The Science of Improving Lives Through STEM Education for All:

Reflections on Expert Conversations on Diversity, Equity, and Inclusion in STEM

While across the United States employers are stressing the need for diversity, equity, and inclusion (DEI) in their workforce, careers in science, technology, engineering and mathematics (STEM) remain heavily dominated by white men. "Higher education pipeline suggests long path ahead for increasing diversity," reads the headline of a recent report from PEW Research.

The higher education pipeline starts well before students graduate from high school. That's why FHI 360 brought together thought leaders for a series of three expert conversations about how to increase DEI in STEM education. Called "The Science of Improving Lives through STEM Education for All," the series was designed to support diverse, equitable and inclusive learning environments and improve knowledge of theory and practice related to DEI in STEM. It also reflects FHI 360's commitment to DEI in all aspects of work and programming, underscoring our mission to "advance equity, health and well-being through data-driven locally led solutions."

The speaker series featured seven STEM education experts from the academic, nonprofit and government sectors who shared insights, research, and personal experiences with DEI in STEM. Below, we discuss six key, interrelated recommendations that emerged.

Introduce Children to STEM Early

Children have a natural curiosity about the world around them that can ignite a life-long passion in STEM. So, each panel began with the question: "What was the first experience that sparked your interest in STEM and how have your background and personal experiences influenced your career choice and research interests?" For most of the panelists, their early positive engagements with STEM as young children—through activities such as exploring outdoors, fishing in a pond, running through cornfields, making mud cakes, or camping—shaped their interest in pursuing science.

But the panelists also noted that for Black and other marginalized children, early experiences with STEM are not necessarily positive. Nicole Joseph, Associate Professor of mathematics and science education in the department of Teaching and Learning at Vanderbilt University, recalled that when she was in her 3rd grade math classroom, she would raise her hand, but the teacher never called on her. One day, her mother was standing outside the classroom door and saw her Black daughter being ignored by the teacher, so she tried to get her transferred to a different class. As it turned out, there was no other class except advanced placement, so that's where she went.

> **"Growing up I thought science was fun and I wanted other people to see that it's fun and a tool to understand the world around you no matter what you did for a living."**
>
> – Anita Krishnamurthi
> Senior Vice President
> STEM and Youth Engagement
> Afterschool Alliance

> **I was initiated into science as a young girl who grew up in rural NC. I fed the hogs and ran through the cornfields. My introduction to nature and science were in front of me. I always had an interest in science but ran into challenges as a black woman in a field dominated by men."**
>
> – Felicia Moore Mensah
> Department Chair of Mathematics, Science, and Technology
> Science Education Program Director
> Teachers College, Columbia University

Nicole Joseph says the transfer changed the trajectory of her entire life. She thrived in the class and continued to take advanced math classes. Today she is a professor of math and science education. While her story ended well, she pointed out that her case is not typical, and many marginalized students don't have the same opportunities she did.

> **The role of mentors for children and young adults is incredibly important in directing them into STEM fields. It was parental influence and direction of mentors that made the difference for me embarking on my career. And the ongoing influence of mentors encouraged me to continue when I sometimes felt I needed to choose a different path."**
>
> – Rosalyn Hobson Hargraves
> Director, Division of Undergraduate Education,
> National Science Foundation
> Associate Professor, Electrical and Computer Engineering, Teaching and Learning
> Virginia Commonwealth University

Engage Families in Their Children's STEM Education

As Nicole Joseph's story illustrates, family support and encouragement are critical to children's success in STEM. The panelists noted good evidence indicating that students are strongly influenced by their family's perceptions of STEM. Participating as a family in STEM activities such as conducting simple experiments, visiting science museums, or stargazing can build children's skills and create positive associations with STEM. It also can help break down stereotypes about who can engage in STEM activities.

The panelists also highlighted the importance of involving parents and other family members in their child's STEM education. "It is not only important to build community with your students in the classroom but to build that community with parents as well," said Elizabeth Edmonson, Research Associate Professor in the Department of Teaching and Learning in the School of Education at Virginia Commonwealth University.

Panelists noted the need for schools to build community with all parents around STEM through translating STEM materials into languages families speak at home, hosting family science nights or planning a science day for the entire school so parents can see their children engaged in STEM activities.

