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COMMENTARY

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Leveraging national laboratories to increase Black representation in STEM: recommendations within the Department of Energy

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Abstract

Increasing diversity in STEM disciplines has been a goal at scientific institutions for many decades. Black representation in STEM, however, has remained critically low at all levels (high school, undergraduate, graduate, and professional) for over 40 years, highlighting the need for innovative strategies that promote and retain Black students and professionals in STEM. We refocus efforts on increasing Black representation in STEM by promoting early exposure and continued engagement while leveraging national laboratories—an underutilized resource with immense potential to centralize diversity and inclusion efforts nationally.

Keywords Black students, STEM education, Department of Energy, Workforce development, Higher education

Introduction

Science, Technology, Engineering, and Mathematics (STEM) have consistently exhibited a shortage of trained professionals in industry and academia, affecting the competitiveness of the United States globally (US NSF-NSF 06-48: National Science Foundation Investing in America's Future Strategic Plan FY, 2006–2011, n.d.). Though colleges and universities have difficulty in recruiting and retaining students from all underrepresented groups in STEM programs (Carver et al., 2017), this difficulty is more pronounced for Black students, who are the least likely to complete an STEM degree. In 2018, Black students accounted for only 8.4% of bachelor's degrees, 8.3% of master's degrees, and 5.5% of doctoral degrees in STEM majors. Previous studies found that Black students are less likely than their white counterparts to complete an STEM degree highlighting disparities in minority representation in STEM. The lack of representation in STEM has been prevalent for over a decade and is not a newly emergent issue in diversity, equity, and inclusion (Hill et al., 2010; Medicine et al., 2016; Wilson, 2020). Although several factors may affect minority representation in STEM, previous studies have highlighted the importance of providing Black students with a nurturing and robust support system.

Main text

For decades, efforts to increase Black representation have been at the forefront of initiatives among the STEM workforce, including industry, academia, and

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government. In large part, programs that promote Black populations in STEM have modeled themselves after the Meyerhoff Scholars Program, administered by the University of Maryland-Baltimore County and considered the quintessential program for inclusion and equity for minorities in STEM, especially Black students (Stolle-McAllister et al., 2011). The Meyerhoff Scholars Program targets underrepresented undergraduate students interested in pursuing their doctorate. Using a cohort-based approach, students meet regularly with mentors and academic advisors to build a sense of community and belonging all in preparation for graduate school. More importantly, the Meyerhoff Scholars Program has 13 key components. These components include faculty involvement to build interpersonal relationships, bridge programs to assist student development and transition, financial support to assist students from low-income families, and cohort-based learning and development to improve student retention through the life of the program. Meyerhoff collaborates with the Howard Hughes Medical Institute, Louis Stokes Access for Minority Participation, and the Leadership Alliance among other programs to provide opportunities for its students. To date, the Meyerhoff Program has 385 alumni who have earned their doctoral degree including 49 alumni who hold faculty appointments.

To further reiterate, one of the primary reasons for the success of the Meyerhoff program is its administrative and financial backing by the institution, as well as being championed by multiple professors (both early- and late-career) across colleges. The Meyerhoff program has helped more than 400 Black students receive their B.Sc. in STEM, with 87% of those individuals continuing to a professional or graduate program (M.D. or Ph.D.). The value of this program is well documented: students within the Maryland area who entered the Meyerhoff Scholars Program were twice as likely to receive their B.Sc. and five times more likely to attend graduate school (Maton et al., 2016; Stolle-McAllister et al., 2011).

Additionally, programs such as Penn State's Millennium Scholars Program and North Carolina's Chancellor's Science Scholars Program have experienced similar successes modeling the Meyerhoff program to promote Black students in STEM (Sto. Domingo et al., 2019). However, faculty and administration's lack of sustained participation presents a significant roadblock to replicating these types of programs. Without sustained and broad-based commitment, which supports pedagogical practices (bridge programs, workshops, recruitment and retention of cohorts, etc.) that advocate for increased underrepresented minorities in academia, programs do not reach their full potential. This may be one of the main reasons Black representation in STEM has declined steadily since 2000, resulting in less than 5% of Black tenured professors across the United States (Stevens et al., 2021).

