

PERSPECTIVE

MyNRMN: A national mentoring and networking platform to enhance connectivity and diversity in the biomedical sciences

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ABSTRACT

Aims: Increasing the diversity of the biomedical sciences workforce is a national priority. Having a mentor, and more crucially, a *personal network of mentors*, improves the likelihood that an individual will pursue an advanced degree and career in the biomedical sciences. The chief mission of the National Research Mentoring Network (NRMN) is to reduce racial and ethnic disparities in the biosciences workforce through the mentoring of historically underrepresented individuals.

Methods: To address this need, we created MyNRMN, an online mentoring platform that connects mentors and mentees nationwide. The platform enables multiple forms of mentoring and recommends connections to mentees that will help them build their personal networks.

Results: The MyNRMN online platform has registered more than 13,500 active mentors and mentees across all 50 states and from more than 2100 institutions. Black and Hispanic mentees are highly represented.

Discussion: MyNRMN has expanded opportunities for mentorship in the biomedical sciences, particularly among those not from a culture or institution that historically supports mentorship. The platform's robust search and recommendation capabilities and graph database technology enable members to grow their personal network of mentors.

Conclusion: The MyNRMN online platform has proven successful in connecting mentees and mentors nationwide, expanding the pipeline in biomedical science careers to attract a more diverse workforce.

KEYWORDS

cultural diversity, health workforce, minority groups, online social networking, user-computer interface

1 | INTRODUCTION

Diversifying the biomedical, clinical, behavioral, and social fields is critical for scientific innovation. Mentoring has long been recognized as a major catalyst for skills advancement, personal development, career progression, and professional success.^{1,2} In the biomedical and behavioral sciences, the need for active mentoring networks is acute, especially for those from underrepresented backgrounds, including racial and ethnic minorities, persons with disabilities, women, and individuals from lower educational and socioeconomic backgrounds—all of whom NIH now considers to be underrepresented individuals in the context of careers in the health-related sciences.³ This deficiency in diversity, which extends to postgraduate programs and faculty positions, and which persists even at larger institutions, can only be rectified by increasing opportunities to move more underrepresented individuals up the ladder. Effective mentorship has been linked to persistence in these fields and fosters an environment conducive to learning, retention and career progression.⁴

Face-to-face mentoring, with its consistent, personal contact, helps forge a mentoring bond that invests the mentor in the mentee's growth and career progression, and has thus long been considered the gold standard for best practices in mentoring. Historically, that is before the advent of online platforms and video calling, mentoring in an academic milieu was largely limited to in-person relationships within the academic institution. Constraints on the availability of local mentoring have had the unfortunate effect of disadvantaging those individuals attending smaller institutions with less developed programs or where mentorship is not a well-established part of the institutional culture.

Compounding this picture of imperfect mentorship opportunities is a research demonstrating that a single mentor may be insufficient to achieve desired career outcomes. Rather, successful individuals often obtain mentoring inputs from multiple mentors,⁵ thus forming a *network* of mentoring connections, including peer mentors.⁴ As an individual's goals shift or become more focused during the process of education, training, or first career steps, a network provides more extensive options, allowing the flexibility to move among mentors with different areas of expertise and specializations. Within such a network, mentoring can be "individual-centered"⁶ to serve the personal aspirations of the individual and support their long-term career and professional growth.⁷ This network of mentoring connections is crucial for ensuring that underrepresented students and those in early career stages do not fall through the STEM leaky pipeline.⁸

A major principle of mentoring is that both sides need to benefit. Advantages to the mentee are readily apparent: access to scientific skills and laboratory research, conduits to graduate programs, and pathways to research and academic

appointments. For the mentor, the benefits can also be significant—the process can help further career progression and can lead to the discovery of engaged students or post-docs interested in the mentor's area of work who might apply to the mentor's school or collaborate on research and manuscript writing.⁹ The most salient benefit to mentors, however, may be the most intangible—the opportunity to give back to a new generation of scientists, and the knowledge that the field or discipline has been enriched by one's personal contribution.⁹ Although non-underrepresented mentors may lack a dimension of experience that underrepresented mentors can provide, their service to underrepresented students and junior faculty is still vital and valued, and will ultimately contribute to a more diversified faculty in the future.

The National Research Mentoring Network (NRMN) is an organization funded by the NIH to provide researchers across all career stages in the biomedical, behavioral, clinical, and social sciences with evidence-based mentorship and professional development programming that emphasizes the benefits while addressing the challenges of diversity, inclusivity, and culture.¹⁰ NRMN is part of the Diversity Program Consortium (DPC) funded by NIH to promote diversity and inclusivity in mentoring opportunities and to expand and diversify the biomedical research workforce. The DPC and subsequently NRMN were created as a result of a report by Ginther et al., which called for new resources to increase diversity among NIH awardees.¹¹ Additional details regarding the mission of NRMN as well as the broader diversity initiative will be discussed in a separate publication.

To address the needs of the diverse population seeking NIH grants, the NRMN created MyNRMN (<https://my.nrmn.net/>), a national online mentoring and networking platform that provides online tools to connect NRMN mentors and mentees across the nation. MyNRMN facilitates one-on-one, peer, near-peer, and group mentoring for the NRMN community of over 13,500 mentors and mentees nationwide.

This paper describes the core features of the MyNRMN platform to support the mentoring process, community engagement, and online tools that enable mentees to build their personal network of mentors. We also share network growth and community engagement data to demonstrate the impact of our paradigm-changing platform in expanding mentoring opportunities in the biomedical sciences, especially for underrepresented individuals.

2 | METHODS

The MyNRMN platform, developed by Vanderbilt University Medical Center in 2016, is designed to help mentees and mentors connect professionally, to support ongoing mentoring relationships and communications, and to enable individuals to build a network of meaningful connections.

These connections can range from a brief exchange of inquiries and responses about research or professional development as a scientist to more formal or long-term arrangements. Mentorships can occur across the city or the country, opening up access to peer mentors, early-career investigators, and established faculty in a wide array of fields, in specialized programs, and at large universities, thus offering opportunities to individuals who otherwise would have few if any options. As discussed in the introduction, underrepresented populations are most affected by not having access to a network of mentors within their proximity. MyNRMN is able to bridge this location gap to connect mentees and mentors who would have otherwise never met.

MyNRMN, using robust search, recommendation engine, and social graph database technology, encourages and facilitates mentees taking the necessary steps to establish a mentorship relationship. The narrative below follows a mentee through the phases involved in finding and making connections with mentors in MyNRMN, details the multiple paths for mentorship available in the platform, and describes how engagement and recommendation algorithms can be used to build a personal network of mentoring connections.

