

This paper was commissioned for the Committee on Effective Mentoring in STEMM. Opinions and statements included in the paper are solely those of the individual author, and are not necessarily adopted, endorsed, or verified as accurate by the Committee or the National Academy of Sciences, Engineering, and Medicine.

Mentoring beyond Hierarchies: Multi-Mentor Systems and Models

Beronda L. Montgomery, Michigan State University and Stephani C. Page, Duke University

Mentoring is critical for promoting success in the academy. Specific benefits of mentoring include socioemotional or psychosocial support, skills development and professional progress, and short-term and long-term career advancement and success (Haggard et al., 2011; Jacobi, 1991; Kram, 1985; Packard, 2016). The support of personal and professional growth through mentoring can counteract low self-efficacy, or a limited belief in one's ability to achieve success, and result in improved competencies that support individual and career advancement (Jacobi, 1991; Kelly & McCann, 2014; Kram, 1985). To mentor effectively sometimes requires radical reformulation of the "spaces" in which mentoring occurs to craft environments that promote self-efficacy broadly for diverse mentees and affirm individual identities, especially those from backgrounds underrepresented in science, technology, engineering, mathematics, and medicine (STEMM) (Emdin, 2016).

Classical forms of mentoring are often about conveying information from a top-down mode, which are generally closely linked to advancing individuals along institutionally-defined paths of success (Lewis & Olshansky, 2016; Montgomery, 2018b; Yun & Sorcinelli, 2009; Yun et al., 2016). Such mentoring frequently takes place in one-on-one pairings of a senior or experienced mentor with a more junior or novice mentee in a mentoring dyad. Such hierarchical relationships are associated with power differentials that can serve to maintain "business as usual" or status quo (Darwin, 2000, p. 198; Thomas et al., 2015). Additionally, individual mentee needs are unlikely to be met by a single mentor (Montgomery, 2017; Yun et al., 2016). Thus, a progressive recognition of the effectiveness of multiple mentors rather than single dyads for supporting success in STEMM and the academy has emerged (de Jansz & Sullivan, 2004; Long et al., 2014; McGee et al., 2015; Montgomery, 2017; Sorcinelli & Yun, 2007; Weiston-Serdan, 2017; Wilson et al., 2012). There is an increasing appreciation for the roles of reciprocity and bilateral engagement in improved mentoring outcomes in the academy (Clarke, 2004; Pololi et al., 2002; Sorcinelli & Yun, 2009; Yun et al., 2016). These outcomes include astute adaptation of mentoring to individual mentee goals and aspirations (Montgomery, 2017).

Related to the personalization of mentoring, some of the benefits attributed to mentoring could be related to increased interactions and engagement that could increase socialization. Indeed, the impacts of social influence have been noted as important for promoting growth in science efficacy and supporting success in STEMM broadly (Estrada, Hernandez, & Schultz, 2018; Smith-Doerr, 2004). Further, socialization has been proposed to influence the decision to pursue a career in STEMM (Anthony & Taylor, 2004; Seymour, 1999), as well as success for URM faculty in the

sciences (Tierney & Rhoads, 1993). Some of the forms of mentoring that we will discuss include platforms that encourage regular interaction, promotion of social influence and mentee socialization. However, we argue that it is critical to discuss these benefits in the context of intentional mentoring to increase the likelihood of equitable access to the interactions correlated with promoting increased science identity, as well as commitment to and success in STEMM. Without intentional incorporation in plans for formal mentoring and associated accountability, rather than leaving these interactions to the chance of daily interactions, many trainees will not have access to them, including underrepresented minoritized (URM) and women trainees (Smith-Doerr, 2004; Ramirez, 2012).

Mentoring Models

Different models of effective mentoring for promoting access and success that extend beyond dyadic mentoring are detailed here, including mentoring triads, group-based or collective mentoring, networked mentoring, and nested or hybrid multi-mentoring models (Figure 1).

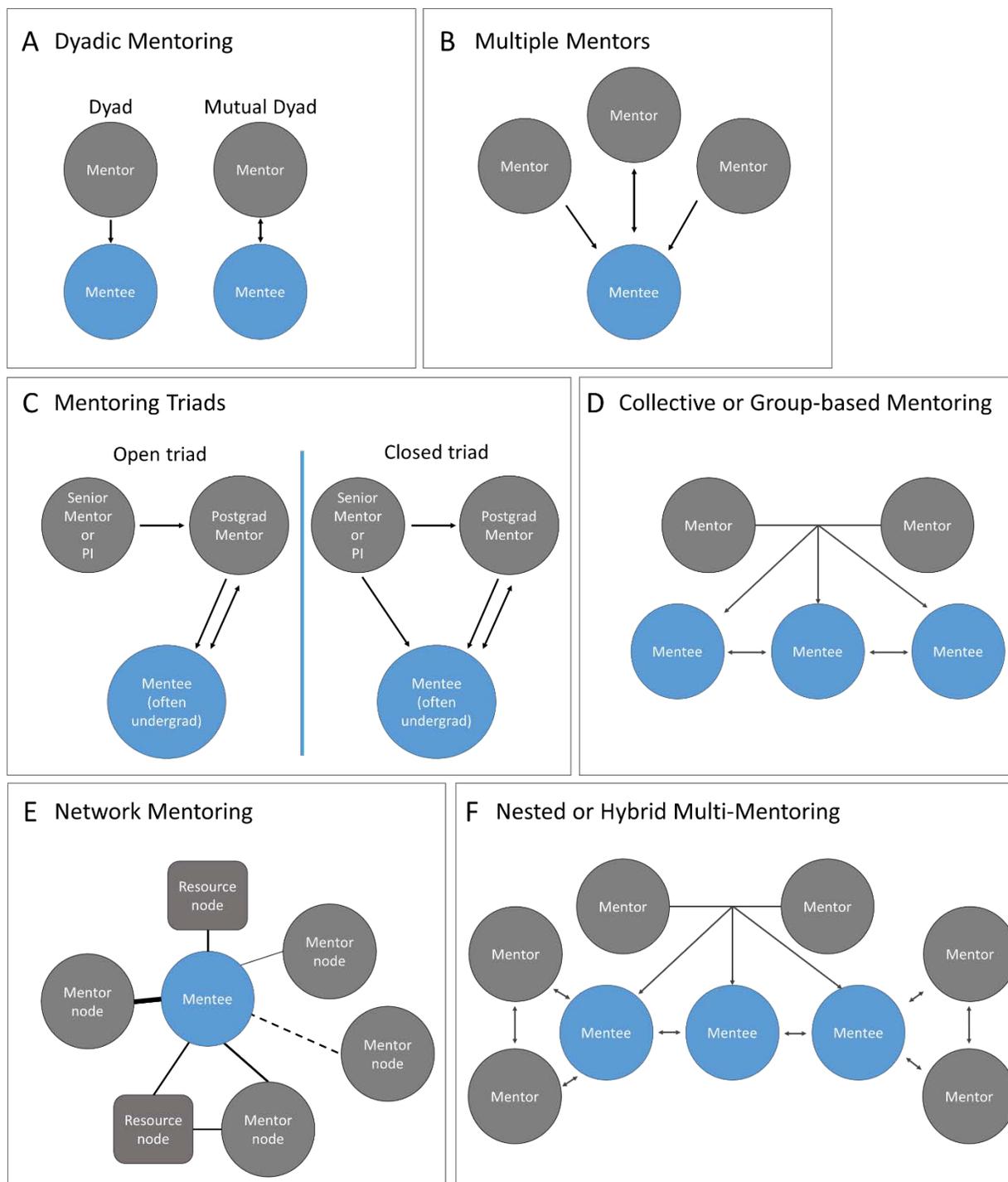


Figure 1. Multiple mentor systems and models. Traditional mentoring models are based on dyads, whereas emerging models recognize the potential for multiple mentors to contribute to success of diverse mentees in STEM. (A) Dyadic mentoring, including traditional hierarchical (depicted by single-headed arrow) dyads and mutual dyads with reciprocal (depicted by double-headed arrow) input from mentor and mentee; (B) General multiple mentor model with multiple mentors engaging a single mentee; (C) Mentoring triads consist of two mentors (typically one senior mentor or primary investigator [PI] and one postgrad [graduate student or postdoctoral scientist] mentor) working with a mentee (typically an undergraduate). Mentoring triads can be open or closed as depicted; (D) Collective or group-based mentoring, which consists of multiple mentors working collaboratively to support multiple mentees who may also provide each other with peer support; (E) Network mentoring in which one mentee draws on multiple

mentors and resources to obtain input into many issues of the academic or professional career. Lines or ties represent relationships or interactions between mentor and mentee with thinner or dotted lines (weaker) or thicker solid lines (stronger) depicting the strength of the relationship [based on Montgomery, 2017]; and (F) Nested or hybrid multi-mentoring models consist of a community of multiple mentors and mentees that have characteristics of both network mentoring and group or collective mentoring. Nested mentoring, in particular, has intentional engagement between mentors to support their growth and efficacy as mentors.