Make STEM Education Culturally Relevant

While the panelists' early experiences with STEM at home were pivotal, their experiences with STEM in school were very different. In many cases, teachers were discouraging, classrooms were not diverse, and lecture halls were huge and impersonal, with little or no interaction. Several panelists called for STEM education to be less threatening and more engaging for all students—especially for those who have been made to feel that they don't belong in STEM.

The panelists pointed out that part of the problem is how STEM is often taught—overly didactic, highly theoretical, and less hands-on. Consequently, students are often uninterested in STEM because they miss the connections to themselves, their cultures, and the real world. Felicia Moore Mensah, Department Chair of Mathematics, Science and Technology at Teachers College, Columbia University, shared that she grounds her teaching in "the three tenets or pillars of culturally relevant teaching—academic success, cultural competence, and social, political consciousness." She asked, "How do we really think about the investment of educational equity and racial equity through the content we are teaching so that we are developing people who can think along the lines of the individual, the community, and the nation?"

> **It is essential to prepare teachers about gender responsive, culturally relevant teaching and curriculum that empowers them to become advocates."**
>
> – Holly Miller
> Afterschool and Summer Learning Fellow,
> Institute of Education Services
> U.S. Department of Education

Panelists pointed out that students need to be prepared to counter the prevailing narrative of who can and can't be a scientist.

Anita Krishnamurthi, Senior Vice President for STEM & Youth Engagement at the Afterschool Alliance, called for working with communities to ensure STEM education is culturally relevant. "We have to design programs with communities and with practitioners," she said. "There is no silver bullet. The question we have to ask ourselves is, what works for who under what circumstances. What does success look for the whole community—young people, parents and community members?"

> **The onus is not on fixing the youth, it is on fixing the system."**
>
> – Julie Johnson
> Program Director
> Division of Research on Learning in Formal and Informal Settings
> National Science Foundation

Create a More Diverse Educator Workforce

Increasing DEI in STEM requires increasing DEI in the teaching workforce. Teachers of color not only are highly underrepresented in the U.S. (nearly 80 percent of U.S. teachers are white), but they also leave the profession at a higher rate than their white peers.

Having a more diverse teacher workforce gives students of color more opportunities to see themselves in STEM. A more diverse teacher workforce has a powerful impact on Black students in particular. For example, a 2018 study found that Black students who had just one Black teacher were 13 percent more likely to enroll in college, while those who had two Black teachers were 32 percent more like to go on to college. For Black boys from families with low incomes, having a Black teacher cut high school dropout rates by 39 percent. Moreover, Black teachers often have higher expectations for Black students than white teachers do.

"We must do the hard work of addressing the diversity problem in our teacher workforce," said Felix Fernandez, a principal research scientist at FHI 360 who facilitated one of the panels. "Students need to see their own cultures reflected in the adults responsible for their learning."

Felicia Moore Mensah added that educators need to do more to uncover their existing biases. "Before we make any changes to our pedagogy, we need to have deep reflections about who we are as teachers and our assumptions," she said.

Change should begin with teacher education. The panelists called for raising awareness among teacher educators about how whiteness is always present and how it impacts how they teach, who they are teaching, and who they are themselves. They also highlighted the importance of better preparing preservice teachers, a majority of whom are likely to identify as white, to reach a diverse student body.

> **"Society needs different people at the table to become STEM faculty to think in more transformative ways."**
>
> – Nicole Joseph
> Associate Professor,
> Mathematics and Science
> Education, Department of
> Teaching and Learning
> Vanderbilt University

Take Advantage of Out-of-School Time

Out-of-school time (OST)—including afterschool programs, museum exhibits and programs, and youth serving organizations—is an extremely valuable resource for DEI in STEM, the panelists said.

This is especially true given the time, resources, and effort required to change how STEM is traditionally taught. Teachers are frequently required to cover a single mandatory curriculum. During OST, educators are more often free to focus on activities based on students' interest, using culturally familiar materials, and with more direct relevance to students' lives. This addresses one of the leading reasons children abandon STEM: lack of relevance.

Research on OST programs in the U.S. indicates that youth from underrepresented groups are more likely to succeed and gain a positive STEM identity in OST. Young et al. (2019) found that OST programs "offer time, tolerance, safety, choice, and the ability to incorporate emotional, aesthetic, and social elements into learning activities.