2.1 | Finding a Mentor

Finding a suitable mentor can be a daunting prospect for some individuals, especially those whose background or current institution may not value mentorship or incorporate it as an established part of the culture. MyNRMN's *Find a*

Mentor feature (Figure 1) is a step-by-step process designed to make it easy for a mentee to find a potential mentor. First, a mentee performs a keyword search. MyNRMN's sophisticated search mechanism performs a deep, multi-level scan of all records and documents associated with a potential mentor, weighing some fields more heavily than others, to yield a mentoring match that is suitable and thus more productive. Once potential mentors are identified, the mentee builds or uploads a CV or resume. Mentors are more likely to connect when they can view a mentee's background, education, and qualifications. The mentee next prepares to send a message to the potential mentor(s). The "introduction" template verbiage is pre-populated into the message field and is customizable. This template language can be especially helpful to new mentees, often from underrepresented minorities, who do not come from a culture of mentorship and who may feel intimidated by mentors and less confident in initiating a connection request. The final step for the mentee is to review all details of the process, revise as necessary, and then confirm and submit. The mentor being approached for mentorship can accept, or, if not perceiving the match as a good fit, can make a referral to another potential mentor. The steps detailed here were created to mitigate mentee hesitancy and help mentees start broadening their network, despite their level ofrepidation.

In addition to the robust search function to identify mentors, mentees can also find mentors through dashboard recommendations, involvement in My Groups, and asking mentors questions. These methods are described in detail later in the paper.

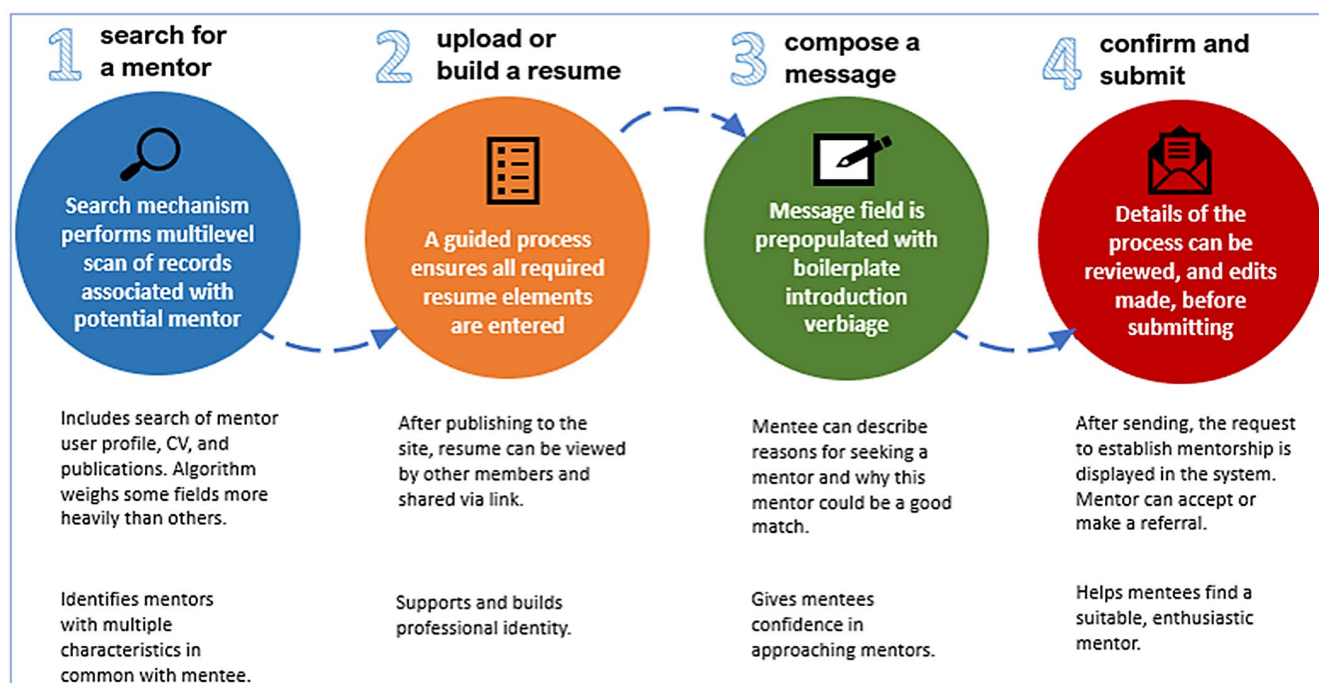


FIGURE 1 Finding a Mentor

2.2 | The Mentoring Process

Mentorship can take many forms, depending on the needs of the mentee, including direct mentoring, group mentoring, and guided virtual mentoring. Importantly, these various mentoring arrangements can take place sequentially or concurrently. For example, a mentee can experience direct mentoring and group mentoring with the same mentor, or pursue mentorship connections on different subjects with multiple mentors. MyNRMN provides a range of features (Table 1) to facilitate the mentorship process, including private and group messaging, video calls, event scheduling, question and answer exchange, and student assessments.

In the direct mentoring format, mentees and mentors can send private messages and questions, share files, and chat via a secure video conferencing feature. Mentors and mentees

each maintain a personal calendar to plan mentorship connections and log events such as office hours, face-to-face meetings, calls, lectures, and seminars.

1. Group mentoring and collaborations.

To support group mentoring and engage the community of mentors and mentees, the My Groups feature allows members to participate in collaborative activities within an area of interest. Members of a group can “Like” and reply to any post within the group, and can use hashtags in the comments section to categorize similar comments within groups. In addition, they can “Star” notable comments to have them displayed to the group more prominently in a starred comments section.

Members can search for and join a group via the global search feature or the *Discover Group* feature, a search feature

TABLE 1 Defined Mentorship Arrangements in MyNRMN

Mentorship Feature	Direct One-on-One Mentoring	Group Mentoring and Collaboration	Guided Virtual Mentoring with MyMentor
Mentor and mentee meet one-on-one	√		√
Meet primarily as a group for collaboration		√	
Video conferencing availability for private, password-secured video call, by invitation	√	√	√
Private messaging and file sharing	√	√	√
Impromptu and scheduled calls	√	√	√
Personal calendar to plan connections, log events, and schedule office hours, face-to-face meetings, calls, lectures, and seminars	√	√	√
Shared calendar where members can schedule activities and events, and assign tasks and due dates to individual members		√	√
Ability to add other participants to activities with email invitations and confirmation of attendance	√	√	
Structured lessons with pre-defined goals broken into discrete tasks			√
Timeline that shows progress toward task completion			√
Focus on a specific biomedical science subject or topic area	√	√	
Focus on academic- and career-focused attitudes and lived experiences, including decision-making, personal drive, stress, the work environment, and handling career obstacles			√
Culturally responsive mentorship discussion topics are incorporated			√
Unlimited duration	√	√	
Defaults to a 4.5-month period (duration can be customized)			√
Can address each stage of a mentee's career	√	√	√
Certificate of successful completion			√
Free to terminate mentorship connection at any time and choose a new mentor	√	√	√

specifically designed for this purpose. Any MyNRMN member can create a group, and the group owner can add one or more co-owners. Owners can turn email notifications on or off for the group and can customize the group's public page by adding a description, unique URL, and group photo. The four types of groups (Table 2) allow for flexibility in purpose, privacy, and accessibility to accommodate the needs of MyNRMN members.