Triads. Mentoring triads often consist of a senior experienced mentor, a near-peer mentor and a mentee. These triads can also consist of all peers or near peers. Notably, peer mentoring has been reported to counteract the isolation and imposter syndrome that can sometimes be associated with classical dyadic mentoring (Driscoll et al., 2009). Frequently in STEMM, however, mentoring triads consist of a faculty member, a graduate student or postdoctoral mentor (i.e., postgraduate mentor), and an undergraduate mentee. There are two types of common triads – an open triad with the undergraduate having a connection to the postgraduate mentor and the postgraduate mentor separately being mentored by the faculty, but with little to no direct engagement between the undergraduate and faculty mentor, or closed triads in which each individual has a direct connection (Aikens et al., 2016). Undergraduates engaged in a closed mentoring triad showed greater growth in terms of critical thinking and science identity, than those mentored by either a postdoctoral researcher or faculty member alone in an open triad (Aikens et al., 2016). Notably, in a recent study, men were found to be more likely to be in closed triads than in open, and URM students were more likely to be in closed triads (Aikens et al., 2017). Notably, engagement in a closed triad was associated with higher rates of scholarly productivity (Aikens et al., 2017). Whereas gender concordance has been shown to have positive impacts on mentoring dyads, triads have unique outcomes with the most significant being a negative impact of a mentee having a lack of gender concordance with neither the postgraduate nor faculty mentor (Morales et al., 2018).

Group-based or collective mentoring. Group- or team-based mentoring includes the collective development and cultivation of communities of mentors. Such group-based efforts can be accomplished in-person (Allen & Joseph, 2018; Comer et al., 2017; Dodson et al., 2009; Eby, 1997; Ireland, et al., 2018; Ko et al., 2014; Martinez et al., 2015; Montgomery et al., 2014; Thomas et al., 2015; Varkey et al., 2012), online through social media and other digital platforms (Montgomery, 2018c), using mixed online and in-person approaches (Martinez et al., 2015), and through short-term engagements at conferences and other spaces where one-time or infrequent interactions occur (Grant, 2015; Montgomery, 2017). Effective mentoring groups or circles can be multi-generational (e.g., Dodson et al., 2009) or can also be comprised of peers, which leads to peer mentoring and reciprocal peer support (e.g., Thomas et al., 2015). Though more extensive empirical analyses are warranted, multi-generational models have potential for providing developmentally-adapted mentoring across relevant career stages (Dodson et al., 2009; Montgomery et al., 2014). Peer-mentoring groups, in particular, have been reported to promote collaboration and perhaps cultural change that may be related to increased retention (Thomas et al., 2015). These peer or near-peer groups may also serve to counteract reifying persistent problems of isolation and perceived low self-efficacy associated with traditional dyadic mentoring structures (Driscoll et al., 2009; Thomas et al., 2015). This outcome is supported in part through shifting the focus from mentor-centered power hierarchies to mentee-centered peer sharing and support (Montgomery, 2018a; Thomas et al., 2015).

Mentoring groups or circles can also be affinity-based, which can result in the creation of microclimates or microcommunities. Such microclimates can be critical for those individuals experiencing isolation and invisibility (Comer et al., 2017; Martinez et al., 2015; Tuitt, 2010).

Affinity-based mentoring groups have been used successfully to support members, including those individuals from groups underrepresented in STEMM (Allen & Joseph, 2018; Dodson et al., 2009; Montgomery et al., 2014; Montgomery, 2018c). Additionally, peer-mentoring groups and circles may have benefits for women and URMs due to low numbers of traditional “senior” mentors (Montgomery, 2018c; Thomas et al., 2015). Critical features of effective communal spaces include an intentional focus on equitably supporting strengths (Allen & Joseph, 2018; Kelly & McCann, 2014; Montgomery, 2017), social support (Mondisa & McComb, 2015), and prioritizing self-definition and self-valuation (Dodson et al., 2009; Montgomery, 2018c). Collective or group mentoring promotes building social capital, identity development and empowerment, socialization, as well as academic and career success (Allen & Joseph, 2018; Dodson et al., 2009; Martinez et al., 2015; Mondisa & McComb, 2015; Montgomery, 2018c; Smith et al., 2014; Thomas et al., 2015; Varkey et al. 2012). These mentoring groups can support recognized communal goals for underrepresented African American and Native American students in STEMM and beyond (Dodson et al., 2009; Smith et al., 2014), and women in STEMM (Thomas et al., 2015; Varkey et al. 2012). Additionally, collective mentoring in affinity groups, in particular, can result in political guidance that disrupts negative impacts of existing in historically white spaces (Allen & Joseph, 2018; Montgomery et al., 2014) and traditionally male spaces (Thomas et al., 2015), as well as leading to advocacy (Montgomery, 2018c; Thomas et al., 2015).

Network-based mentoring. Mentoring networks, or the assemblage of a constellation of mentors or set of mentoring relationships, have gained increasing support and recognition (Higgins & Kram, 2001; Long et al., 2014; Sorcinelli & Yun, 2007; van Emmerik, 2004). Mentoring networks can result in “non-hierarchical, relational and reciprocal mentoring” (Yun et al., 2016, p. 449). Networks can serve as critical for the provision of support, affirmative spaces and accountability. One means of ensuring equitable access to mentoring networks requires efforts and accountability on the part of institutional leaders in transitioning from solely promoting top-down mentoring to supporting mentoring centered on individual aspirations and needs, which can be effectively accomplished through construction and engagement of mentoring networks (Beach et al., 2016, p. 69; Ko et al., 2014; Lloyd-Jones, 2014; Montgomery, 2018b; Turner et al., 2011; Whittaker et al., 2015).

Recent assessment of the Mutual Mentoring model, which is a “flexible, network-based model of support” including “multiple mentors who provide support in their respective area(s) of expertise” (p. 443), indicates that such engagement leads to mutually beneficial mentoring exchanges and career-enhancing outcomes (Yun et al., 2016). Additionally, longitudinal studies indicate increased long-term outcomes based on engagement with mentoring networks, as opposed to short-term goals being effectively supported in traditional hierarchical dyads (Higgins & Thomas, 2001). Recently, specific tools to promote the building and cultivating of mentoring networks intentionally, rather than learning through retrospective analyses or sense-making of established networks, are emerging (Montgomery, 2017). The formal inclusion of a network-based or multiple mentor-based framework into STEMM programs may have challenges in terms of coordinating accountability or other aspects of mentoring. However, analysis of a multiple mentor doctoral program between NIH and universities indicated benefits to the mentees that included fostering independence and development of more complex scientific and collaboration skills (McGee & DeLong, 2007). Though empirical studies on the formal inclusion of such models are limited, these outcomes suggest significant potential for supporting success in STEMM.

Nested mentoring or hybrid multi-mentoring models. Nested mentoring is neither hierarchical nor peer mentoring. This is an emerging approach best described as a “partnership model” (Fouché and Lunt, 2010, p. 398). Additionally, nested mentoring has been described as “fluid rather than hierarchical” with individuals being mentored having “access to a team of mentors” (Portillo, 2015). The nested mentoring model includes a community of individuals such as academic mentors, peer mentors, and practitioners, all of whom are involved in a networked mentoring partnership comprised of “collegial relationships of mutual benefit” (Fouché and Lunt, 2010, p. 400). Nested mentoring configurations are “not premised on a single matched pair or dyad” (Fouché and Lunt, 2010, p. 400); thus, in practice such a mentoring model has parallels to group- or network-based approaches. Additionally, nested mentoring has potential to build a dense set of mentoring relationships that can serve to provide “a counter to any potential power imbalances that may arise” in dyadic interactions (Fouché and Lunt, 2010, p. 400).

The concept of nested mentoring, in particular, has merit for interdisciplinary training and mentoring networks. One nested model was described as support that “builds off of a “see, hear, do” approach, [thereby] exposing students to research” (Portillo, 2015). If such a model is used with interdisciplinary teams of participants, the individuals not only develop skills for building their own research plans, but also can engage in collaborative and innovative engagement in a structured, mentored research innovation and team-building format. Used effectively, nested mentoring configurations can provide a model for supporting individuals in the establishment of research questions and programs, which also includes participants serving as mentors cultivating their own mentoring skills to support robust research management. That is, the nested mentoring model can cultivate individual mentoring skills through structured and reflective mentoring in a defined process. Indeed, the “process of reworking [mentoring relationships or exchanges] continue throughout the life of [mentoring] relationships as the networks develop” (Fouché and Lunt, 2010, p. 398). Initial outcomes of effective nested mentoring based on analysis of its use in practitioner-based groups indicate expected gains in career advancement, in addition to increased mutual understanding of individual roles and contributions. Additionally, participants exhibited increased research capabilities and reported collegial engagement with mutual benefits (Fouché and Lunt, 2010).

