Mentor relationships are crucial to retention, success, and wellbeing of women and underrepresented minority scientists in academia. A network of diverse mentors may support achieving long-term career goals, advancement, and retention of both mentors and mentees, thus enhancing diversity, equity, and inclusion initiatives.

**Diversified mentorship is essential to break systemic bias and make effective retention efforts**

Multiple efforts have been made by institutions, societies, and organizations to offset gender disparity and exclusion of underrepresented minority scientists (URMs, i.e. racial/ethnic and gender groups constituting a lower proportion in the field than in the general population). Programs addressing gender bias and lack of diversity are slowly, but increasingly, addressing ingrained sexism and ableism in STEM fields and academia. However, institutions and funding agencies should continue to invest in minimizing gender-specific obstacles; for example,
promoting work-life balance; equalizing salaries, promotions, and start-up packages. Institutions must also address cultural taxation, discrimination, and isolation of URMs. Further, institutions should act as tools of social justice by acknowledging women and URMs in leadership positions where they were historically ignored; honoring them with awards and nominations; and promoting and compensating them when serving as role models and mentors. Here, we recommend tangible action focused on the latter.

Mentor relationships are crucial to retention, success, and wellbeing of women and URMs in academia. Mentoring not only provides professional support, guidance, information, and advice; mentoring also offers templates of the behaviors that are needed to achieve success in the field. Effective mentorship requires a unique personal relationship between individuals at different career stages, with the potential of benefiting the career advancement of both the mentor and the mentee. Further, mentorship is distinct from supervision: “Mentoring is an opportunity to connect meaningfully with individuals in service to their pursuit of personally-defined goals or aspirations.” Thus, mentorship is not automatically achieved in a supervisor-supervisee relationship. However, even when dyadic mentor-mentee relationships have been shown highly beneficial, the traditional model of mentoring can be insufficient to ensure retention, success, and wellbeing of underrepresented groups (by either race/ethnicity or gender identity in academia). Women and URMs face many obstacles during their academic careers, in great part due to ingrained institutional disparity: decreased recognition in publications, fewer citations of papers authored by them, lower research funding allocations, and greater academic and domestic responsibilities. These biases lead to gender and ethnic underrepresentation in academia, particularly at senior levels. Indeed, women and URMs are less represented at later stages in the career path (a phenomenon known as ‘the leaky pipeline’). A network of diverse mentors may support achieving long-term career goals, advancement, and retention of both mentors and mentees, thus synergistically enhancing diversity, equity, and inclusion (DEI) initiatives and perpetuating a virtuous cycle of enriched mentoring. Programs focusing on building diverse mentorship networks have been effective in promoting the success of women and other URMs in Science, Technology, Engineering and Mathematics (STEM) fields. Cross-cultural mentoring relationships have been particularly successful when they included strategies to foster mentors’ awareness, sensitivity, and commitment to their mentees. In this context, improved culturally and socially diverse mentorship can enable institutions to effectively increase DEI and overcome bias in STEM fields and academia. While multiple organizational efforts are focused on increasing DEI, the actual practice of these efforts is challenging. To achieve the goal of increased DEI, we suggest that institutions aim to: (1) emphasize mentoring strategies to increase DEI, especially those that address gender bias and URM exclusion, (2) promote multi-mentor programs and acknowledge their utility in increasing DEI, and (3) reference examples of diverse, institutional mentoring efforts.

Multi-mentor systems have potential to enhance retention and DEI

Having diverse role models and mentors can be transformative and enhance academic performance, especially for women and URM mentees. Retention, motivation, and persistence in STEM fields and academia can be positively influenced by mentorship. This is particularly impactful when female students and URMs are introduced, at an early undergraduate stage, to role models and mentors by whom they feel represented. For instance, different mentorship programs focused on equity and inclusion of URMs have proven to be effective long after the relationship ended, sustaining the retention and success of underrepresented scientists.