Higher education institutions have been the primary developers of programs focused on increasing Black representation in STEM. However, developing such programs becomes increasingly difficult when the undergraduate student body exceeds 1,000 students, because it becomes increasingly difficult to support individual student needs as student class size increases. These programs implement two strategies: (1) provide exposure to STEM and (2) create mentorship opportunities in STEM. Facilitated through workshops, short courses, and symposia, STEM exposure (1) is designed to immerse the greatest number of students in the STEM experience while also serving the purpose of helping to build foundational skills. Ideal for early undergraduates still exploring majors and potential career paths, students typically participate in journal clubs, skill development workshops, research methodology courses, and conferences to clarify what STEM fields are and develop transferable skills (Carpi et al., 2017). Though STEM exposure allows students to glimpse into potential careers, these experiences do not necessarily build a student's confidence to pursue an STEM degree. By contrast, providing mentorship opportunities (2) creates a fuller STEM experience by directly pairing students with faculty through summer internships, research for class credit, and independent study, allowing minority students to explore a potential STEM career.

This strategy facilitates strong personal relationships between students and faculty while also identifying potential candidates for graduate school. Though beneficial to creating the relationships needed to guide interest in STEM careers, many programs rest solely on the shoulders of professors or departments, which can only cater to a small subset of students. Additionally, other duties (acquiring funding and publishing) can supersede outreach efforts (Dzirasa, 2020; Erosheva et al., 2020), further limiting mentoring capacity. In that case, we need to investigate programs that have the capacity to mentor Black students. The lack of equitable access to resources––a common and recurring problem––must be addressed if there is a focus on increasing Black representation in STEM fields. Often, Black students are first-generation college students and may not possess the skills necessary to navigate STEM fields alone, making mentor–mentee relationships crucial in their development. When Black students foster a healthy relationship with a mentor, it can have a positive impact on their graduate experiences, providing support and a sense of connection and greater comfort (Alexander & Bodenhorn, 2015; Esposito et al., 2017; Young-Jones et al., 2013).

Department of Energy (DOE) laboratories foster and grow STEM programs that increase the number of Black students participating in STEM activities at multiple levels (Avendano et al., 2019; Corneille et al., 2020; King et al., 2021). There are 17 national laboratories that make up the DOE network encompassing an array of scientific disciplines ranging from computer science to high-energy physics to climate modeling. Located near many large cities; national laboratories are also geographically accessible to large numbers of minority populations throughout the United States—Chicago, Los Angeles, and New York—which are also home to the three largest U.S. public school systems. While these labs do not exist in the backyard of these communities, there is ample opportunity to develop satellite STEM education centers/sites to coordinate research activities; this strategy has already been applied by DOE labs and is not a new strategy to increase collaboration. Additionally, national laboratories participate in research areas that place a greater value on fostering collaborative and interdisciplinary teams, which is critical for establishing large-scale efforts and programs serving as an immersive learning environment for students to explore career opportunities. Examples of these types of programs include research initiatives on supercomputing, nuclear security, nanomaterials, and climate change, among other areas of interest, all of which can be leveraged to promote diversity, equity, and inclusion while also increasing Black representation in STEM. Even though equity in STEM is not the main focus of national laboratories, it remains one of their focus areas. Funding (whether governmental, foundational, or private) is readily available to improve Black representation in STEM at all levels. Also, national laboratories employ a highly diverse workforce, not only in terms of research disciplines but also in terms of cultural and demographic backgrounds. In addition to workshops and outreach programs, students also gain hard skills such as computer programming and coding of big data, nanomaterial fabrication, and molecular techniques in next-generation sequencing. Additionally, national laboratories provide soft skills that are directly translatable to the research workforce, such as grant writing, public speaking opportunities, and grant development that aligns with funding areas (Weller et al., 2010).