A community of practice-based model, The Academy for Future Science Faculty, was designed to support the cultivation of science identity and provide coaching for career success. The approach includes research mentors, intentionally trained coaches to engage some of the limitations of traditional mentoring such as career preparation, as well as group-based learning and engagement, including peer support and mentoring (Thakore, Naffziger-Hirsch, Richardson, Williams, & McGee, 2014). This career-coaching intervention was designed to build connections between individual coaching groups and larger groups – thus, it has parallels to nested mentoring models. The relationship with coaches supported mentees in learning about careers in ways that students reported they did not in their relationship with their research mentor (Williams, Thakore, & McGee, 2016a). In some cases, the coaches were able to provide identity-matched coaching and input to URM students who did not have access to such mentors in their academic environments (Williams et al., 2016a). The career coach complementation to traditional dyadic mentoring promoted persistence towards academic careers (Williams, Thakore, & McGee, 2016b).

Critical considerations beyond specific models

Culturally-relevant mentoring. It is critical that mentors engage culturally relevant practices in the process of providing mentoring and support to increase access, persistence and success of individuals broadly from diverse populations (Ireland et al., 2018; Kelly & McCann, 2014; Montgomery, 2017). Such approaches are particularly critical in cross-cultural mentoring, which “involves an ongoing, intentional, and mutually enriching relationship with someone of a different race, gender, ethnicity, religion, cultural background, socioeconomic background, sexual orientation, or nationality” (Crutcher, 2014). Culturally-relevant mentoring approaches must include a focus on campus and societal climates, as well as on mitigating environmental or virtual barriers to be broadly successful (Kelly & McCann, 2014; Montgomery, 2018b; Rasheem et al., 2018; Whittaker et al., 2015). For effective culturally-relevant mentoring, “mentors must maintain a dual perspective, seeing the mentee as an individual, as well as part of a larger social context” (Crutcher, 2014). Cross-cultural mentoring is, thus, critical for all individuals to have access to support and mentoring in environments where some continue to be vastly underrepresented, especially in the ranks from which mentors are likely to be drawn. Additionally, cross-cultural mentoring allows the expansion beyond “narrow training” available in many environments (Crutcher, 2014). At its core, culturally-relevant mentoring allows “mentoring researchers and practitioners...to better understand that problems facing marginalized and minoritized [mentees] are rooted in pervasive, systemic, and institutional inequity” and offers these mentors opportunities to “align those understandings with key components of mentoring processes” (Weiston-Serdan, 2017, p. 14).

Context-based mentoring. Effective mentoring also serves to counteract some of the negative outcomes of isolation or low structural representation in particular contexts, one of which is a limited opportunity for access to heuristic knowledge, accessible resources, and opportunities that could support personal and professional advancement (Montgomery, 2018a; Turner et al., 2011; Williams & Williams, 2006). When one focuses on the environment and individuals’ access, or lack thereof, to needed support and resources, as described by Torie Weiston-Serdan (2017), “mentoring becomes much more about interrogating context and acting based on a critical analysis of that context, rather than an immobile relationship reinforced by hierarchy and saviorism” (pp. 1-2). Moving away from immotility in mentoring exchanges is also promoted by disengaging from fixed mindset perspectives and transitioning to growth-promoting mentoring, as well as actively supporting individuals’ self-defined professional visions rather than acculturative mentoring (Montgomery, 2018a, 2018b). This idea of supporting growth of individuals may be most effectively supported over the long-term through moving beyond dyads alone towards supporting a network of mentors (Higgins & Kram, 2001; Montgomery, 2017; Rockquemore, 2013; Sorcinelli & Yun, 2007). Recognizing the need for systemic change in the system related to mentoring and addressing institutional inequities head on also are critical to allow mentoring to work well and broadly for a diverse range of individuals (Montgomery, 2018a, 2018b; Weiston-Serdan, 2017, p. 14).

Core Needs of Mentee and Mentor for Effective Mentoring

Mentor-mentee relationships are often defined by hierarchies that align with, and which are frequently driven by, institutionally-defined paths to success (Lewis & Olshansky, 2016;

Montgomery, 2018b; Yun & Sorcinelli, 2009; Yun et al., 2016). These institutionally-aligned relationships do not necessarily fit into the various mentoring models we have discussed here. Yet, the models discussed here and others call for focusing on mentee needs and aspirations in mentoring (Rockquemore, 2013; Montgomery, 2018a, 2018b) in order to support individual success while simultaneously contributing to attainment of institutionally-defined milestones and achievements. For the purposes of continued discussion, we explore the mentor and mentee roles based on assigned needs of each position in an effective mentoring exchange. We then discuss specific examples of mentoring opportunities, how assigned needs are met within each setting, and the specific models represented.

Shared needs. While there are undoubtedly more than two shared needs, mentoring beyond traditional dyads and hierarchies requires exploring two shared needs in a different light – expectations and trust (Figure 2A). Whether they are outwardly discussed or an implied understanding, expectations provide a basis for a mentoring relationship to occur (Brace et al., 2018; Cunningham, 1993; Grant, 2015; Montgomery, 2017; Washington & Cox, 2016). Communication of expectations is often the point at which a mentoring contract or agreement is entered. However, and more often than not, explicit conversations about expectations do not occur. An understood mentoring contract is often employed and relies on participating individuals having reasonable expectations and those expectations becoming known as the mentoring relationships are explored. Those occupying the mentor role cannot be the sole determinants of expectations (Byars-Winston et al., 2015; Grant, 2005; Greco, 2014; Montgomery, 2017; Montgomery et al., 2014; Washington & Cox, 2016). Regardless of the mentoring model being explored, moving beyond traditional hierarchies requires giving all parties the space to communicate expectations and require accountability.

In any agreement that relies on revelation and exposure, trust is a core need of participating individuals. Mentoring models that align with institutionally-defined paths to success often grant those in the mentor role with an implied trust. By virtue of attaining a certain level of success, it is assumed that this individual can be trusted. It is important to point out that this assertion can further pronounce differentials in power and access. Neither the mentor nor mentee role should dictate whether or not someone is trusted – one should be able to assume that some level of trust is present at the moment a mentoring contract is entered into along with the expectation that the trust will be actively cultivated and will not be violated. Effective mentoring relationships need to be built on and actively cultivate bilateral trust as well as mutual accountability and responsibility (Greco, 2014; Hund et al., in press; Johnson-Bailey & Cervero, 2004; McGee et al., 2015; Montgomery, 2017).

Mentee needs. Here we discuss five broad categories of needs of individuals occupying a mentee role. These categories were determined after extensive conversations with individuals, review of literature, and our own anecdotal experiences. By no means do we assert that these categories are exhaustive; yet, they are consistent themes that arise in our investigation of mentoring models. The broad categories are personalization, guidance, correction, affirmation, and agency (Figure 2B). Many of these categories and their importance to particular mentees may also vary across the trajectory of an academic career, including as mentees transition from initial engagement to more advanced stages characterized by increased competency, identity, autonomy and efficacy (Montgomery et al., 2014; Ramirez, 2012).

Personalization integrates the identity of the mentee into the interaction. It is what is sometimes alluded to, in part, in discussions of mentoring the ‘whole’ person. In personalized mentoring, there is a recognition of who the mentee is beyond the titling or positioning of graduate student, postdoctoral scholar, assistant professor, etc. Often, this is where people differentiate between a mentoring relationship and a transactional or advising relationship (Baker & Griffin, 2010; Kirchmeyer, 2005; Montgomery, 2017; Montgomery et al., 2014; Ramirez, 2012). A transaction is determined by institutionally-defined paths of success and there is often a fixed term for the transaction. An example of a transactional relationship can be a group consisting of a graduation student, a research advisor, and a dissertation committee that only functions to meet graduate program requirements and exists only until the student graduates. A mentoring relationship may consider additional information about the mentee. For example, if the mentee is a URM scientist, the group may encourage and support attendance at identity-based conferences, participation as an advisor for a URM summer research student, or integration of URM identity into specific research questions. Personalization recognizes that the mentee is the expert on their lived experiences and values that expertise as a cornerstone of an effective mentoring relationship. When the need for personalization is met, this also gives the mentoring relationship space to evolve and extend beyond the terms established by an institutional program.

There has been increasing focus on personalization and strategic mentee self-assessment using an individual development plan (IDP; Clifford, 2002; Vincent et al., 2015). IDPs are particularly relevant to personalization as they are designed to “develop an ‘individualized’ career and professional development plan based on one’s unique skills, interests, and values” (Hobin et al., 2014, p 51). The use of IDPs supports structured bilateral engagement and personalization in the mentoring exchange (Hobin et al., 2014; Vincent et al., 2015). Assessments of the use of IDPs indicate utility in facilitating skills identification and development of abilities needed to support career success (Hobin et al., 2014). Given that the use of IDPs is correlated with greater reports of satisfaction and scientific productivity on the part of postdoctoral scientists (Davis, 2009), their expanded use in training programs is expected to be beneficial for a broad range of students and postdoctoral scientists (Fuhrmann, 2016).

Guidance builds on the theme of personalization. Across different mentoring models, the understanding is that the existence of the mentoring relationship involves individuals needing guidance. Guidance is different from instruction. The former does not encompass a mentee being told what to do, rather they are engaged in a process on how to best navigate their paths. Whereas in STEMM, there may be a need for instruction in basic methods and scientific experimentation, in other areas related to STEMM mentoring such as career pathways, guidance rather than instruction should be considered (Gibbs & Griffin, 2013). Guidance ideally considers the identity of the mentee, including the distinct cultural capital or obstacles that may arise for URM mentees because of their identity (Griffin et al., 2015).