For mentorship to be impactful for academic advancement, the individuals in the relationships cannot be separated from their cultural and societal backgrounds. Mentors and mentees pairing often reflect unconscious biases (e.g., majority-culture mentors interacting with mentees with ethnic, religious or gender affinities in ways that reflect majority-culture priorities rather than tailoring mentoring to these URM mentees’ priorities). Thus, active efforts from institutions are required to counteract the systemic inequities. Such efforts, particularly when formalized as programs, expand opportunities for both mentors and mentees to be more productive and innovative. For example, women usually devote a substantial part of their time, more than men, to mentorship and teaching. This imbalance can reduce publication and grant success which then contributes to unequal attention of women mentors. Further, if women and URMs are less represented in advanced career stages, diverse mentors and whole lines of research are less present in STEM, which increases the burden on the available mentors even more. A pyramidal structure toward less representation of women and URMs in senior positions thereby undermines efforts to overcome mentorship and research biases while exacerbating the burden on those few women and URMs who are retained long enough to become mentors. One solution is promoting mentorship networks, involving multiple mentor-mentee relationships, to increase collective performance by magnifying resources. In effective mentorship networks, mentorship extends beyond the relationships of mentors and their direct mentees. Indeed, mentors can be purposely picked outside the mentee’s direct advisory network. Building a multi-mentor network is an emergent property of other available systems, as programs often center around matching mentor/mentee pairs (Table 1). Such programs frequently offer the possibility of establishing peer and group mentoring relationships (for example, National Research Mentoring Network), thereby building networks for people in both shared and different career stages. However, we note a gap in formal programs: resources and recognition are needed for establishing these multi-mentor networks (Table 1 and Fig. 1). First, effective mentorship programs require changing institution-wide practices and interactions to challenge systemic inequalities on all organizational levels. For example, institutional policies can mitigate the overburden of mentoring by women and URMs (which, as noted, exacerbates attrition) by establishing review and promotion guidelines and responsibility re-allocation to encourage and credit mentors who participate in diverse mentoring programs. While some solutions can be generalized, each institution faces unique circumstances that require specific actions. Although doing so is challenging, not addressing these issues in local contexts may cause even the best program to fail. Furthermore, once efforts and programs are established, their methods and outcomes must be continuously monitored and evaluated to ensure institutions reassess successful or failed activities dynamically and responsively. Effectiveness may also be achieved when pre-established programs are synchronized and interconnected, thereby helping to identify diverse mentors for specific aspects of academic life. Successful programs will offer continuous support throughout the academic path, enabling professional development of both mentors and mentees and empowering diverse groups by promoting access to available resources and providing appropriate recognition.
| Program | Institution, organization, or society | Link | Purpose | Coverage | Target | Career stage |
|---------|--------------------------------------|------|---------|----------|--------|--------------|
| Career development | Life Sciences Career Development Society | https://lscds.org/events/career-development-program/ | Matches mentees with industry mentors, career transition to industry coaching, networking | Institutional (University of Toronto, Canada) | Open to all participants | Graduate students, postdocs, research associates (Life Sciences) |
| Inclusive Graduate Education Network | | | | Regional (North America) | Minorities – Black, Latinx and Indigenous | Graduate students (Physics) |
| Center for the Improvement of Mentored Experiences in Research (CIMER) | | | | Regional (North America) | Minorities | Undergraduate and graduate students |
| Public Health Policy - Leadership/Mentorship Program for Latin American women | | | | Regional (Latin America) | Women | Unrestricted |
| The World Bank – XL Africa | | | | Multi-national (African countries) | African entrepreneurs | Unrestricted |
| The Interamerican Task Force OEA | | | | Multi-national (Latin America) | Women | Unrestricted |
| The African Academy of Sciences | | | | Multi-national (African countries) | Open to all applicants affiliated to African universities or research institutions | Postdocs and junior faculty |
| SACNAS | | | | Multi-national (Latin America) | Minorities - Chicanos/Hispanics and Native Americans | Unrestricted |
| Gordon Research Conferences & Workshops | | | | Multi-national (North America, Asia, Europe) | Open to all participants | Unrestricted |
| Yale Young African Scholars – Yale University | | | | Multi-national (African countries) | Open to all African secondary students | Secondary students |
| Asian Scholars (CARA) | | | | Multi-national (Syria, Zimbabwe, Iraq) | Open to academically at-risk countries | Unrestricted |
| Inclusive Graduate Education Network | | | | Multi-national (unrestricted) | Open to all participants | Unrestricted |
| Leadership | The ASPET Mentoring Network | https://www.aspet.org/aspet/education-careers/mentorship-network/ | Professional development training and coaching, group mentoring, networking | Regional (North America) | Open to all participants | Graduate students, postdocs |
| Leadership | Austrian Academy der Wissenschaften Mentoring Program | https://www.oew.ac.at/index.php?id=3294&L=3 | Matches mentees with experienced academic mentors, career development training, networking | Regional (Austrian Academy of Sciences affiliated institutions) | Open to all participants | Graduate students, postdocs and junior faculty |
| Leadership | Leadership for LATAM Program | https://www.slaninternacional.org/lilanut/sobre_nosotros.php | Matches mentees with industry and academic mentors, group mentoring, professional and project development training, networking | Multi-national (Latin America) | Open to all participants | Early career researchers (Public Health Nutrition and Related Health Policy) |
| Leadership | eLife Innovation Leaders Program | https://elifesciences.org/labs/e1f315/introducing-innovation-leaders-2020 | Matches mentees with industry and academic mentors, group mentoring, professional and project development training, networking | Multi-national (Latin America) | Women | Unrestricted |
| Leadership | The Council for At-Risk Academies (CARA) | | | Multi-national (Latin America) | Minorities - Chicanos/Hispanics and Native Americans | Unrestricted |
| Leadership | Yale University The Council for At-Risk Academies (CARA) | | | Multi-national (Latin America) | Women | Unrestricted |
| Leadership | Internacional Task Force OEA | | | Multi-national (Latin America) | Minorities - Chicanos/Hispanics and Native Americans | Unrestricted |
| Leadership | LILANUT Leadership in Nutrition for LatAm Program | | | Multi-national (Latin America) | Open to all participants | Early career researchers (Public Health Nutrition and Related Health Policy) |
| Leadership | The African Academy of Sciences | | | | | |
| Leadership | Public Health Policy - Leadership/Mentorship Program for Latin American women | | | | | |
| Leadership | Center for the Improvement of Mentored Experiences in Research (CIMER) | | | | | |
| Leadership | National Research Mentoring Network | | | | | |
In this non-exhaustive list of career development, leadership, and mentorship programs from around the world, programs were identified by coauthors within their institutions, funding agencies, known publications, collaboration networks, and their close scientific community. Out of Innovation and Out to Innovate were identified by coauthors outside the institutions. Regions and target populations are given. Please note that regional classifications are not an exhaustive list of countries. Programs were included under their regional affiliation and targets (Target and Career stage) only after evaluating the available information. Target and Career stage indicates the ambition of the programs. Coverage indicates the reach of influence of the institution/program (up to a few countries). Multi-national indicates a reach of more than four countries of influence or not restricted to nationality. Target indicates the focal participants: women, URMs, institutional staff, or unrestricted (open to all participants). Career stage indicates the career level for focal participants. We cite published outcomes of listed programs, if available.