OST can also provide opportunities to provide smaller, more intimate settings for learning with the staff as role models frequently from the same demographic as the students. The panelists also noted that OST settings are more frequently open to include parents and families in general programming or special activities.

Holly Miller, Afterschool and Summer Learning Fellow in the Institute of Education Sciences at the U.S. Department of Education, pointed out the specific advantage of OST for girls. "Out-of-school time can hold special magic for girls," she says. "Afterschool and summer programs allow young women to work alongside scientists and role models. They can experience STEM in their own comfort zone."

> **In order to help students develop a STEM identity, you have to prepare them to counter the prevailing narrative of who can/should be a scientist. You need to be reflective of your own beliefs and biases."**
>
> – Elizabeth Edmondson
> Research Associate Professor, Department of Teaching and Learning
> School of Education, Virginia Commonwealth University

Help Students Develop Their STEM Identity

Several panelists shared that it was important for them personally to develop a strong and positive identity as a STEM practitioner and that this identity was essential in propelling them forward. Data show that students who have a strong STEM identity are more likely to take STEM courses and persist to the academic finish line.

Formation of this identity is critical for students to see themselves as "belonging to" or as legitimate members of the community. As panelists explained, a STEM identity goes a long way in supporting retention in the STEM pipeline, generating a desire to pursue a STEM career and in fostering greater resilience in the face of obstacles. Having a solid STEM identity has been linked to students developing a sense of agency, and strong agency is often necessary to propel students along the STEM pipeline and into productive STEM careers.

Having a positive STEM identity has been linked to students developing a capacity for self-efficacy. As Rosalyn Hargraves explained, "It is important to know how to support self-efficacy. It has a lot to

do with success. It is important to ask, 'Am I successful at doing this?' and then to provide opportunities for students to demonstrate their capacity to be successful in this field."

Therefore, there is a need to help students develop a STEM identity and to foster their belief that they are competent, that they belong, and that STEM is for them. This is partly achieved by allowing them to do STEM as STEM professionals do it as well as through the influence and perceptions of immediate and extended family and the wider community. "You can never underestimate how hard it is for a young person to let go of "naysaying" from the community," said Julie Johnson, Program Director in the Division of Research and Learning at NSF.

Fostering a Strong STEM Identity

FHI 360 has developed programs and materials to support students' formation of a positive STEM identity—an identity that is key to their interest and persistence in STEM education and careers.

About FHI 360

FHI 360 believes that improving lives in sustainable, measurable ways is possible only when we connect ideas, resources and people who have a stake in the issues affecting their communities. We bring together experts across multiple disciplines to address ever-evolving human development challenges. FHI 360 hosts events in the United States and around the world, where speakers examine findings from research and practice in the areas of health sciences, education, social and economic development, and equity.

Our education work in the United States focuses on improving educational opportunities for people through services that include program design (e.g., the creation of models, protocols, tools, and materials), project management, professional development, school-based coaching, creation of local and national networks, and collective impact and program evaluation. We have worked at the intersection of education and community engagement for 50 years, solving critical issues in education and youth development through projects in 48 states and with more than 400 school districts.

Most recently, we have redoubled our focus on advancing and increasing equity in the US. We are committed to using an equity lens to guide and strengthen our work and decision-making processes so that we can make greater contributions to addressing social inequities based on, among other characteristics, race, sex, sexual orientation, religion, immigration status, and ability. We seek to bring about long-term systemic change in how our work, across all departments, reduces or eliminates social inequities. This new approach is intentionally designed to influence: (1) the kind of work that we pursue and respond to, (2) how we implement our work, and (3) how we communicate our work.

> An FHI 360 literature review revealed that implementing practices that support a positive mathematical identity can lead to improved outcomes, participation, and persistence in mathematics. The studies also suggested that numerous intervention programs have been developed to encourage women to pursue the field of mathematics. Potential strategies that have succeeded to some extent in making many women feel welcome in the discipline include constructivist learning techniques that encourage hands-on, real-world applications and problem solving; the use of positive same-sex mentors and role models; and reminding women of their many roles and identities to combat the negative influence of stereotype threat.