Correction gives mentees insight into opportunities for improvement. Where specific correction is extended, it must be constructive and address factors that are within the control of the mentee. An effective mentoring relationship requires an assessment of strengths and of areas of growth (Montgomery, 2017, 2018; Montgomery et al., 2014). Correction can also take into account giving thoughtful advice on whether a desired career path may require work in certain areas or whether considering alternate career paths may benefit the mentee. There is an understanding that the mentee does not benefit from passive mentoring practices.

Due to the imposed consequences of underrepresentation, *affirmation* can be particularly valuable for URM mentees. Affirmation can include recognition of strengths and abilities, taking

time to highlight successes, and showing the mentee that they belong in their chosen path. The latter may be accomplished through intentional connections of the mentee with roles models with shared identity. Affirmation can also involve helping a mentee define their own boundaries when it comes to assimilation and the treatment they accept in professional environments. This relies on an understanding that there is an inherent value in the individual that is not contingent on their placement and level of power.

Agency builds on affirmation and recognizes that the mentee is responsible for helming their ship. Empowering the mentee to own their path can be considered a break from traditional hierarchies. Particularly for mentoring models that are network or group based, the mentee needs to take responsibility for having their needs met (Montgomery, 2018c). When mentors recognize and affirm the agency of mentees, the resulting confidence and assertiveness ultimately benefits the mentoring relationship.

Mentor needs. Often the scope of traditional mentoring relationship hierarchies leaves little room for consideration of the needs of the mentor. Where hierarchies may impose a power differential, they may not necessarily encourage reciprocity and bilateral engagement. The mentality that the mentee is the only benefactor in a mentoring relationship can limit the benefit received by all involved individuals. There are undoubtedly bidirectional, and often unexpected, benefits to mentors (Chesler & Chesler, 2002; Lechuga, 2011; McKinsey, 2016; Montgomery, 2017; Varkey et al., 2012). Recognized benefits of mentoring are both practical and intrinsic. One practical benefit is that the careers of mentors are enriched by their participation in mentoring and providing development support to others (Bozionelos, 2004). Some noted intrinsic benefits of mentoring are related to mentor aptitude and motivation (Rogers et al., 2016).

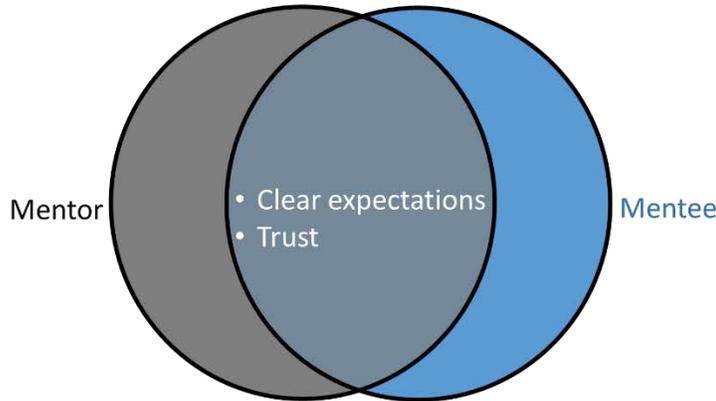
Here, we discuss five broad categories of needs of individuals occupying a mentor role. As with *mentee* needs, these categories were determined after extensive conversations with individuals, review of certain literature, and our own anecdotal experiences. Again, we do not assert that these categories are exhaustive; however, they emerge from our investigation of mentoring models. The broad categories are space to grow, openness, active participation, value, and correction (Figure 2C).

Mentoring models that facilitate *space to grow* for mentors meet a specific and often overlooked need (Montgomery, 2018a). Being more experienced in an area of interest, particularly a research focus, does not render a mentor static or stalwart, nor necessarily a good supporter of someone with overlapping interests. Mentoring relationships include individuals who are navigating various stages on their paths to success, and mentors need be facile guides that can adapt mentoring to different stages of the academic path. Mentoring models can address this in many ways. The open triad, for example, builds in an additional mentor to support growth of the research mentor. Models in which participants simultaneously occupy mentor and mentee roles (e.g. network-based and collective mentoring, as well as nested mentoring), are often highly considerate of this particular need. These models allow specific growth of mentors and can address a need for mentors to grow in experience of supporting mentees to avoid negative perceptions of the mentoring relationship (Burk & Eby, 2010).

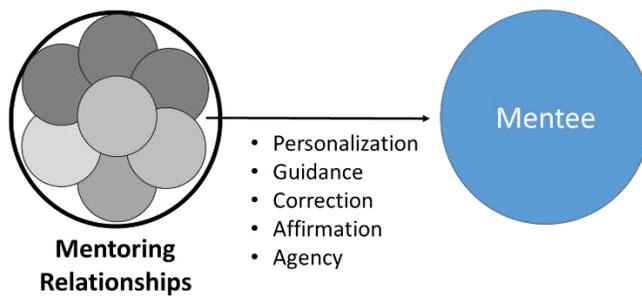
Openness can be difficult to navigate while being a necessity. Mentoring models rely on the mentee giving mentors the information required to guide the mentee. An effective mentoring model needs some type of goal or vision to pursue. Depending on the model being employed and the setting, openness can mean sharing career goals and personal vision. In other cases, a greater

degree of openness may be warranted. Regardless, the mentor needs information from the mentee in order to help and guide the mentee.

A Shared needs of mentees and mentors



B Core needs of mentees



C Core needs of mentors

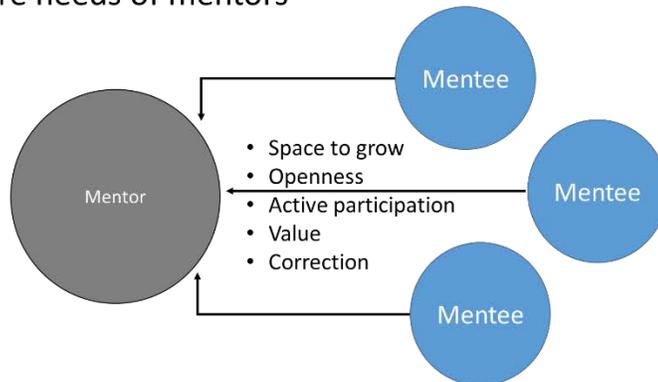


Figure 2. Core needs of mentee and mentor for effective mentoring. In mentoring relationships there are (A) shared needs of mentees and mentors; (B) core needs of mentees, including personalization, guidance, correction, affirmation, and agency; and (C) core needs of mentors, including space to grow, openness, active participation, value, and correction.

Active participation on behalf of the mentee can make or break a mentoring relationship. Moving beyond classical hierarchies often means that the mentee cannot rely on the mentor to

keep the mentoring relationship afloat. This can be particularly important with models that are executed in social media settings where there is not a designated physical location for engagement. Active participation includes the mentee taking an active partnership role in the relationship, engaging in bilateral communication, communicating needs, and updating the mentor on specific guidance that the mentee has used. Such active participation, or responsibility and accountability, on the part of the mentee for advancing objectives of a mentoring relationship has been referred to as “mentoring up” (Lee, McGee, Pfund, & Branchaw, 2015).

Though it can be mistaken as a superficial need on the part of the mentor, *value* can be an important factor in any mentoring contract. Value implies an understanding of the expertise, time, and energy that a mentor is contributing to a mentoring relationship (Montgomery, 2017). Nested mentoring models may serve this need well, as often the partnerships form out of an awareness of the value all parties bring to the table. Value as a need can be more profound for URM mentors – they tend to be overextended and underserved. Often URM mentors are highly sought after by potential mentees regardless of whether there is overlap in disciplines and career trajectories. URM mentors are also less likely to be valued at their respective institutional settings, making it even more important to communicate value toward them.

Correction directed toward those occupying the mentor role can be very distinct from that directed toward mentees. Despite moving beyond classical hierarchies, approaching a mentor with an evaluation of that mentor’s approach to mentoring can be difficult (Burk & Eby, 2010). However, it is important to keep in mind that effective mentoring relationships rely on meeting the difficult needs. Mentees should be receptive to addressing missteps in ways that grant the mentor much needed space to learn. For example, a mentoring group may consist of women of color who occupy different roles and URM distinctions. For example, members of the group may offer advice to a neurodivergent member that does not consider her needs in addition to being a woman of color. Those members need to be constructively corrected so that they can better guide this individual and others who share her neurodivergent status. Correction takes into account the expertise of the mentor(s) while recognizing that they are not omniscient. In addition to correction between those individuals involved in the mentoring exchange, evidence-based training of mentors is also an increasingly valued avenue for improving mentor effectiveness. Among methods having strong support for training of mentors are community of practices approaches to mentoring (Brace et al., 2018) and the Entering Mentoring curriculum that is associated with improved mentoring outcomes (Byars-Winston et al. 2015; Pfund et al. 2006, 2014, 2015).