2. Guided virtual mentoring with MyMentor.

For some mentees and mentors, mentoring itself is a new concept, one that has multifaceted aspects that may require learning and discussing. This may be particularly true for underrepresented individuals. For these reasons, MyNRMN offers the option of a guided virtual mentoring experience through the *MyMentor* program, which serves as an introduction to the process of mentoring. The MyMentor program offers a limited duration, pre-planned experience with paths specifically tailored for mentees at five different career stages: undergraduate, post baccalaureate, graduate student, postdoctoral, and junior faculty. For each path, the program includes structured lessons with text and sometimes video, and pre-populated goals broken into discrete tasks. The pre-defined goals focus not on particular STEM areas, but on academic- and career-focused attitudes. Culturally responsive mentorship discussion topics are incorporated into each of the career stages. One goal, for example, is to consider and discuss the experience of being the “other” on campus or at work because of race, gender, or other personal characteristics, whereas another goal is to share aspects of cultural identity that the mentor and mentee may have in common or that are important to them. The intention of these goals is to focus on growing a mentee's confidence, self-efficacy, and independence to help them transition from their current position to the next, rather than focusing on their day-to-day activities.

In the MyMentor program, mentees have three ways to find a mentor: 1) choose among three potential members recommended by the MyNRMN mentor matching algorithm; 2) search keywords; or 3) choose “*select for me*,” which allows a program administrator to view the mentee profile and match it with a suitable mentor. Only MyNRMN mentors who have specifically opted into MyMentor will appear in the search. However, a mentee may also request a mentor by name, and

that mentor will be invited to join MyMentor. Mentees can connect with only one guided virtual mentor at a time, but they are free to terminate the connection at any time and choose a new mentor. In many cases, particularly for students in lab settings, a mentor is assigned to them who is also their professor or employer. Having this mentoring connection in a virtual setting with a mentor outside of their proximity allows a mentee more autonomy in their mentoring connections, providing them the space to communicate freely and openly.

3. Ask a Mentor and Ask Me a Question.

MyNRMN also includes two question-and-answer features that can serve as “mini-mentoring” opportunities or as icebreakers to establish mentorship connections. The first, *Ask a Mentor*, is a community question-and-answer forum in which a mentee can pose a question to be answered by any mentor. If the answer provided is helpful to the mentee and shows an understanding of the topic or situation, the mentee may want to consider asking that person to be a mentor. Questions posted by mentees via *Ask a Mentor*, and any posted answers, are visible by all MyNRMN members.

The *Ask Me a Question* feature differs because it can be accessed only on a specific mentor's profile page, or else via the search results that appear when a mentee searches for additional member connections. A mentee would use this feature to ask a question directly and privately to a specific mentor, whether the mentee is connected with that mentor or not. The mentee also has the option to send a connection request along with their question. Mentors will receive an email and a system notification of the mentee's question. Mentors can answer the question, and also decide whether to connect.

2.3 | Building a Personal Network of Mentors

Networking and Mentoring: Research has shown that individuals benefit from multiple mentoring inputs.⁴ A network of mentors,⁷ each providing individual-centered mentoring,⁶ can more efficiently deliver the range of components needed to support the personal career aspirations and professional goals of a mentee. The larger the pool of mentor connections, the more the resources are available to the individual. Social

TABLE 2 Types of Groups on MyNRMN

Group type	Member accessibility and level of privacy
Public	Visible in search results and available for any MyNRMN member to join
Invitation Only	Visible in search results, but mentees and mentors must send a request to the group owners to join
Private	Not visible in search results; completely private
Announcement	Any user can subscribe to receive up-to-date information on topics of interest. Whereas only group owners can post announcements, other members can react and reply.

networking, a paradigm explicitly designed for expanding connections, is ideally suited to this purpose. Moreover, most mentees and mentors are already highly familiar with social networking and online communication through the use of online platforms.

Social Capital and Social Networks: Social capital, as explained by Bourdieu,¹² is comprised of an individual's social network connections and the exchanges and obligations that result, the combination of which provides access to informational, emotional, and instrumental resources and supports. In the mentoring context, social capital can be defined as the resources available to a mentee through membership in social networks,¹³ and can be measured by the size of the mentees' personal network.¹² Regular interaction within a mentoring network enables information exchange and knowledge sharing crucial to career and professional growth; thus, social capital can be greatly enriched by those mentee actions facilitated by direct and indirect links to mentors in their social network.¹⁴

Personal Network of Mentors: A personal network of mentors is the web of connections a member has with other people, who are in turn connected to other people. A mentee's personal network can grow as others they are connected to grow their own networks. Having access to a personal network of mentors from different backgrounds and institutions, and with varying skill sets and fields of interest, can contribute greatly to career opportunities. A mentee's personal network can be analyzed and compared to others to measure its breadth, and thus its capacity for enabling career success. To facilitate analysis of an individual's MyNRMN network

connections, we have developed an extensive graph database using the open-source graph database software *Neo4 J* (<https://en.wikipedia.org/wiki/Neo4j>), which supports native graph processing and storage and allows powerful graph querying (using *Cypher* query language). Using this database system, we represent members (mentors and mentees), institutions, and groups as *nodes* in a network, and the relationships or connections between these nodes as *edges* (links). Network analysis algorithms then enable us to map relationships between individuals (nodes) in the network and interactions between these nodes,¹⁵ to analyze and study how personal connections are being made across member domains. Other attributes, including location, research interests, academic degrees, career levels, and ethnicity data (from the NRMN member profile) are added to member nodes. In addition, two types of relationships between mentor and mentee (Mentoring connection or Networking connection) are also captured as attributes of the edge linking them. Figure 2 shows an example of sub-network of a mentee.

