity* ▶ Sense of STEM belonging* ▶ Number and quality of STEM mentoring relationships ▶ Knowledge of STEM careers ▶ Interest in STEM careers ▶ School attendance and behavior

MATRIX OF STEM MENTORING PROGRAM FEATURES IN HIGH SCHOOL

OVERARCHING GOALS	MENTORS (TYPICAL)	MENTORING MODEL	SETTING AND SUPPORT	MENTORING ACTIVITIES (TYPICAL)	OUTCOMES MEASURED (TYPICAL)
▶ Develop advanced STEM skills and abilities ▶ Solidify STEM identity* ▶ Fully explore STEM careers and higher education pathways ▶ Plan for STEM post-secondary enrollment* ▶ Establish or strengthen youths' network of STEM relationships	▶ STEM undergrads, grad students, or faculty ▶ Employees at STEM companies ▶ Women, minorities, or adults with disabilities working or studying in STEM fields*	▶ 1:1* ▶ Group (in-person)* ▶ Group (online)*	▶ Higher education institutions' laboratories ▶ STEM companies' laboratories or facilities ▶ Youth's school ▶ Online *Common supports*: ▶ Parental education about STEM higher education pathways and careers ▶ Information sharing around the college application process ▶ Training for mentors on sharing their experiences in STEM, particularly related to gender, race/ethnicity, and disability* ▶ Training for youth on behavioral expectations in workplace and higher education settings ▶ Incentive to earn college STEM credits or publish research	▶ Long-term research projects and advanced science experiments ▶ Teaching of meaningful science skills (e.g., data collection and analysis, methodology, use of equipment) ▶ Job shadowing ▶ Internships ▶ Sharing information about, or assisting with, college application and enrollment ▶ Deep discussion of personal experiences in STEM, particularly related to gender, race/ethnicity, and disability* ▶ Preparation and presentation of a capstone project or published research ▶ Use of online discussion platforms for access to additional STEM mentors and increased overall engagement*	▶ Solidifying interest in STEM and STEM careers ▶ Performance in STEM subjects in school ▶ STEM skills and knowledge ▶ STEM self-efficacy or confidence ▶ STEM identity* ▶ Sense of STEM belonging* ▶ Number and quality of STEM mentoring relationships* ▶ Active planning for STEM enrollment or careers ▶ Commitment to STEM careers ▶ Knowledge of college application process ▶ Completion of college application process ▶ Enrollment in higher education (especially as a STEM major) ▶ Completion of undergraduate STEM degree ▶ Employment at STEM company

MATRIX OF STEM MENTORING PROGRAM FEATURES IN HIGHER ED./UNDERGRADUATE

OVERARCHING GOALS	MENTORS (TYPICAL)	MENTORING MODEL	SETTING AND SUPPORT	MENTORING ACTIVITIES (TYPICAL)	OUTCOMES MEASURED (TYPICAL)
▸ Develop advanced STEM skills and abilities ▸ Solidify STEM identity and sense of belonging* ▸ Completion of undergraduate degree in STEM major ▸ Strengthening planning for ongoing postsecondary advancement or career transitions	▸ Faculty and doctoral students in STEM subject areas	▸ 1:1* ▸ Group (in-person)*	▸ Higher education institutions' laboratories ▸ Other on- and off-campus locations for relational activities *Common supports*: ▸ Training for mentors on sharing their experiences in STEM, particularly related to gender, race/ethnicity, and disability* ▸ Training for mentors on directing mentees to additional on-campus resources ▸ Coordination of mentor role with faculty advisors ▸ Incentive of publishing original research	▸ Long-term research projects, typically as part of a faculty-led research team ▸ Teaching of advanced science skills (e.g., data collection and analysis, methodology, use of equipment) ▸ Internships of field placements ▸ Deep discussion of personal experiences in STEM, particularly related to gender, race/ethnicity, and disability* ▸ Discussion of other campus resources to enhance or support the undergraduate experience ▸ Preparation and presentation of a capstone project or published research	▸ Improved academic performance in STEM courses ▸ STEM skills and knowledge ▸ STEM skills and knowledge ▸ STEM self-efficacy or confidence ▸ Use of undergraduate campus resources ▸ STEM identity* ▸ Sense of STEM belonging* ▸ Number and quality of STEM mentoring relationships* ▸ Commitment to STEM careers ▸ Persistence in STEM major ▸ Completion of undergraduate STEM degree ▸ Active planning for ongoing STEM education or careers ▸ Employment at a STEM company or in a STEM field

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