Mentoring models and meeting needs in practice

Applications of mentoring models outside of institutional settings represents an area of interest that we believe warrants greater discussion and study. Often, the organizations and individuals who build and maintain this type of programming were charged with filling a need(s) in a way that preceded structured, rigorous study. We highlight these efforts, not only for discussion of critical aspects of mentoring models, but to also provide various examples of execution along with suggestions for future areas of study on effective mentoring models and systems.

Here we discuss mentoring models, many of which are emergent, that are based on two broad groups: URM-status encoded and nonencoded. URM-status encoded models are executed at conferences and within communities that are tailored to populations of STEMM students and professionals who are URM in their respective career disciplines. Often URM-status encoded events, organizations, or institutions make the critical considerations that are important beyond

specific models and that were outlined previously, i.e., supporting culturally-relevant and context-based mentoring. This is largely tied to cultural competence and contexts being interwoven into the mission and practice of such organizations, groups, or settings. In addition to highlighting mentoring models in practice in URM-status encoded settings, we present an example of a nonencoded setting where culturally-relevant and context-based mentoring are integrated into the mentoring model in practice.

We discuss two examples of digital-based mentoring models. Models such as these often empower mentees to identify mentors outside of the networks of their institutional advisors (Montgomery, 2018c). This can be beneficial to URM trainees whose success necessitates moving away from traditional hierarchical paths of networking and mentoring. The adaptability of digital spaces including social media can allow for innovative approaches to facilitating various mentoring models.

#BLACKandSTEM. Twitter offers a level of connectivity that has made it a mainstay in the lives of many STEM professionals. Twitter provides an opportunity for users to connect with people who may live hundreds of miles away and/or who work different schedules with varying workloads, but who ultimately share common lived experiences and career trajectories. Started in 2014 by co-author Stephani Page, #BLACKandSTEM is one Twitter community that is considered a model of the many benefits of using Twitter as a professional resource (Montgomery, 2018c). The Twitter account has over 8,700 followers (as of 11.13.18) and represents a range of STEM professionals, students, and teachers. Featuring Black individuals connected to STEM, the community grew largely out of a willingness of individuals to occupy the mentor and mentee roles on a regular basis, often simultaneously. Often, resources are offered ranging from assistance in professional writing (such as personal statements and grant proposals) to guidance in selecting job positions.

Group-based or collective mentoring. A hallmark of the #BLACKandSTEM community is that its development can be attributed to simultaneous occupation of mentor and mentee roles such that a community evolved to reciprocally serve the advancement of Black STEM students and professionals. This outcome parallels the finding that mentors can advance as they support mentees (Bozionelos, 2004). Because identity and affinity are core to the mission of #BLACKandSTEM, there is targeted attention given to addressing the imposed consequences of being Black in STEM fields. Also, certain features of the #BLACKandSTEM community can result in short-term, though valuable, mentoring engagements. Specific examples include two consecutive Twitter chats (moderated online discussions that occur on a specific day) during which members discussed, supported, and provided guidance on navigating STEM career paths in environments where they are the only or one of few persons who share their immutable identity. Several resources for advocacy and activism were shared during the chats and people were empowered to work to disrupt the negative impacts of existing in predominantly white spaces. The networked-basis of #BLACKandSTEM and other similar platforms built and cultivated using digital platforms may be explored for long-term benefits using social network analysis of researcher or stakeholder engagement as a means to explore and validate their utility for community building and impacts on participant success (Montgomery, 2018c; Robinson-Garcia et al., 2018).

Network-based mentoring. Mentoring engagements can be ongoing and lead to long-term mentoring networks, as is also the case with the #BLACKandSTEM community. A core constellation of individuals, again, serving simultaneously as mentee and mentor have led to the

persistence of the community for almost five years. In turn, #BLACKandSTEM has assembled a network that expands as new people join who account for a range of STEMM career trajectories and professional hierarchical positions. As a result, for example, #BLACKandSTEM has a strong representation of Black academics who have navigated the path from graduate student to tenured professor at major universities. Those professors are now using #BLACKandSTEM to identify and recruit students and staff for their own labs. The hallmark of having multiple mentors has helped people successfully traverse arduous paths to an extent that they are able to give back to the community.

Mentor and mentee needs. For mentoring settings like the #BLACKandSTEM community, the impacts on self-definition and self-valuation can be profound and especially critical for URM individuals in STEMM (Collins, 1986; Ireland et al., 2018). For individuals who are typically relegated to inferior positions in their professional relationships, such communities can help them experience a sense of affirmation and agency. Taking this confidence back to their respective institutions can impact their ability to thrive, leading to increased academic success even in communities where local structural diversity remains low (Montgomery, 2018c). #BLACKandSTEM exists as a community as a result of the dedication to openness and compassionate correction that supports the advancement of its members.

VanguardSTEM Conversations. This community extends its digital footprint beyond Twitter. Featuring monthly live-streaming conversations, VanguardSTEM was started in 2015 by astrophysicist Jedidah Isler. VanguardSTEM is now the signature program of the non-profit STEM en Route to Change Foundation, Inc. (SeRCH) which seeks to advocate for all people of color, gender non-conforming individuals, and other marginalized populations in STEMM. Each Wednesday, a woman or non-binary person of color in STEMM is featured through the Twitter page and blog site. Additionally, VanguardSTEM has embarked in 2018 on providing onsite mentoring at URM-status encoded conferences, including annual conference of the Society for Advancing Chicanos/Hispanics and Native Americans in Science (SACNAS) and the National Society of Black Physicists (NSBP). The effectiveness of such mentoring moments has recently begun to be explored (Grant, 2015; Montgomery, 2017)

Group-based or collective mentoring. VanguardSTEM thrives as a conduit for marginalized populations in STEMM to coalesce around many topics. Episodes of the live stream have included timely topics such as the lack of support in STEMM spaces and the grassroots recovery efforts after 2017's Hurricane Maria. Not only were the conversations contextualized for members of the STEMM community who are from and who have loved ones in Puerto Rico and the US Virgin Islands, it also served to share what the devastation has meant for the careers of individuals whose research was housed on the islands. Featured guests were able to offer guidance to viewers who were touched by the catastrophe, particularly how to continue in their career paths in the face of major setbacks. The mentoring that was facilitated spoke specifically to the people who felt invisible in their daily lives as parts of the world moved on from and even ignored their plight. Programming that extended opportunities for displaced investigators to find mentored research programs on the mainland were introduced during and sprung from this conversation.

Mentor and mentee needs. In the example of the Post-hurricane Recovery episode, the individual guests continued to make themselves available to individuals impacted by Hurricane Maria. Mentees who had lost family and labs were shown that they and their work are valued by the STEMM community. Involvement in key mentoring initiatives such as this are powerful ways to combat the social isolation and 'invisibility' that can significantly impact academic outcomes

(Charleston, Adserias, Lang, & Jackson, 2014; Settles et al., in press; Thomas & Hollenshead, 2001). Participants and mentees were extended the safe space to experience their emotions, regroup, and rebuild – often learning of new spaces and reframing how they mentor others. Mentees who experienced profound vulnerability were met with guidance that was considerate of their unique circumstance, which further affirmed their place in their various STEM fields.

DiverseScholar. In 2004, Alberto Roca hosted the inaugural Minority Postdoc Summit during the 31st annual meeting of the SACNAS. In the following years, Roca founded and became CEO of MinorityPostdoc, a nonprofit aimed at providing tangible support and resources for URM postdoctoral scholars. In 2017, Roca convened the 1st annual DiverseScholar conference as an intensive professional development program for URM postdoctoral scholars. Targeted content is aimed at helping postdoctoral scholars prepare for their next career steps and includes workshops and hands-on training on CV preparation, oral presentations, leading a lab, and following through with getting your first academic faculty position. Training is helmed by individuals who recruit and/or serve on faculty search committees. Thus, the mentoring provided is directly linked to potential positive career outcomes, as described for a career coaching mentoring model (Williams et al., 2016b). Each year Bill Lindstaedt, co-author of ScienceCareers MyIDP (along with several other publications on preparing for and gaining faculty positions), gives directed guidance to the group of postdoctoral scholars who are present.

Nested mentoring. Though this conference facilitates other mentoring models, it is an excellent example of nested mentoring. The effectiveness of the meeting lies heavily in the outcomes of career advancement of postdoctoral scholars in attendance. Nearly all of the scholars who attended the 2017 meeting, and who were entering the faculty search cycle of 2017, now have faculty positions. Longer-term longitudinal analyses would strengthen the view of the efficacy of engagement based on these early outcomes. The initial success appears to be attributed to several features including access to resources and mentoring that are often withheld from or unavailable to URM postdoctoral scholars in their institutions. Beyond mentoring along the lines of professional hierarchies, peer mentoring is also a hallmark of DiverseScholars – postdoctoral scholars who have been successful in receiving K99/R00 awards, for example, share their tips and experiences in completing successful grant proposals. Such interventions are highly critical given the persistent disproportionately lower rates of success in obtaining funding for URM applicants, especially Black women, in STEM (Ginther et al., 2011; Ginther, Kahn, & Schaffer, 2016). The environment is highly interdisciplinary with representation of fields ranging from anthropology to biophysics with at least one common goal – to increase faculty diversity at US institutions while empowering scholars to thrive.