At the high school level, multiple DOE laboratories collaborate with local chapters of the National Association for the Advancement of Colored People's (NAACP) Afro-Academic, Cultural, Technical, and Scientific Olympics (ACT-SO). ACT-SO is the NAACP's flagship STEM program, which provides an immersive research experience for Black high school students interested in STEM. ACT-SO is designed in the same fashion as a college undergraduate research experience combined with a college readiness program. Following the conclusion of their research experience, students present their independent research project at the NAACP national conference. There are participating chapters throughout the United States; however, these programs differ among local chapters, often coinciding with the quality of labs students can access and the level of mentorship. Because DOE-sponsored chapters provide students access to top-tier facilities and have world-renowned scientists available to mentor, they have consistently been among the top awarded programs nationally. Students from Argonne's ACT-SO program have obtained STEM degrees from Washington St. Louis University, University of Chicago, and the California Institute of Technology, among many other esteemed universities. Also, multiple students are currently pursuing their doctoral degrees in STEM, suggesting that early exposure via the ACT-SO program helps promote their college readiness pertaining to STEM.

For undergraduates, DOE's Science Undergraduate Laboratory Internships (SULI) program places minority students in summer research programs. SULI emphasizes selecting students from historically Black colleges and universities and minority-serving institutions, indirectly helping facilitate the matriculation of these students into graduate programs at prominent universities. National laboratories also engage with Louis Stokes Alliances for Minority Participation (LSAMP) programs. Like ACT-SO, LSAMP programs differ significantly between institutions due largely to available resources. ACT-SO and LSAMP chapters that partner with research institutions (especially those run by community leaders or teaching-focused institutions) fare much better than those without similar partnerships.

While fostering early exposure opportunities are important for increasing Black representation in STEM, developing programs that facilitate the retainment of Black representation in STEM is just as critical. For graduate students, 12 of 17 DOE institutions actively participate in the National Consortium for Graduate Degrees for Minorities in Engineering and Science (GEM) Fellowship, which supports Black graduate students in STEM pursuing a master's and/or doctoral degrees by matching them to employers actively seeking to increase the diversity of their workforce. From an employer's perspective, the benefit of such a program is the direct access to young and diverse talent pursuing STEM degrees and looking for employment upon graduation. This also lowers significant cost and time barriers associated with identifying and recruiting diverse populations for potential employment.

Students who complete the GEM fellowship are 90% more likely to get a job with their GEM employer after

graduation, making this pursuit highly advantageous. Many U.S. universities participate in GEM, including the University of Michigan, Brown University, Harvard University, and Stanford University. Students also receive two summer internships with their matched GEM employer, and their tuition is fully covered during the program. While the program provides one-on-one mentorship, employers can select many GEM fellows, creating a cohort experience for the underrepresented students that is a critical component to minority success in STEM. This programmatic structure has worked particularly well for national laboratories, with more than ten participating institutions, including Argonne National Laboratory, Fermi National Accelerator Laboratory, Idaho National Laboratory, and Sandia National Laboratories. To promote minority representation at the tenure-track level, DOE has recently instituted many fellowships, such as the Walter Massey, Carolyn Parker, and James Gates fellowships, effectively bridging the doctorate to early career researcher pathway for minority researchers.

Conclusion

Although the aforementioned pipeline that bridges undergraduate, graduate, and postgraduate Black representation in STEM is framed in the context of ongoing work conducted at both Argonne and Fermi National Laboratories, similar strategies to connect Black STEM programs with national laboratories and their researchers already exist. However, connecting efforts among academia, community programs, and government into a nationalized program supported by DOE (or any other governmental institution) that bridges students at all levels have yet to be developed. Undertaking this endeavor builds Black STEM programs that can be sustainable, modular, and interconnected to support students and provide them with new opportunities. To that end, and to continue to increase Black representation in STEM careers, we recommend the following.