Such database mapping is critical to discovering “structural holes”¹⁶ in a mentee's network—places where the mentee lacks a tie between nodes which represent potentially beneficial connections. These gaps are opportunities. A mentee's professional growth and career mobility can be vastly enhanced by locating these structural holes and bridging them. MyNRMN's matching algorithm functions as a “brokerage”¹⁷ system to bridge these gaps by recommending connections that can link disconnected nodes and thus increase a mentee's mentoring and networking opportunities. This is especially important for underrepresented mentees and mentors

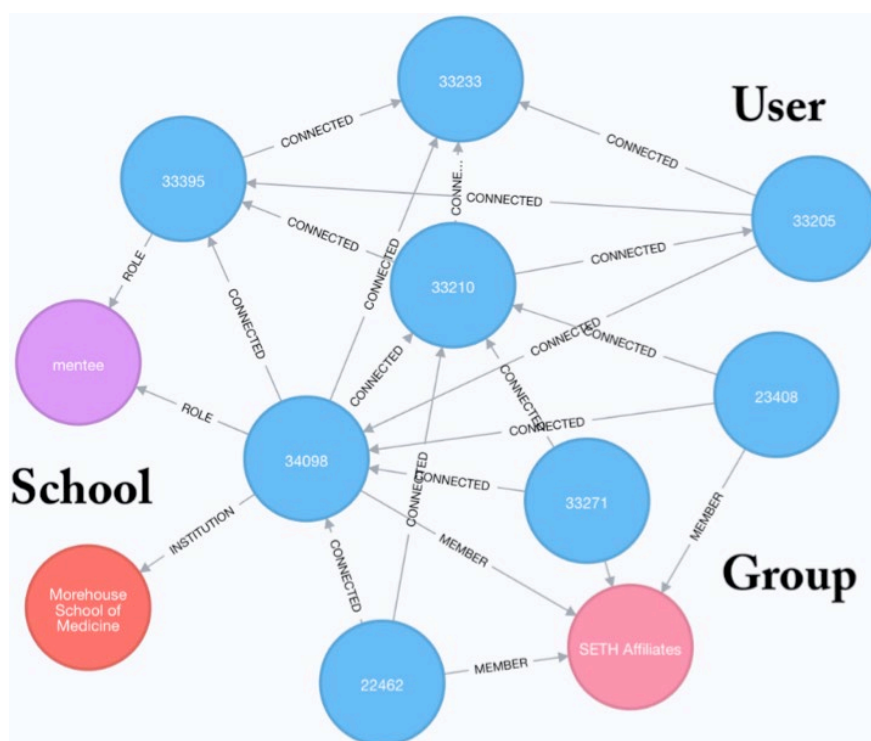


FIGURE 2 Example network of a mentee. Includes the mentee's mentor connection, institution, groups belonged to, and other connections with MyNRMN members. **Key:** Node or Circle representations: Purple: Main Mentee (member whose connections are being analyzed). Blue: Member (can be either mentor or mentee, who is connected to the Main Mentee). Pink: Group (that the Main Mentee is connected to). Edge or Link representations: Role: Connection between Main Mentee and any mentor. Connected: Connection between Main Mentee and individual member. Institution: Main Mentee institution

who would not otherwise be able to bridge this gap with the networks available to them locally.

Network Expansion Algorithm: To facilitate the building (and expanding) of a *personal network of mentors*, MyNRMN allows members to browse profiles of mentors and mentees and connect with those who share interests. MyNRMN's matching and recommendation algorithm (Figure 3) uses mentee profile data and existing network connections to recommend new mentors and peers. This algorithm draws on a graph database to efficiently retrieve member data and relationships by treating the relationships between data as equally important to the data itself.¹ The algorithm provides names of members who share common attributes, such as a member's first degree connections, institution, career level, geographic location, or mentorship by the same mentor. It also takes into consideration the member's role as a mentor or mentee, so that for mentees, recommended members will include more mentors than mentees and vice versa. Results are sorted by member engagement scores (see "Engagement Features" below), to place the most highly engaged members at the top of the list. Mentees see a different set of recommended members every time they log in to the system. These member recommendations are extremely helpful for new members just joining MyNRMN who want to build their personal network of mentors. In addition to recommending members to connect with, the algorithm also suggests My Groups and "communities" to join that are relevant to a mentee's profile and existing professional network, or that have members with similar interests, locations, or backgrounds.

2.4 | Engagement Features

Engagement of members is a critical part of the MyNRMN experience. When a member first joins and completes their profile, a list of suggested My Groups to join is immediately generated. Participation in these My Groups enables a mentee to become involved with peers and mentors with common interests, right from the start. In addition, each time the member logs in to the MyNRMN portal, the dashboard offers

recommendations for additional My Groups with which to connect.

Gamification on the site promotes continuing engagement with the platform. NRMN Points are awarded to mentees for completing certain activities, such as finishing their initial profile, building or uploading a resume, accepting a new connection, joining a group, or asking a mentor a question. Mentors earn points for many of the same activities, including the completion of onboarding steps, providing their ORCID number, answering a mentee question, accepting connections, writing a MyNRMN journal entry, etc. A mentor's point total is an indication of mentoring engagement and suggests which mentors are likely to respond if asked a question or asked to be a mentor. High point values also push mentors up in search results when a mentee is looking for a new mentor.

Furthermore, the MyNRMN platform includes an online module to host asynchronous courses. MyNRMN launched its inaugural asynchronous online course, "Unconscious Bias," in July 2020.¹⁸ The course, geared toward reducing bias toward those historically underrepresented in STEM fields, discusses how unconscious bias and microaggressions affect everyone, including in the biosciences, and provides a solutions toolkit for developing self-awareness. On September 14, 2020, the Unconscious Bias course surpassed 400 participants.