Mentor and mentee needs. Within the nested mentoring model, it is important to keep in mind the idea of mutual benefit. Successful models in the context of professional development meetings rely on demonstrable outcomes such as postdoctoral scholars attaining professorships. This outcome naturally supports future proposals for funding of DiverseScholar (which includes full travel support for a select number of scholars for which there is a need), expansion of the number of universities participating, utilization of other products made available by DiverseScholar, and overall association of value to the programming model itself. Settings such as the DiverseScholar meeting require personalization, guidance, and correction toward the mentees in order for them to develop a competitive application packet that speaks to their unique skills and vision. Mentors require active participation on the part of mentees in order to best support the efforts of the mentee.

PROMISE Summer Success Institute. For over 15 years, the University System of Maryland has hosted the PROMISE Summer Success Institute (SSI) helmed by Renetta Tull. The meeting was initially a professional development program for participants of the NSF funded Maryland PROMISE: Alliance for Graduate Education and the Professoriate (AGEP), which serves to increase the number of domestic STEM doctorates with particular focus on URM groups. The meeting has now grown to include career development and mentoring for professionals and postdoctoral scholars.

Closed triad. As with *DiverseScholar*, SSI facilitates group-based and nested mentoring models. However, what is of particular interest is its representation of the closed triad mentoring model that is not dictated by an institutional setting. Due to the length of time that the SSI has been in existence, several individuals who attend are a part of academic lineages anchored by URM senior mentors. The nature of the environment allows for all tiers of a lineage-based triad to interact and form mentoring relationships, both those mentoring moments happening in the setting of the meeting (Montgomery, 2017) and longer-term, ongoing mentoring. One recent addition to the programming for SSI intentionally includes forming triads with table-mates, sharing goals, and holding each other accountable for reaching those goals. Evidence of the impact of the closed triads is the growth in the number of returning participants year-by-year such that there was a need to expand programming to encompass later career stages. Analyses of the outcomes have indicated that participants gain meaningful suggestions for professional advancement and input into solutions related to meaningful career planning and life balance, among other benefits (Tull et al., 2017).

Mentor and mentee needs. Affirmation and value are consistent underlying themes of each annual SSI meeting. Additionally, the range of mentoring activities support a sense of belonging and promote the building of cultural wealth associated with academic success (Tull et al., 2017). Two cornerstones of the programming include recognizing the achievements of scholars. The Circle of Doctorates and Embracing the “Pact” activities include a call for all attendees with Doctorates to form a circle around the room. They are instructed to share their current position, and recent graduates are applauded. In addition, those with doctorates make a pact to support each other and those coming after them in successfully navigating their desired career paths. Later in the program, there is a ceremony to recognize those who have reached candidacy in their doctoral programs. Their accomplishments are affirmed and applauded. Throughout the meeting, there are opportunities for more informal mentoring, often following the group-based model wherein mentees are able to receive additional guidance from the network of mentors in attendance.

URM-status encoded settings provide a basis to discuss the various non-dyadic mentoring models because those settings tend to be structured toward facilitating effective, mutually beneficial mentoring engagement with the added consideration of cultural-relevance and contexts in terms of mentees. Despite significant need, there are few settings that are non-encoded in which STEM professionals of URM status experience high levels of belonging and benefit. We discuss one example here, a burgeoning program from the American Heart Association (AHA).

AHA Research Leaders Academy. In 2018, AHA Ivor Benjamin and Svati Shah co-chaired the 3rd annual Research Leaders Academy (RLA) with the goal of making the AHA program the standard for inclusive, effective training and mentoring for the best and brightest in cardiovascular research and advocacy. The 2018 meeting marked a large step toward holistic and humanistic approaches

to training the research leaders charged with changing the tides of one of the deadliest categories of disease in the US and worldwide. Programming included engagement with survivors, basic and clinical research training, personal development, workshops on starting and running a lab, among others.

Group-based or collective mentoring. Despite the presence of some of the most prolific researchers in the field, the RLA was very successful in facilitating mentoring beyond hierarchies. One way this was achieved was through having some of the most established researchers share personal stories that highlighted how they were mentored by others in navigating their successful careers. The inclusion of such individual stories of advancement and group engagement are critical for demystifying the diversity of paths towards success and can be helpful in combating imposter syndrome and sense of belonging (Clance & Imes, 1978). Seating for meals and plenary talks were intentionally set up to encourage engagement amongst attendees. Nearly every workshop included group activities that fostered empowerment and socialization between trainees, early career investigators, and senior investigators. The co-chairs encouraged attendees to not only share parts of the programming, but to also use Twitter to network and engage with the expansive AHA community.

Mentor and mentee needs. For any mentee in settings such as the AHA RLA, affirmation can have a profound effect – particularly for URM individuals who may rarely experience a sense of value and belonging when in majority spaces filled with remarkable talent. The experience of having senior mentors identify strengths and offer guidance further affirms the mentees. Because there was a clear departure from classical hierarchies, mentees were able to be open about their career goals and actively participate in the mentoring process.

Conclusions

The persisting underrepresentation of specific groups in STEMM relative to national population demographics, with increasing underrepresentation of many URM groups with increasing rank in higher education settings (Whittaker et al., 2015; Montgomery, 2018b), suggests continuing deficits in equitably supporting individuals. Mentoring is critical in contributing to successful outcomes in terms of skills attainment, gaining support and academic or career advancement (Haggard et al., 2011; Jacobi, 1991; Kram, 1985; Packard, 2016). Despite this recognized importance of mentoring in supporting success, some of the prevailing challenges in mentoring include failures in ensuring access to suitable and effective mentoring for a diverse range of individuals entering STEMM fields. Broadening the impact and efficacy of mentoring for the range of individuals in STEMM, including URM individuals, requires the consideration and enactment of mentoring models beyond traditional dyadic models of mentoring associated with maintaining status quo (Darwin 2000; Thomas et al., 2015). Multiple models from triads to collective and group-associated forms of mentoring expand input from a single mentor to multiple mentors or mentoring networks to increase the likelihood of adapting mentoring to the needs of individual mentees. When such approaches additionally are strongly grounded in culturally-responsive framing and highly attuned to context and personal aspirations, significant increases in potential for success are anticipated. Indeed, assessment of current models that are embracing some of these non-dyadic approaches are yielding improved outcomes for mentees, including those from URM individuals in STEMM disciplines.

Literature Cited

- Aikens, M. L., Robertson, M. M., Sadselia, S., Watkins, K., Evans, M., Runyon, C. R., Eby, L. T., & Dolan, E. L. (2017). Race and gender differences in undergraduate research mentoring structures and research outcomes. *CBE Life Science Education, 16*: ar34
- Aikens, M. L., Sadselia, S., Watkins, K., Evans, M., Eby, L. T., & Dolan, E. L. (2016). A social capital perspective on the mentoring of undergraduate life science researchers: An empirical study of undergraduate–postgraduate–faculty triads. *CBE Life Science Education, 15*, ar16.
- Allen, E. L., & Joseph, N. M. (2018). The Sistah Network: Enhancing the educational and social experiences of Black women in the academy. *NAPSA Journal About Women in Higher Education, 11*(2), 151-170.
- Anthony, J. S., & Taylor, E. (2004). Theories and strategies of academic career socialization: improving paths to the professoriate for Black graduate students. In D. H. Wulff & A. E. Austin (Eds.), *Paths to the professoriate: Strategies for enriching the preparation of future faculty* (pp. 92-113). San Francisco, CA: Jossey-Bass.
- Baker, V. L., & Griffin, K. A. (2010). Beyond mentoring and advising: Toward understanding the role of faculty “developers” in student success. *About Campus, 14*(6), 2-8.
- Beach, A. L., Sorcinelli, M. D., Austin, A. E., & Rivard, J. K. (2016). *Faculty development in the age of evidence: Current practices, Future imperatives*. Sterling, VA: Stylus Publishing.
- Bozionelos, N. (2004). Mentoring provided: Relation to mentor’s career success, personality, and mentoring received. *Journal of Vocational Behavior, 64*(1), 24-46.
- Brace, J. L., Baiduc, R. R., Drane, D. L., Flores, L. C., Beitel, G. J., & Lo, S. M. (2018). Design, implementation, and evaluation of a multi-disciplinary professional development program for research mentors. *Mentoring & Tutoring: Partnership in Learning*, doi: 10.1080/13611267.2018.1530101
- 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*, 2533-2554.
- Burk, H. G., & Eby, L. T. (2010). What keeps people in mentoring relationships when bad things happen? A field study from the protégé’s perspective. *Journal of Vocational Behavior, 77*(3), 437-446.
- Charleston, L. J., Adserias, R. P., Lang, N. M., & Jackson, J. F. L. (2014). Intersectionality and STEM: The role of race and gender in the academic pursuits of African American women in STEM. *Journal of Progressive Policy & Practice, 2*(3), 273-293.