- Implement system-wide high school research programs: National laboratories should implement a system-wide high school research program focused primarily on developing Black students, leveraging their research workforce, state-of-the-art facilities, and focus areas to expand Black representation within their respective fields.
- Develop strategic partnerships among community leaders, academics, and researchers in STEM: Program ambassadors should consist of early career researchers, community partners, and senior leadership working toward multi-institutional support to generate a bridge pipeline that transects multiple academic levels, including high school, undergraduate, graduate, and postgraduate levels. The pipeline should highlight three areas: promoting early exposure to research, creating sustainable undergraduate research opportunities that align with graduate research programs, and developing collaborations that increase the recruitment of Black students for entry into this pipeline at the high school level.
- Create early exposure research opportunities for Black students: (1) Universities should seek to promote minority STEM programs like LSAMP that prepare students for summer internships. (2) National laboratories should leverage their postdoctoral workforce to mentor minority students who are not from R1 institutions, aligning research experiences with national laboratory directives. Also, (3) national laboratories should seek to develop collaborations with professors that allow students in minority research programs to transition to summer internships within the national laboratory system. Symposiums and workshops should be provided for these students at a local and/or national level to generate cohorts to assist students in building professional networks.
- Increase investment of graduate fellowships for Black students that support engagement with government and industry: National laboratories should increase their vested interest in the GEM program (and similar programmatic structures) by increasing the number of minority candidates accepted at each site. To increase engagement, mentors should sit on the committees of GEM fellows to increase communication between the student and lab mentor. Furthermore, national laboratories should create postdoctoral fellowships that bridge students from their doctoral to postdoctoral positions, focusing on aligning their research with DOE scientific focus areas.
- Leverage joint appointments to foster collaborations between government and academia: To strengthen institutional ties, a cooperative agreement between national laboratories and nearby academic institutions should be established between two to develop joint appointments. This will simultaneously give researchers at national laboratories access to students while also strengthening funding applications for academics via access to state-of-the-art facilities and resources.

We recognize that each recommendation presented has its own set of inherent challenges and barriers. The programmatic structure presented represents a large-scale effort with many moving parts requiring stakeholder at the executive levels of academia and government. Additionally, cooperative strategic agreements would require an immense funding source, and the program would

need to be self-sustainable beyond the life of the funding. Most importantly, national laboratories are not teaching institutions making it challenging to align values of high-level research with student development. As previously mentioned, multiple models exist within national laboratories to develop the next generation of researchers. The main challenge is interconnecting this infrastructure.

We urge everyone—academics, governmental researchers, and community programs—to take action and collectively work together to improve Black representation in STEM that fosters collaborative engagement to promote diversity, equity, and inclusion. The same innovative approaches we use to advance research can be directed at improving diversity, equity, and inclusion and the number of Black researchers in STEM. National laboratories, such as DOE, provide an excellent opportunity to increase Black representation in STEM and are especially useful in developing programs that strategically foster and bridge the development of minorities in emergent areas of STEM.

Abbreviations

ACT-SO	Afro-Academic Cultural, Technical, and Scientific Olympics
DOE	Department of Energy
GEM	Graduate Education for Minorities
LSAMP	Louis Stokes Access for Minority Participation
NAACP	National Association for the Advancement of Colored People
STEM	Science, Technology, Engineering, and Math

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References

Alexander, Q. R., & Bodenhorn, N. (2015). My rock: black women attending graduate school at a southern predominantly White University. *Journal of College Counseling, 18*(3), 259–274. https://doi.org/10.1002/jocc.12019

Avendano, L., Renteria, J., Kwon, S., & Hamdan, K. (2019). Bringing equity to underserved communities through STEM education: Implications for leadership development. *Journal of Educational Administration and History, 51*(1), 66–82. https://doi.org/10.1080/00220620.2018.1532397

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

Carver, S. D., Van Sickle, J., Holcomb, J. P., Jackson, D. K., Resnick, A. H., Duffy, S. F., Sridhar, N., Marquard, A. M., & Quinn, C. M. (2017). Operation STEM: increasing success and improving retention among mathematically underprepared students in STEM. *Journal of STEM Education: Innovations and Research, 18*(3), 30–39.

Corneille, M., Lee, A., Harris, K. N., Jackson, K. T., & Covington, M. (2020). Developing culturally and structurally responsive approaches to STEM education to advance education equity. *Journal of Negro Education, 89*(1), 48–57.