3 | RESULTS

3.1 | Network Growth and Member Demographics

Utilization of the MyNRMN platform continues to grow steadily (Figure 4) and is attracting widely diverse participation. The population depicted in this section represents the active members within MyNRMN, not the entire NRMN population. Figure 5 shows representation of mentors and mentees by demographic characteristics. Among mentors, 58% are women, and among mentees, 70% are women. Individuals

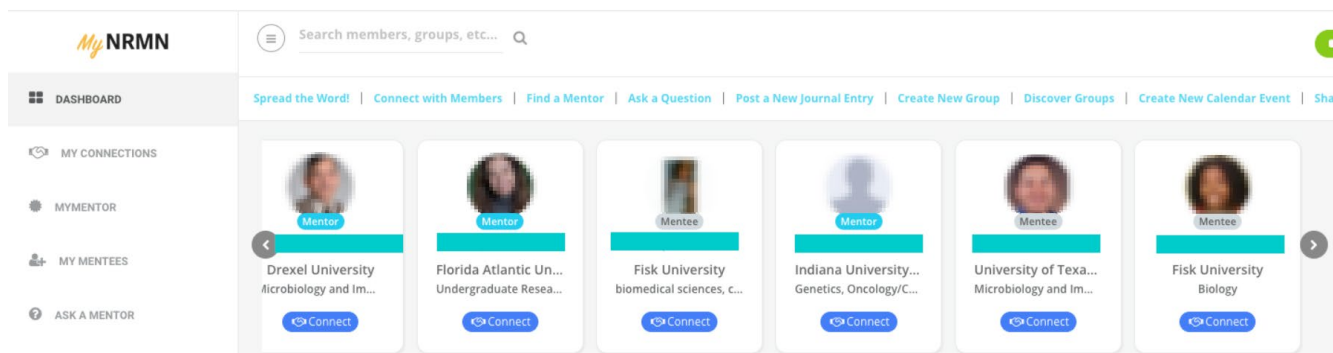


FIGURE 3 Suggested Recommendations on Mentee Dashboard

MyNRMN Network Growth (Cumulative)

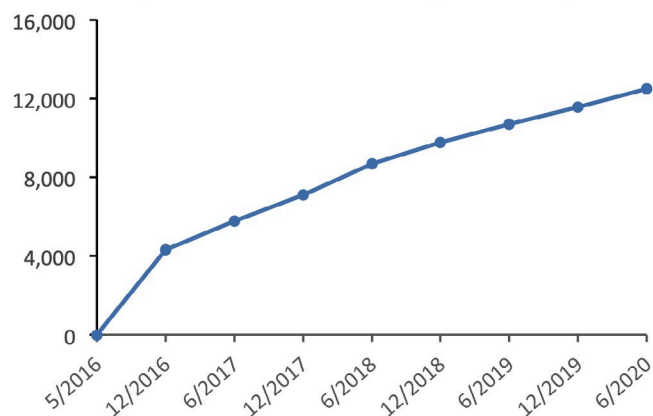


FIGURE 4 Cumulative growth in active users of the MyNRMN platform

historically underrepresented in the biosciences show strong levels of participation on the platform: of all mentees, 34% are black, 21% Hispanic, and 4% Native American.³ Notably, the proportion of underrepresented individuals is considerably larger among mentees than mentors, demonstrating that the platform is successfully attracting those who would most benefit from mentorship.

The range of educational attainment among mentees is also well-distributed, with just over a third (35%) being current undergraduates, 22% in graduate school, 18% in a postdoctoral program, and 22% either faculty or working. These data suggest that the platform is working at many levels to connect persons who are interested in furthering their careers and taking next steps through mentoring to achieve their goals. Among mentors, the most (77%) are faculty or working in biomedical science careers. Further analysis of the NRMN population demographics will be discussed in a separate publication.

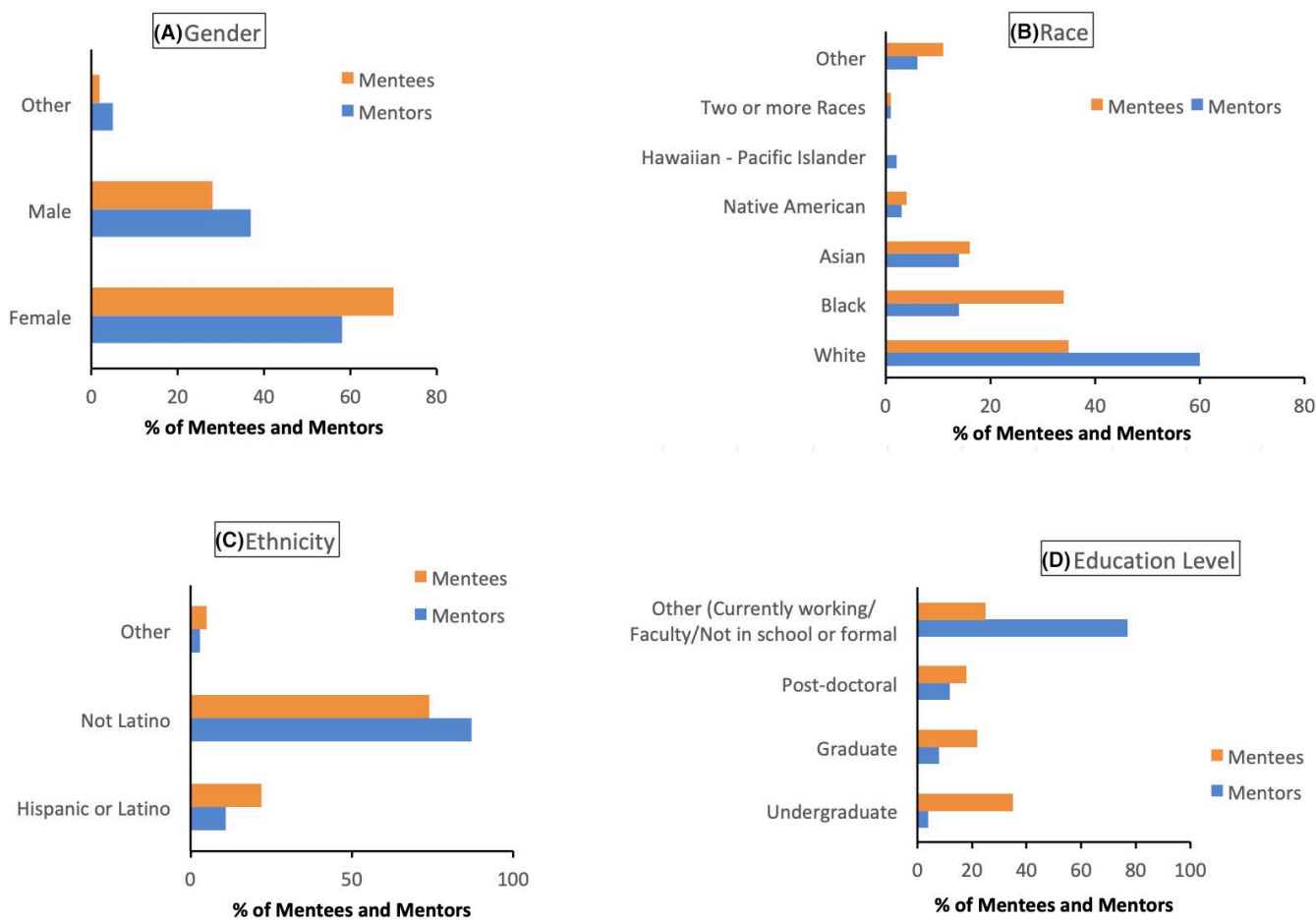


FIGURE 5 Demographic characteristics of MyNRMN Mentors and Mentees

3.2 | Mentor and Mentee Engagement on the Platform

The MyNRMN platform currently has 13,551 active members (as of September 26, 2020), with 13,196 requests to connect, over 5400 current connections, and over 1000 formal mentorships (Table 3). The 196 groups active on the platform tally over 3900 group participants. Platform engagement is robust as well, measured by files shared (528), posted comments (6175), and CVs/resumes created/published (1640).