- 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, 49-55.
- Clance, P. R., & Imes, S. (1978). The imposter phenomenon in high achieving women: Dynamics and therapeutic intervention. *Psychotherapy Theory, Research and Practice*, 15(3), 1-8.
- Clarke, M. (2004). Reconceptualising mentoring: Reflections by an early career researcher. *Issues in Educational Research*, 14, 121-143.
- Clifford, P. S. (2002). Quality time with your mentor. *The Scientist*, 16(19), 59.
- Collins, P. H. (1986). Learning from the outsider within: The sociological significance of Black feminist thought. *Social Problems*, 33, S14-S32.
- Comer, E. W., Medina, C. K., Negroni, L. K., & Thomas, R. L. (2017) Women faculty of color in a predominantly white institution: A natural support group. *Social Work with Groups*, 40, 148-155.
- Cunningham, J. B. (1993). Facilitating a mentorship programme. *Leadership & Organization Development Journal*, 14(4), 15-20.
- Crutcher, B. N. (2014). Cross-cultural mentoring: A pathway to making excellence inclusive. *Liberal Education*, 100, 26.
- Darwin, A. (2000). Critical reflections on mentoring in work settings. *Adult Education Quarterly*, 50(3), 197-211.
- Davis, G. (2009). Improving the postdoctoral experience: an empirical approach. In R. B. Freeman & D. L. Goroff (Eds.), *Science and Engineering Careers in the United States: An Analysis of Markets and Employment* (pp. 99-127). Chicago, IL: University of Chicago Press.
- de Janasz, S. C., & Sullivan, S. E. (2004). Multiple mentoring in academe: Developing the professorial network. *Journal of Vocational Behavior*, 64, 263-283.
- Driscoll, L. G., Parkes, K. A., Tilley-Lubbs, G. A., Brill, J. M., & Pitts Bannister, V. R. (2009). Navigating the lonely sea: Peer mentoring and collaboration among aspiring women scholars. *Mentoring & Tutoring: Partnership in Learning*, 17, 5-21.
- Dodson, J. E., Montgomery, B. L., & Brown, L. J. (2009). 'Take the Fifth': Mentoring students whose cultural communities were not historically structured into U.S. higher education. *Innovative Higher Education*, 34, 185-199.
- Eby, L. T. (1997). Alternative forms of mentoring in changing organizational environments: A conceptual extension of the mentoring literature. *Journal of Vocational Behavior*, 51, 125-144.

- Emdin, C. (2016). *For white folks who teach in the hood—and the rest of y'all too: Reality pedagogy and urban education*. Boston, MA: Beacon Press.
- Estrada, M., Hernandez, P. R., & Schultz, P. W. (2018). A longitudinal study of how quality mentorship and research experience integrate underrepresented minorities into STEM careers. *CBE—Life Sciences Education*, 17(1), ar9.
- Fuhrmann, C. N. (2016). Enhancing graduate and postdoctoral education to create a sustainable biomedical workforce. *Human Gene Therapy*, 27(11), 871-879.
- Fouché, C., & Lunt, N. (2010). Nested mentoring relationships: Reflections on a practice project for mentoring research capacity amongst social work practitioners. *Journal of Social Work*, 10, 391-406.
- Gibbs, Jr., K. D., & Griffin, K. A. (2013). What do I want to be with my PhD? The roles of personal values and structural dynamics in shaping the career interests of recent biomedical science PhD graduates. *CBE—Life Sciences Education*, 12, 711-723.
- Ginther, D. K., Kahn, S., & Schaffer, W.T. (2016). Gender, race/ethnicity, and National Institutes of Health R01 research awards: Is there evidence of a double bind for women of color? *Academic Medicine*, 91(8), 1098-1107.
- Ginther, D. K., Schaffer, W. T., Schnell, J., Masimore, B., Liu, F., Haak, L. L., & Kington, R. (2011). Race, ethnicity, and NIH research awards. *Science*, 333(6045), 1015-1019.
- Grant, C. S. (2015). Mentoring: Empowering your success. In P. A. Pritchard & C. S. Grant (Eds.), *Success strategies from women in STEM: A portable mentor* (pp. 63-96). Waltham, MA: Elsevier.
- Greco, V. (2014). Establishing an academic laboratory: Mentoring as a business model. *Molecular Biology of the Cell*, 25, 3251-3253.
- Griffin, K. Gibbs Jr, K. D., Bennett, J., Staples, C., & Robinson. T. (2015). “Respect me for my science”: A Bourdieuan analysis of women scientists’ interactions with faculty and socialization into science. *Journal of Women and Minorities in Science and Engineering*, 21 (2), 159-179.
- Haggard, D. L., Dougherty, T. W., Turban, D. B., & Wilbanks, J. E. (2011). Who is a mentor? A review of evolving definitions and implications for research. *Journal of Management*, 37, 280-304.
- Higgins, M. C., & Kram, K. E. (2001). Reconceptualizing mentoring at work: A developmental network perspective. *Academy of Management Review*, 26, 264-288.
- Higgins, M. C., & Thomas, D. A. (2001). Constellations and careers: Toward understanding the effects of multiple developmental relationships. *Journal of Organizational Behavior*, 22, 223-247.

- Hobin, J. A., Clifford, P. S., Dunn, B. M., Rich, S., & Justement, L. B. (2014). Putting PhDs to work: Career planning for today's scientist. *CBE—Life Sciences Education*, 13(1), 49-53.
- Hund, A. K., Churchill, A. C., Faist, A. M., Havrilla, C. A., Love Stowell, S. M., McCreery, H. F., Ng, J., Pinzone, C. A., & Scordato, E. S. C. (in press). Transforming mentorship in STEM by training scientists to be better leaders. *Ecology and Evolution*, doi: 10.1002/ece3.4527.
- Ireland, D. T., Freeman, K. E., Winston-Proctor, C. E., DeLaine, K. D., Lowe, S. M., & Woodson, K. M. (2018). (Un)Hidden figures: A synthesis of research examining the intersectional experiences of Black women and girls in STEM education. *Review of Research in Education*, 42, 226-254.
- Jacobi, M. (1991). Mentoring and undergraduate academic success: A literature review. *Review of Educational Research*, 61, 505-532.
- Johnson-Bailey, J., & Cervero, R. M. (2004). Mentoring in Black and White: The intricacies of cross-cultural mentoring. *Mentoring & Tutoring: Partnership in Learning*, 12(1), 7-21.
- Kelly, B. T., & McCann, K. I. (2014). Women faculty of color: Success stories behind the statistics. *Urban Review*, 46, 681-702.
- Kirchmeyer, C. (2005). The effects of mentoring on academic careers over time: Testing performance and political perspectives. *Human Relations*, 58, 637-660.
- Ko, L. T., Kachchaf, R. R., Hodari, A. K., & Ong, M. (2014). Agency of women of color in physics and astronomy: Strategies for persistence and success. *Journal of Women and Minorities in Science and Engineering*, 20, 171-195.
- Kram, K. E. (1985). *Mentoring at work: Developmental relationships in organizational life*. Glenview, IL: Scott, Foresman.
- Lechuga, V. (2011). Faculty-graduate student mentoring relationships: Mentors' perceived roles and responsibilities. *Higher Education*, 62, 757-771.
- Lee, S. P., McGee, R., Pfund, C., & Branchaw, J. (2015). Mentoring up: learning to manage your mentoring relationships. In G. Wright (Ed.), *The Mentoring Continuum: From Graduate School Through Tenure*. Syracuse: The Graduate School Press of Syracuse University.
- Lewis, C., & Olshansky, E. (2016). Relational-cultural theory as a framework for mentoring in academia: Toward diversity and growth-fostering collaborative scholarly relationships. *Mentoring & Tutoring: Partnership in Learning*, 24, 383-398.
- Lloyd-Jones, B. (2014). African-American women in the professoriate: Addressing social exclusion and scholarly marginalization through mentoring. *Mentoring & Tutoring: Partnership in Learning*, 22, 269-283.

- Long, Z., Buzzanell, P. M., Anderson, L. B., Batra, J. C., Kokini, K., & Wilson, R. F. (2014). Episodic, network, and intersectional perspectives: Taking a communicative stance on mentoring in the workplace. In E. L. Cohen (Ed.), *Communication yearbook 38* (pp. 387-422). New York, NY: Routledge.
- Martinez, M. A., Alsandor, D. J., Cortez, L. J., Welton, A. D., & Chang, A. (2015). We are stronger together: Reflective *testimonies* of female scholars of color in a research and writing collective. *Reflective Practice, 16*, 85-95.
- McGee, R., & DeLong, M. J. (2007). Collaborative co-mentored dissertations spanning institutions: influences on student development. *CBE—Life Sciences Education, 6*(2), 119-131.
- McGee, R., Lee, S., Pfund, C., & Branchaw, J. (2015). Beyond “finding good mentors” to “building and cultivating your mentoring team.” In B. L. Huang (Ed.), *Advancing Postdoc Women Guidebook* (pp. 23-33). Washington, DC: National Postdoctoral Association.
- McKinsey, E. (2016). Faculty mentoring undergraduates: The nature, development, and benefits of mentoring relationships. *Teaching & Learning Inquiry, 4*(1), 1-15.
- Mondisa, J.-L., & McComb, S. A. (2015): Social community: A mechanism to explain the success of STEM minority mentoring programs, *Mentoring & Tutoring: Partnership in Learning, 23*, 149-163.
- Montgomery, B. L. (2017). Mapping a mentoring roadmap and developing a supportive network for strategic career advancement. *SAGE Open, 7*, doi:10.1177/2158244017710288.
- Montgomery, B. L. (2018a). From deficits to possibilities: Mentoring lessons from plants on cultivating individual growth through environmental assessment and optimization. *Public Philosophy Journal, 1*(1), doi:10.25335/M5/PPJ.1.1.
- Montgomery, B. L. (2018b). Pathways to transformation: Institutional innovation for promoting progressive mentoring and advancement in higher education. *Susan Bulkeley Butler Center for Leadership Excellence and ADVANCE Working Paper Series, 1*, 10-18.
- Montgomery, B. L. (2018c). Building and sustaining diverse functioning networks using social media and digital platforms to improve diversity and inclusivity. *Frontiers in Digital Humanities, 5*, 22.
- Montgomery, B. L., Dodson, J. E., & Johnson, S. M. (2014). Guiding the way: Mentoring graduate students and junior faculty for sustainable academic careers. *SAGE Open, 4*, doi:10.1177/2158244014558043.
- Morales, D. X., Grineski, S. E., & Collins, T. W. (2018). Effects of gender concordance in mentoring relationships on summer research experience outcomes for undergraduate students. *Science Education, 2018*, 1-22. doi: 10.1002/sce.21455