Our STEM projects engage all students from historically marginalized communities in STEM pathways. Most recently, “Furthering Girls’ Math Identity,” an NSF-funded project, advanced research and practice to foster girls’ engagement in math, and “Bridge to Employment” and “Women in Science, Technology, Engineering, Mathematics, Manufacturing and Design (WiSTEM2D),” both funded by Johnson & Johnson, introduce youth to STEM and related fields, connect students with STEM mentors and prepare them for STEM-related college and career readiness activities. FHI 360’s STEM programs, curricula and resources are used by more than 2,500 educators each year.

Acknowledgements

FHI 360 would first like to thank the panelists (described below) who so generously shared their time, expertise, and wisdom. Your conversations were both thoughtful and illuminating.

Thanks go to the team who planned and coordinated all the panels: Merle Froschl, Michelle Gilliard, Teshell Ponteen Greene and Maryann Stimmer. Thanks also to Linda Colon and Ben Dworken for their invaluable technical assistance as well as Felix Fernandez and Danielle Woodhouse Johnson for their help facilitating the panel discussions.

We would also like to acknowledge the team who worked together to turn the panel discussions into this publication, "The Science of Improving Lives Through STEM Education for All": Dylan Busa, Linda Colon, Merle Froschl, Maryann Stimmer, Pam Sutton, Jen Kristen Taylor, and Kelly Tungett.

Recommended Resources

The following resources were suggested by the panelists who participated in this series:

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- Gupta P, Hammerness K, Chaffee R, MachPerson A. (2022). Staying in science: examining the pathways of underrepresented youth mentored in research. American Museum of Natural History Longitudinal Research Overview. 2022;7. Available from: https://www.amnh.org/learn-teach/evaluation-research-and-policy/research/science-stem-career-pathways/staying-in-science-research-study-articles-and-presentations.
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- SciGirls CONNECT [Internet]. PBS Learning Media; c2024 [cited 2024 Apr 22]. Available from: https://pbsnc.pbslearningmedia.org/collection/scigirls/.

About the Speakers

Dr. Elizabeth Edmondson is a Research Associate Professor in the Department of Teaching and Learning in the School of Education at Virginia Commonwealth University (VCU). Her research interests include student engagement in classroom dialogue, culturally relevant practices in science classrooms, teachers as researchers, and teacher retention and induction models. Dr. Edmondson is the principal investigator on an NSF Noyce Track 1 grant and NIH NIDA funded project that engages teachers in research labs (Hero-T). She is also the co-principal investigator on the VCU SEED grant funded by the US Dept of Education, a Noyce Track 4 grant with the American Museum of Natural History, and a NOAA BWet grant. She has published book chapters, numerous peer-reviewed articles and reports, and has served on more than six dissertation committees. Dr. Edmondson has been involved with curriculum development with Carolina Biological and a national high school biology curriculum developed with Dr. W. Leonard at Clemson University. She delivers professional development for teachers across the K-12 spectrum.

Dr. Rosalyn Hobson Hargraves, Director, Division of Undergraduate Education, National Science Foundation (NSF) and Associate Professor, Electrical and Computer Engineering, Teaching and Learning, Virginia Commonwealth University (VCU). At NSF, she serves as the principal spokesperson and expert in undergraduate education research and works to advance the division's mission to "promote excellence in undergraduate science, technology, engineering, and mathematics (STEM) education for all students" at two-year and four-year institutions. Her research interests are in diversity, inclusion, and equity in higher education, STEM-H education, and biomedical signal/image processing. She is the recipient of numerous awards including the 2015 VCU Presidential Award for Community Multicultural Enrichment, the 2015 VCU Reise-Melton Award, the 2008 Dominion Strong Men & Women Excellence in Leadership Award, the Richmond Joint Engineers Council 2006 Engineer of the Year, and the National Society of Black Engineers National 2001 Janice A. Lumpkin Educator of the Year Award.

Dr. Julie Johnson is a Program Director in the Division of Research on Learning at the National Science Foundation where she has worked since 2013. She works with the Advancing Informal STEM Learning (AISL), Innovative Technology Experiences for Students and Teachers (ITEST), the Faculty Early Career Development (CAREER), and the Future of Work at the Human-Technology Frontier (FW-HTF) programs. Prior to coming to NSF, Dr. Johnson was a middle school science and math teacher, worked in museum education, and was the chief operating officer of an aquarium. She is experienced in performance assessment, creating organizational systems, supporting systems change, program development, evaluation, group facilitation, and effective communication with diverse external stakeholders. Dr. Johnson has B.S., M.S., and M.A. degrees in biology, instructional technology, and deaf education; she received her doctorate in Leadership and Change from Antioch University. Her current research interests focus on organizations with STEM-engagement as a major focus and include leader/leadership development, the intersections of relational practice and leadership, the intersections of organizational learning and leader development in place, and leadership in complex systems.