| Program | Institution, organization, or society | Purpose | Target | Career stage | Coverage |
|---------|--------------------------------------|---------|--------|--------------|----------|
| University of Minnesota - Clinical and Translational Science Institute | Mentor Training | People with faculty appointments at the university | Graduate students and faculty | Institutional (University of Minnesota, USA) |
| Center for the Integration of Research, Teaching and Learning | Mentor Training, group mentoring, networking | People affiliated or with appointments at the university | Graduate students and faculty | Institutional (Affiliated institutions) |
| University of Hong Kong - Mentorship Programs | Matches mentees with professional mentors, group mentoring, networking | Applicants from Austria, Germany and Switzerland | Women | Regional (German institutions) |
| Leopoldina National Academy of Sciences | Matches mentees with professional mentors, group mentoring, networking | Applicants from Austria, Germany and Switzerland | Unrestricted | Regional (North America) |
| Hong Kong Baptist University - Mentoring Programs | Matches mentees with professional mentors, group mentoring, networking | Women | Unrestricted | Unrestricted |
| Leopoldina National Academy of Sciences | Matches mentees with professional mentors, group mentoring, networking | Alumni and former members of the network | Unrestricted | Unrestricted |
| The University of Hong Kong - Mentorship | Matches mentees with professional mentors, group mentoring, networking | Applicants from Austria, Germany and Switzerland | Unrestricted | Regional (North America) |
| Leopoldina National Academy of Sciences | Matches mentees with professional mentors, group mentoring, networking | Applicants from Austria, Germany and Switzerland | Unrestricted | Regional (North America) |
| Out to Innovate - LGBTQ+ people | Matches mentees with professional mentors, group mentoring, networking, DEI advocacy | Applicants from Austria, Germany and Switzerland | Unrestricted | Unrestricted |
Building networks enhances institutional efforts and promotes inclusivity