- Packard, B. W. (2016). *Successful STEM mentoring initiatives for underrepresented students: A research-based guide for faculty and administrators*. Sterling, VA: Stylus Publishing.
- Pfund, C., House, S. C., Asquith, P., Fleming, M. F., Buhr, K. A., Burnham, E. L., Eichenberger Gilmore, J.M., et al. (2014). Training mentors of clinical and translational research scholars: A randomized controlled trial. *Academic Medicine*, 89(5), 774-782.
- Pfund, C., Pribbenow, C. M., Branchaw, J., Lauffer, S. M., & Handelsman, J. (2006). The merits of training mentors. *Science*, 311(5760), 473-474.
- Pfund, C., Spencer, K. C., Asquith, P., House, S. C., Miller, S., & Sorkness, C. A. (2015). Building national capacity for research mentor training: An evidence-based approach to training the trainers. *CBE-Life Sciences Education*, 14(2), ar24.
- Pololi, L. H., Knight, S. M., Dennis, K., & Frankel, R. M. (2002). Helping medical school faculty realise their dreams: An innovative, collaborative mentoring programme. *Academic Medicine*, 77, 377-384.
- Portillo, Shannon (2015, August 28). Nested Mentoring [Blog post]. Retrieved from <https://www.culjp.com/blog/portillo-nested-mentoring/>
- Ramirez, J. J. (2012). The intentional mentor: Effective mentorship of undergraduate science students. *Journal of Undergraduate Neuroscience Education*, 11(1), A55-A63.
- Rasheem, S., Alleman, A.-S., Mushonga, D., Anderson, D., & Ofahengau Vakalahi, H. F. (2018). Mentor-shape: exploring the mentoring relationships of Black women in doctoral programs. *Mentoring & Tutoring: Partnership in Learning*, 26, 50-69.
- Robinson-Garcia, N., van Leeuwen, T. N., and Ràfols, I. (2018). Using altmetrics for contextualized mapping of societal impact: from hits to networks. *Science and Public Policy*, scy024.
- Rockquemore, K. A. (2013, July 22). A new model of mentoring. *Inside Higher Ed*. Retrieved from <https://www.insidehighered.com/advice/2013/07/22/essay-calling-senior-faculty-embracenew-style-mentoring/>
- Rogers, A., Luksyte, A., & Spitzmueller, C. (2016). Predictors of effective formal mentoring: Is the mentor's commitment all that matters? *Human Performance*, 29(3), 209-225.
- Settles, I. H., Buchanan, N. T., Dotson, K. (in press). Scrutinized but not recognized: (In)visibility and hypervisibility experiences of faculty of color. *Journal of Vocational Behavior*. doi: 10.1016/j.jvb.2018.06.003
- Seymour, E. (1999). The role of socialization in shaping the career-related choices of undergraduate women in science, mathematics, and engineering majors. *Annals of the New York Academy of Sciences*, 869(1), 118-126.

- 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*, 413-429.
- Smith-Doerr, L. (2004). Flexibility and fairness: Effects of the networks form of organization on gender equity in life science careers. *Sociological Perspectives, 47*, 25-54.
- Sorcinelli, M. D., & Yun, J. (2007). From mentor to mentoring networks: Mentoring in the new academy. *Change: The Magazine of Higher Learning, 39*, 58-61.
- Sorcinelli, M. D., & Yun, J. (2009). Thriving in academe: Finding a mentor. *NEA Higher Education Advocate, 26*(5), 5-8.
- Thakore, B. K., Naffziger-Hirsch, M. E., Richardson, J. L., Williams, S. N., & McGee, R. (2014). The Academy for Future Science Faculty: Randomized controlled trial of theory-driven coaching to shape development and diversity of early-career scientists. *BMC Medical Education, 14*(1), 160.
- Thomas, N., Bystydzienski, J., & Desai, A. (2015). Changing institutional culture through peer mentoring of women STEM faculty. *Innovative Higher Education, 40*(2), 143-157.
- Thomas, G., & Hollenshead, C. (2001). Resisting from the margins: The coping strategies of Black women and other women of color faculty members at a research university. *The Journal of Negro Education, 70*, 166-175.
- Tierney, W. G., & Rhoads, R. A. (1993). *Enhancing promotion, tenure, and beyond: Faculty socialization as a cultural process*. ASHE-ERIC Higher Education Report (Report No. 6). Washington, D.C.: Association for the Study of Higher Education.
- Tuitt, F. (2010). Enhancing visibility in graduate education: Black women's perceptions of inclusive pedagogical practices. *International Journal of Teaching & Learning in Higher Education, 22*, 246-257.
- Tull, R. G., Reed, A. M., Felder, P. P, Hester, S., Williams, D. N., Medina, Y., Lo, A., Aparaka, E. T., & Ordonez, P. (2017). Hashtag #ThinkBigDiversity: Social media hacking activities as hybridized mentoring mechanisms for underrepresented minorities in STEM. Paper presented at the 124th ASEE Annual Conference and Exposition, Columbus, OH.
- Turner, C. S. V., González, J. C., & Wong, K. (2011). Faculty women of color: The critical nexus of race and gender. *Journal of Diversity in Higher Education, 4*, 199-211.
- van Emmerick, I. J. H. (2004). The more you can get the better: Mentoring constellations and intrinsic career success. *Career Development International, 9*, 578-594.

- Varkey, P., Jatoi, A., Williams, A., Mayer, A., Ko, M., Files, J., Blair, J., & Hayes, S. (2012). The positive impact of a facilitated peer mentoring program on academic skills of women faculty. *BMC Medical Education*, *12*, Article 14.
- Vincent, B. J., Scholes, C., Staller, M. V., Wunderlich, Z., Estrada, J., Park, J., Bragdon, M. D., Lopez Rivera, F., Biette, K. M., & DePace, A. H. (2015). Yearly planning meetings: individualized development plans aren't just more paperwork. *Molecular Cell*, *58*(5), 718-721.
- Washington, R., & Cox, E. (2016). How an evolution view of workplace mentoring relationships helps avoid negative experiences: The developmental relationship mentoring model in action. *Mentoring & Tutoring: Partnership in Learning*, *24*, 318-340.
- Weiston-Serdan, T. (2017). *Critical mentoring: A Practical guide*. Sterling, VA: Stylus Publishing.
- Whittaker, J. A., Montgomery, B. L., & Martinez Acosta, V. G. (2015). Retention of underrepresented minority faculty: Strategic initiatives for institutional value proposition based on perspectives from a range of academic institutions. *Journal of Undergraduate Neuroscience Education*, *13*, A136-A145.
- Williams, B. N., & Williams, S. (2006). Perceptions of African American male junior faculty on promotion and tenure: Implications for community building and social capital. *Teachers College Record*, *108*, 287-315.
- Williams, S. N., Thakore, B. K., & McGee, R. (2016a). Career coaches as a source of vicarious learning for racial and ethnic minority PhD students in the biomedical sciences: A qualitative study. *PloS One*, *11*(7), e0160038.
- Williams, S.N., Thakore, B.K., McGee, R. (2016b). Coaching to augment mentoring to achieve faculty diversity: A randomized controlled trial. *Academic Medicine*, *91*(8), 1128-1135.
- Wilson, Z. S., Holmes, L., deGravelles, K., Sylvain, M. R., Batiste, L., Johnson, M., McGuire, S. Y., Pang, S. S., & 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*, 148-156.
- Yun, J. H., Baldi, B., & Sorcinelli, M. D. (2016). Mutual mentoring for early-career and underrepresented faculty: Model, research, and practice. *Innovative Higher Education*, *41*, 441-451.
- Yun, J. H., & Sorcinelli, M.D. (2009). When mentoring is the medium: Lessons learned from a faculty development initiative. *To Improve the Academy*, *27*, 365-384.