Dr. Nicole M. Joseph, Associate Professor of mathematics and science education in the department of Teaching and Learning at Vanderbilt University. She is the founder of the Tennessee March for Black Women in STEM, an event held every fall which seeks to bring together the Tennessee community to raise awareness of the gendered racism Black women and girls experience in STEM. Her research explores two lines of inquiry: (a) Black women and girls, their identity development, and their experiences in mathematics and (b) Whiteness, White Supremacy and how it operates and shapes underrepresentation of Black women and girls in mathematics.

Dr. Anita Krishnamurthi rejoined the Afterschool Alliance in August 2022 as Senior VP for STEM & Youth Engagement to design and lead the new Collective for Youth Empowerment in STEM & Society (CYESS) initiative to actively engage young people in tackling problems that impact their futures—solutions to which are often rooted in STEM. She had previously served as the Vice-President for STEM Policy at the Alliance from 2010-2017. Prior to rejoining the Alliance, Dr. Krishnamurthi lived and worked in the UK from 2017-2022 most recently serving as the Head of Education and Learning at the Wellcome Trust, a global health philanthropy based in London. She has a Ph.D. in Astrophysics and previously was the John Bahcall Public Policy Fellow at the American Astronomical Society. Dr. Krishnamurthi worked at NASA for six years at the agency's headquarters in Washington, D.C. and at its Goddard Space Flight Center. Prior to joining NASA, she worked at the U.S. National Academy of Sciences. She serves on the Boards of the STEM Education Coalition and National Girls Collaborative Project in the U.S. and Nobel Prize Outreach in Sweden.

Dr. Felicia Moore Mensah is the Department Chair of Mathematics, Science, and Technology and Professor of Science Education at Teachers College, Columbia University (New York City). Her most recent research utilizes critical race theory and intersectionality to transform teacher education research and practice. Her focus on preparing future teacher educators and teacher educators of color for racial literacy combines years of teaching, mentoring, and outreach in PreK-12 schools and postsecondary education. Prior to her life in academics, Dr. Mensah was a former high school science teacher, laboratory scientist, and worked in a regional hospital in their laboratory. She was the recipient of the 2024 Outstanding Mentor Award and 2017 Outstanding Science Teacher Educator of the Year (ASTE); the 2012 Early Career Award, Division K Teaching and Teacher Education (AERA); and an Equity and Ethics Scholar in 2005 (NARST). She is co-editor of the Journal of Research in Science Teaching, a Lead Editor of Cultural Studies of Science Education, and an associate editor of Learners of the African Diaspora Journal.

Dr. Holly Miller serves as the Afterschool and Summer Learning Fellow in the Institute of Education Sciences at the U.S. Department of Education. Dr. Miller is passionate about research-based educational policy that supports students and teachers achieving their full potential in STEM. She just completed an Albert Einstein Distinguished Educator fellowship and served in the U.S. Senate in Senator Jacky Rosen's office, working on policy and projects that promote success in STEM education. Prior to serving as an Einstein Fellow on Capitol Hill, Dr. Miller served as a STEM teacher for 12 years, teaching high ability students while serving as the school's

high ability and science fair coordinator. She has a B.S. in Psychological Science and Social Work, a M.A. in Teaching from Marian University, a M.S.W. in Clinical Social Work from Boston University, and recently completed her Ph.D. in STEM Curriculum and Instruction at Texas Tech University. Dr. Miller has received numerous awards for innovative STEM teaching including the 2020 Connections Award for Exemplary Teaching from the School Science and Mathematics Association, the 2017-2018 Presidential Award for Excellence in Math and Science, the 2020 Indiana Teacher of the Year, and the 2019-2020 National STEM Scholar Award. She currently serves as the Editor of STEM Stories for Indiana Council of Teachers of Mathematics Journal.