3.3 | Mentoring Connections and Personal Network of Mentors

The primary goal of the platform is to connect mentees with suitable mentors. These mentors could be from the same institution or from somewhere across the country. By facilitating access to a pool of mentors who can help with different aspects of a mentee's mentoring needs, the platform enables a mentee to build a personal network of mentors from different backgrounds and institutions and with varying skill sets and fields of interest. These varied mentor experiences and qualifications can contribute greatly to career opportunities for the mentee. Table 4 demonstrates that the MyNRMN platform is successful in helping mentees (and mentors) from Historically Black Colleges and Universities to form mentorship connections outside of their institutions. Figure S1 shows the geographic reach of the MyNRMN platform. Mentees and mentors in each state are listed in the format: number of mentees/number of mentors. All 50 states are represented, as well as several U.S. territories. Although heavy concentrations of members are found in the largest cities, there is substantial rural representation as well. Table S1 shows mentoring connections between mentors and mentees across the nation. Table S2 further details the number of individual and group connections by race and ethnicity. The average number of connections mentees have is 2.98, and the average number of connections mentors have is 6.32. In the graph database, the edge (link) representing a connection is unidirectional. If a mentee initiates the connection with a mentor, it is marked as a mentee–mentor connection, and if a mentor initiates the connection with a mentee, it is marked as a mentor–mentee connection. The average number of connections for mentee–mentor is 2.36 and for mentor–mentee is 1.77. We also tracked peer-mentoring connections of mentee–mentee and mentor–mentor, and these averages are 0.62 and 4.55, respectively.

4 | DISCUSSION

A single mentor is rarely sufficient for a mentee to achieve optimal career growth. Aspiring biomedical scientists,

TABLE 3 MyNRMN Engagement Metrics (through September 26, 2020)

Total user accounts (includes every account created on MyNRMN)	16,399
Total active members (includes every user who has chosen a role of mentor and/or mentee)	13,551
Active member log-in methods (multiple methods possible if multiple accounts)	
Username–password	11,071
Google	1,433
LinkedIn	721
Facebook	405
Connection requests (whether accepted or not)	13,196
Connections accepted (counted as one connection if between two members)	5,408
Member and mentoring connections	
Mentor–mentee	2,791
Mentor–mentor	1,869
Mentee–mentee (peer or near-peer)	748
Formal requests for a mentor	1,054
Accepted mentoring requests	792
Rejected mentoring requests	13
Pending response	249
Comments posted on members' dashboards	6,175
Calendar events scheduled by members (e.g., seminars, lectures, video calls)	166
Files shared on the site (visible by all a member's connections)	528
Resumes	1,640
Published on the site	1,397
Created with CV/Resume builder (may not have been shared yet)	407
Uploads of existing CVs/resumes	1,233
Groups	
Total groups	196
Public groups	66
Private groups	51
Invite-only groups	79
Total members of groups (counted multiple times if a member of multiple groups)	3,986
Institutions	
Total institutions represented by mentees and mentors	2,194
MyCourses	
Enrollment in course, "Unconscious Bias"	429

particularly those traditionally underrepresented in the field, need to connect with mentors from a variety of personal, educational, and scientific backgrounds to serve as models, provide encouragement, answer questions, collaborate on

TABLE 4 MyNRMN Mentoring Connections at Historically Black Colleges and Universities (Top 15 Institutions, as Measured by Number of Connections) [through July 08, 2020]

Institution	Number of mentees	Number of mentors	Intra- Institution connections (within the same Institution)	Out-degree to other institutions	In-degree from other institutions	Inter- institution connections (out-degree plus in-degree)
1 Morehouse School of Medicine	38	16	14	31	41	72
2 Alabama State University	55	9	26	42	26	68
3 Xavier University of Louisiana	59	26	7	30	22	52
4 Fisk University	15	4	22	22	28	50
5 Tuskegee University	45	7	51	44	2	46
6 Savannah State University	50	9	21	23	14	37
7 Morgan State University	30	10	3	12	21	33
8 North Carolina A & T State University	8	5	0	8	18	26
9 Alcorn State University	9	2	1	9	8	17
10 Florida A&M	4	4	0	9	8	17
11 Langston University	7	1	2	8	4	12
12 Benedict College	37	11	12	10	0	10
13 Edward Waters College	6	0	1	5	5	10
14 Howard University	22	6	1	1	6	7
15 Hampton University	12	5	4	0	6	6

research, and introduce new ideas, new techniques, and new people. A mentor can help a mentee overcome difficult career obstacles that may otherwise seem insurmountable. The MyNRMN platform enables mentees to build their own personal network of mentors who will help them achieve their individual career and professional goals. For a mentoring network to be successful, connections must be easy to navigate, find, and make. To facilitate this process, we have developed informatics tools using a graph database that demonstrates the type of interconnections needed to achieve success in the biosciences field.

Mentoring is important for every career stage, but especially for the undergraduate, graduate, and postdoctoral levels. Mentoring has been shown to have a measurable impact on career trajectories and achieving career goals.^{8,21} At the same time, studies have found that underrepresented minorities typically have less access to mentoring than their non-minority peers.^{4,22} When underrepresented students lack connections to anyone on a personal level who has attended graduate school or established a career in the biomedical sciences, they are less likely to pursue that path themselves. The future of scientific innovation, however, needs highly skilled scientists working in teams with diverse backgrounds and perspectives, not only to solve the difficult biomedical questions facing our nation today, but also to ensure that health disparities are being addressed and that all individuals can participate in and benefit from our collective research discoveries.³ Additionally, MyNRMN provides a space for interdisciplinary collaboration which does not often occur when sequestered in a lab researching a specific area of focus.

The mentoring mechanisms within MyNRMN allow mentees autonomy not only in how they obtain their mentoring connections, but also from whom they receive mentoring. Those from areas with low population, those from disadvantaged socioeconomic backgrounds, and those who identify as underrepresented minorities often struggle to find mentors with similar backgrounds with whom they can connect and feel comfortable speaking freely. With over 13,000 requests to connect, it is evident that the underrepresented populations in the STEM fields are looking to expand their networks beyond their local capabilities.