Building a diverse and inclusive network helps promote a sense of identity and community that counteracts feelings of isolation often experienced by scientists throughout their careers. Mentoring networks, including peer mentors, should also be encouraged because they are more balanced in power and transparency, and less hierarchical. Peer mentor networks can be particularly effective for tackling same-career-stage challenges and opportunities. All these efforts should be accompanied by human resources training and implementing codes of conduct detailing best practices to make the whole experience for mentors and mentees more enjoyable and successful. By diversifying the academic community with which mentors and mentees actively engage, scientific advancement can be achieved in a nurturing environment that can have a strong, positive impact on productivity. Therefore, fostering mentorship networks should be a high priority for any academic institution undertaking DEI efforts.

Though not widely adopted, there are models for this approach worldwide (Table 1). Select academic institutions, professional societies, and conference organizers offer training programs to promote successful mentorship relationships that subsequently support diverse and more inclusive work environments. Although the outcomes of many programs have not yet been quantified or evaluated, some programs have minimized gender-specific barriers and reduced exclusion of URM scientists. Evaluating outcomes of mentorship programs remains challenging; traditional quantitative approaches may not be sufficient to capture how programs promote careers in nuanced, individualized ways that transcend the normative metrics of academic productivity and research impact (which themselves can promote inequalities). Even though assessment for such programs is challenging, the outcomes can be qualified within a range of acceptable parameters assessing individual, group, and institutional growth. Since women and URM scientists are generally more involved in formal and informal mentoring activities, overburdening may be detrimental for program implementation and success. Therefore, evaluations should be accompanied by incentive programs for mentors, such as release from administrative and departmental duties and provision of funding awards. Funding agencies should also: (1) explicitly include DEI requirements in their guidelines for grant spending, (2) provide resources to support reviewers, grantees, and institutions in the implementation of mentoring networks that could arise within institutions or from collaboration networks, and (3) hold grantees accountable if not following those guidelines.

Steps forward

Policy changes and active implementation of programs that promote effectively, diverse mentorship networks can help women and URM to fully achieve their potential as scientists. And yet, we see a disheartening lack of resources directed to career development, leadership, and mentorship programs in some regions. For example, our own experiences and observations indicate there is a particular dearth of these resources across the Global South (i.e. Latin America, Africa, and South Asia). Indeed, other than collaboration groups or a few institutional efforts, many academics worldwide have no support to successfully navigate the mentoring process, establish healthy relationships with their mentors or mentees, or even have a resource to which they can turn should problematic situations arise.

A diverse environment improves working and learning experiences for the people involved, brings new perspectives to research, encourages more people to work in STEM fields and academia, and improves opportunities for everyone involved. To achieve this goal, we urge all agencies, foundations, institutions,
and societies to use the many existing examples to inform their development of programs to generate effective mentoring relationships within their sphere of influence. We also present a step-by-step framework to diversify and build mentorship networks that includes all the aspects discussed in this commentary (Fig. 2). Building effective, diverse, multi-mentor networks can only work when programs are informed and accompanied by institution-wide DEI policy implementation, reflect diversity of the community in which institutions are embedded, and synchronize support for all organizational and career levels. Healthier work environments, more inclusive science training, and better outcomes for professionals from all backgrounds would ideally ensue as successful program implementation broadens, creating a virtuous cycle of enriched mentoring for future generations.

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**Competing interests**

The authors declare no competing interests.

**Additional information**

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