Dzirasa, K. (2020). Revising the a priori hypothesis: systemic racism has penetrated scientific funding. *Cell, 183*(3), 576–579. https://doi.org/10.1016/j.cell.2020.09.026

Erosheva, E. A., Grant, S., Chen, M.-C., Lindner, M. D., Nakamura, R. K., & Lee, C. J. (2020). NIH peer review: Criterion scores completely account for racial disparities in overall impact scores. *Science Advances, 6*(23), eaaz4868. https://doi.org/10.1126/sciadv.aaz4868

Esposito, J., Lee, T., Limes-Taylor Henderson, K., Mason, A., Outler, A., Rodriguez Jackson, J., Washington, R., & Whitaker-Lea, L. (2017). Doctoral students' experiences with pedagogies of the home, pedagogies of love, and mentoring in the academy. *Educational Studies, 53*(2), 155–177. https://doi.org/10.1080/00131946.2017.1286589

Hill, C., Corbett, C., & St. Rose, A. (2010). Why So Few? Women in Science, Technology, Engineering, and Mathematics. In: *American Association of University Women*. American Association of University Women. Retrieved from https://eric.ed.gov/?id=ED509653

King, N. S., Collier, Z., Johnson, B. G., Acosta, M., & Southwell, C. N. (2021). Determinants of Black families' access to a community-based STEM program: a latent class analysis. *Science Education, 105*(6), 1100–1125. https://doi.org/10.1002/sce.21669

Maton, K. I., Beason, T. S., Godsay, S., StoDomingo, M. R., Bailey, T. C., Sun, S., & Hrabowski, F. A. (2016). Outcomes and processes in the Meyerhoff scholars program: STEM PhD completion, sense of community, perceived program benefit, science identity, and research self-efficacy. *CBE Life Sciences Education, 15*(3), 48. https://doi.org/10.1187/cbe.16-01-0062

National Academies of Sciences, Engineering, and Medicine. (2016). *Barriers and opportunities for 2-year and 4-year stem degrees: systemic change to support students' diverse pathways*. National Academies Press.

Stevens, K. R., Masters, K. S., Imoukhuede, P. I., Haynes, K. A., Setton, L. A., Cosgriff-Hernandez, E., Lediju Bell, M. A., Rangamani, P., Sakiyama-Elbert, S. E., Finley, S. D., Willits, R. K., Koppes, A. N., Chesler, N. C., Christman, K. L., Allen, J. B., Wong, J. Y., El-Samad, H., Desai, T. A., & Eniola-Adefeso, O. (2021). Fund Black scientists. *Cell, 184*(3), 561–565. https://doi.org/10.1016/j.cell.2021.01.011

Sto Domingo, M. R., Sharp, S., Freeman, A., Freeman, T., Harmon, K., Wiggs, M., Sathy, V., Panter, A. T., Oseguera, L., Sun, S., Williams, M. E., Templeton, J., Folt, C. L., Barron, E. J., Hrabowski, F. A., Maton, K. I., Crimmins, M., Fisher, C. R., & Summers, M. F. (2019). Replicating Meyerhoff for inclusive excellence in STEM. *Science, 364*(6438), 335–337. https://doi.org/10.1126/science.aar5540

Stolle-McAllister, K., Sto. Domingo, M. R., & Carrillo, A. (2011). The Meyerhoff way: How the Meyerhoff scholarship program helps black students succeed in the sciences. *Journal of Science Education and Technology, 20*(1), 5–16. https://doi.org/10.1007/s10956-010-9228-5

US NSF - NSF 06–48: National Science Foundation Investing in America's Future Strategic Plan FY 2006–2011. (n.d.). Retrieved November 8, 2022, from https://www.nsf.gov/pubs/2006/nsf0648/nsf0648.jsp

Weller, R. E., Burbank, R. L., & Mahy, H. A. (2010). *Outreach and education in the life sciences a case study of the U.S. Department of Energy National Laboratories (PNNL-19237)*. Pacific Northwest National Lab (PNNL.

Wilson, C. J. (2020). What needs to change in academia to increase the number of black scientists and engineers? A son of redlines. *Cell Systems*. https://doi.org/10.1016/j.cels.2020.06.014

Young-Jones, A. D., Burt, T. D., Dixon, S., & Hawthorne, M. J. (2013). Academic advising: Does it really impact student success? *Quality Assurance in Education, 21*(1), 7–19. https://doi.org/10.1108/09684881311293034

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