The MyNRMN networking and mentoring platform is helping mentees and mentors connect nationwide. Our engagement data demonstrate the platform's success in enabling mentees to build their personal network of mentors and further their career goals. Data from the platform, including enrollment numbers, connections, resume creation, and group interaction, reveal a highly engaged membership. Although the MyNRMN platform is not restricted to underrepresented individuals, a major aim of our mission is to ensure that MyNRMN is promoted specifically to underrepresented groups, and that individuals from these groups are welcomed and their needs accommodated. To that end, we

have personally recruited such individuals to the NRMN at national conferences, including the Society for Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS, www.sacnas.org) and the Annual Biomedical Research Conference for Minority Students (ABRCMS, www.abrcms.org) both of which are well attended by underrepresented potential mentees. The success of MyNRMN in attracting underrepresented members is also a result of our filling an immense need among these individuals for productive mentorship opportunities. Although it is too soon to determine the longitudinal outcomes from underrepresented minorities engaging in the mentoring and networking resources within MyNRMN, the engagement metrics discussed in the results indicate that there will be rich data in the future.

4.1 | User Feedback and Future Directions

We continue to build on the success of the MyNRMN platform. We have continually introduced new features to increase its usability and functionality, based on user feedback we receive through our service desk (MyNRMN service desk: <https://mynrmn.zendesk.com/hc/en-us>), where we also host our help articles and how-to video tutorials.

A common member request has been for the integration of guided virtual mentoring with the networking platform to provide a better user experience. Others have suggested enhancing functionality to enable MyNRMN to serve as a hub of all resources and tools that a mentor or mentee would use within the network. Mentor and mentee training has been one of the most requested features. With My Courses, we have begun developing online training content and courses in best practices for mentorship, which will include such topics as cultural awareness in mentoring.²³ We expect these trainings to be especially salient for mentors and mentees from underrepresented groups, who may have had less exposure to the mentorship process. We anticipate that increased trainings will expand the productivity of the platform, particularly for these groups.

Another plan to increase engagement among our community of members is to build native mobile applications for both Apple and Android devices. We also hope to motivate consistent activity on the platform by engaging users in new ways, such as by offering them—as soon as they join the platform—recommendations for potential mentors and suggestions for valuable groups in which to participate, and by providing regular MyNRMN activities they can join and contribute to, including webinars and career and professional development resources.

Every mentee is a potential mentor—either now or in the future—including peers, near-peers, postdocs, and early-career faculty. Research has shown that the mentoring support an individual receives from peers or near-peers can be as

valuable as that received from faculty,^{24,25} including “vicarious learning” benefits.²⁶ Peer mentoring, or co-mentoring, has been shown to increase mentee skills in the areas of collaboration and research management, provide relational and career support, and foster accountability and independence.^{4,27,28} We are developing a Peer Mentoring module, which will include a guided mentoring program, a search for mentors available for peer mentoring, automatic matching for peer mentors, goal creation, milestones, and completion certificates.

More than just a network, MyNRMN has been built as a *resource for mentoring research* and informatics-based *mentoring interventions*. The graph database underlying our platform mimics the actual real-world network. This enables us to study how the network behaves, how it is growing, and how an individual is leveraging the network.

4.2 | Challenges and Limitations

MyNRMN is only as good as its usage. Our main challenge is continually finding new ways to engage NRMN members, especially those from underrepresented groups, and motivate them to stay active on the platform. Although it may be ideal for mentors and mentees to meet face-to-face, the reality is that meeting virtually may be the most economical and timely option for those underrepresented individuals not located in metropolitan areas or at major universities. During a pandemic such as COVID-19, our online platform offers an alternative to in-person mentoring. If most mentoring continues to take place online, then mentors, mentees, academic institutions, and professional societies nationwide can take advantage of our proven mentoring and networking platform for their mentoring needs.

Another limitation encountered thus far is the lack of sufficient data to analyze longitudinal outcomes for underrepresented groups engaging in the mentoring and networking resources of MyNRMN. To evaluate such outcomes and results among these key groups, MyNRMN is tracking profile transition changes and is continuing to develop additional data tracking features to answer questions regarding effectiveness. We hope to release these findings in future publications.

5 | CONCLUSION

The MyNRMN online platform is changing the mentoring paradigm for biomedical sciences across the country and has proven successful in connecting mentees and mentors across all 50 states and from more than 2100 institutions. Built using scalable technologies, MyNRMN not only fulfills its mission of helping individuals from different backgrounds, cultures, and locations to connect with mentors in the biomedical

sciences, but its unique graph database allows us to study mentoring connections and growth of an individual's personal network of mentors to evaluate mentoring interventions, and then to disseminate these pathways to mentees looking to achieve their own career goals. As we continue to build, refine, and adapt the MyNRMN platform to the evolving needs of its members, we are excited about the level of engagement in the platform by those it is intended to serve, especially those underrepresented in the biosciences, and we look forward to future evaluations of the platform's efficacy in expanding and diversifying the biomedical research workforce.

CONFLICT OF INTEREST

No conflict of interest exists.

AUTHOR CONTRIBUTIONS

T. Ahmed, J. Johnson and Z. Latif designed and implemented the platform and software; T. Ahmed, Z. Latif and N. Kennedy analyzed the data; N. Kennedy and T. Ahmed wrote the paper; T. Ahmed, D. Javier, K. Stinson and J. Vishwanatha performed research and reviewed the manuscript.

ENDNOTE

^a To put these figures in perspective, The National Center for Education Statistics reports that among the U.S. population aged 25 or older, 21% of U.S. Blacks and 15% of Hispanics and Native Americans had completed a bachelor's degree or higher.¹⁹ Similarly, data from the National Science Foundation (NSF) show that of the total U.S. population earning a bachelor's degree in science in 2016, 55.7% were non-Hispanic white, 13.5% Hispanic, 10.3% non-Hispanic black, 0.5% Native American or Native Alaskan, and 0.2% Native Hawaiian or Pacific Islander.²⁰ Although these NSF statistics combine race and ethnicity and thus cannot be strictly compared with our data, they do suggest that the MyNRMN platform includes a highly favorable representation of these minorities:

REFERENCES

1. Packard BW-L. Successful STEM Mentoring Initiatives for Underrepresented Students: A Research-Based Guide for Faculty and Administrators. *Strylus Publishing, LLC*. 2015. <https://stryluspub.presswarehouse.com/browse/book/9781620362969/Successful-STEM-Mentoring-Initiatives-for-Underrepresented-Students>
2. Haggard DL, Dougherty TW, Turban DB, Wilbanks JE. Who Is a Mentor? A Review of Evolving Definitions and Implications for Research. *J Manage*. 2011;37(1):280–304. <https://doi.org/10.1177/0149206310386227>
3. NOT-OD-20-031: Notice of NIH's Interest in Diversity. Release date: November 22, 2019. Accessed April 16, 2020. <https://grants.nih.gov/grants/guide/notice-files/NOT-OD-20-031.html>
4. Dahlberg M, Byars-Winston A, editors. *Findings and Recommendations. The Science of Effective Mentorship in STEMM*. Washington, DC: The National Academies Press, National Academies of Sciences, Engineering, and Medicine; 2019. Accessed March 3, 2021. <https://www.ncbi.nlm.nih.gov/books/NBK552779/>
5. McGee R, Lee S, Pfund C, Branchaw J. Beyond “finding good mentors” to “building and cultivating your mentoring team.” In:

- Huang BL, ed. *Advancing Postdoc Women Guidebook*. National Postdoctoral Association; 2015:23-33. <http://www.awis.org/wp-content/uploads/NPA-Advancing-Postdoc-Women-2015.pdf>
6. Higgins MC, Kram KE. Reconceptualizing Mentoring at Work: A Developmental Network Perspective. *The Academy of Management Review*. 2001;26(2):264. <https://doi.org/10.2307/259122>
 7. Sorcinelli MD, Yun J. From Mentor to Mentoring Networks: Mentoring in the New Academy. *Change: The Magazine of Higher Learning*. 2007;39(6):58–61. <https://doi.org/10.3200/CHNG.39.6.58-C4>
 8. Pfund C, Byars-Winston A, Branchaw J, Hurtado S, Eagan K. Defining Attributes and Metrics of Effective Research Mentoring Relationships. *AIDS Behav*. 2016;20(Suppl 2):238–248. <https://doi.org/10.1007/s10461-016-1384-z>
 9. The Mentoring Manual: IBP Guide to Mentoring for all program participants. *The Institute for Broadening Participation, Pathways to Science*; 2012. Accessed March 3, 2021. <https://www.pathwayastoscience.org/pdf/ManualComplete.pdf>
 10. Sorkness CA, Pfund C, Ofili EO, et al. A new approach to mentoring for research careers: the National Research Mentoring Network. *BMC Proc*. 2017;11(Suppl 12):22. <https://doi.org/10.1186/s12919-017-0083-8>
 11. Ginther DK, Schaffer WT, Schnell J, et al. Race, Ethnicity, and NIH Research Awards. *Science*. 2011;333:1015–1019. <https://doi.org/10.1126/science.1196783>
 12. Bourdieu P. The Forms of Capital. In: Biggart NW, ed. *Readings in Economic Sociology*. Blackwell Publishers Ltd; 2002:280-291. <https://doi.org/10.1002/9780470755679.ch15>
 13. Carrillo Álvarez E, Riera RJ. Measuring social capital: further insights. *Gac Sanit*. 2017;31(1):57–61. <https://doi.org/10.1016/j.gaceta.2016.09.002>
 14. Adler PS, Kwon S-W. Social Capital: Prospects for a New Concept. *The Academy of Management Review*. 2002;27(1):17–40. <https://doi.org/10.2307/4134367>
 15. Abbasi A, Wigand RT, Hossain L. Measuring social capital through network analysis and its influence on individual performance. *Library & Information Science Research*. 2014;36(1):66–73. <https://doi.org/10.1016/j.lisr.2013.08.001>
 16. Podolny JM, Baron JN. Resources and Relationships: Social Networks and Mobility in the Workplace. *Am Sociol Rev*. 1997;62(5):673–693. <https://doi.org/10.2307/2657354>
 17. Burt RS. *Brokerage and Closure: An Introduction to Social Capital*. Oxford University Press; 2005.
 18. Short A. Unconscious Bias Course. NRMNet. Accessed August 18, 2020. <https://nrmnet.net/blog/2020/07/29/unconscious-bias-course/>
 19. Indicator 27: Educational Attainment. National Center for Education Statistics. Accessed June 18, 2020. https://nces.ed.gov/programs/raceindicators/indicator_RFA.asp
 20. National Science Foundation, National Center for Science and Engineering Statistics. Women, Minorities, and Persons with Disabilities in Science and Engineering: 2019. Special Report NSF 19-304. Alexandria, VA; 2019. Accessed March 3, 2021. <https://nces.nsf.gov/pubs/nsf19304/>
 21. Montgomery BL. Mapping a Mentoring Roadmap and Developing a Supportive Network for Strategic Career Advancement. *SAGE Open*. 2017;7(2):2158244017710288. <https://doi.org/10.1177/2158244017710288>
 22. Thomas DA. The truth about mentoring minorities. *Race matters. Harv Bus Rev*. 2001;79(4):98–107, 168.
 23. Womack VY, Wood CV, House SC, et al. Culturally aware mentorship: Lasting impacts of a novel intervention on academic administrators and faculty. *PLoS One*. 2020;15(8):e0236983. <https://doi.org/10.1371/journal.pone.0236983>
 24. Williams SN, Thakore BK, McGee R. Career Coaches as a Source of Vicarious Learning for Racial and Ethnic Minority PhD Students in the Biomedical Sciences: A Qualitative Study. *PLoS One*. 2016;11(7): <https://doi.org/10.1371/journal.pone.0160038>
 25. Thakore BK, Naffziger-Hirsch ME, Richardson JL, Williams SN, McGee R. The Academy for Future Science Faculty: randomized controlled trial of theory-driven coaching to shape development and diversity of early-career scientists. *BMC Med Educ*. 2014;14:160. <https://doi.org/10.1186/1472-6920-14-160>
 26. Dahlberg M, Byars-Winston A, editors. *Findings and Recommendations. The Science of Effective Mentorship in STEMM*. Washington, DC: The National Academies Press, National Academies of Sciences, Engineering, and Medicine; 2019. Accessed March 3, 2021. <https://www.ncbi.nlm.nih.gov/books/NBK552779/>
 27. McRae M, Zimmerman KM. Identifying Components of Success Within Health Sciences-Focused Mentoring Programs Through a Review of the Literature. *Am J Pharm Educ*. 2019;83(1): <https://doi.org/10.5688/ajpe6976>
 28. Trujillo G, Aguinaldo PG, Anderson C, et al. Near-peer STEM Mentoring Offers Unexpected Benefits for Mentors from Traditionally Underrepresented Backgrounds. *Perspect Undergrad Res Mentor*. 2015;4(1). Accessed April 24, 2020. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5034940/>

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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