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RESEARCH

Broadening Participation in STEM

Evidence-based Strategies for Improving Equity and Inclusion of Individuals in Underrepresented Racial and Ethnic Groups

This summary is based upon work supported by the National Science Foundation under Grant No. 1818635. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

What Is the Issue?

Racial/ethnic groups (Blacks or African Americans, Hispanics or Latinos, American Indians, Native Hawaiians, Alaskan Natives, and other Pacific Islanders), women, and persons with disabilities continue to be underrepresented in science and engineering (S&E) fields (NSF, 2019). To address the persistent disparities, it is critical to develop and implement strategies that attract and retain students and professionals in STEM from these groups.

Why Is It Important?

Peckham, et al, (2007) argued that involving a range of perspectives in STEM discovery promotes innovation and can lead to better solutions for society. According to the 2017-2018 report to the U.S. Congress, the Committee on Equal Opportunities in Science and Engineering (CEOSE) emphasized that inclusion of diverse voices will result in more innovative and transformative S&E and an empowered society. Full participation of all STEM talent in the U.S. is essential for excellence in research and for the success of America in the global economy (CEOSE, 2016). To help develop U.S. STEM talent from all sectors of society, employers, higher education and PK-12 leaders, and out-of-school educators must make well-informed efforts to attract and retain people from underrepresented minorities.

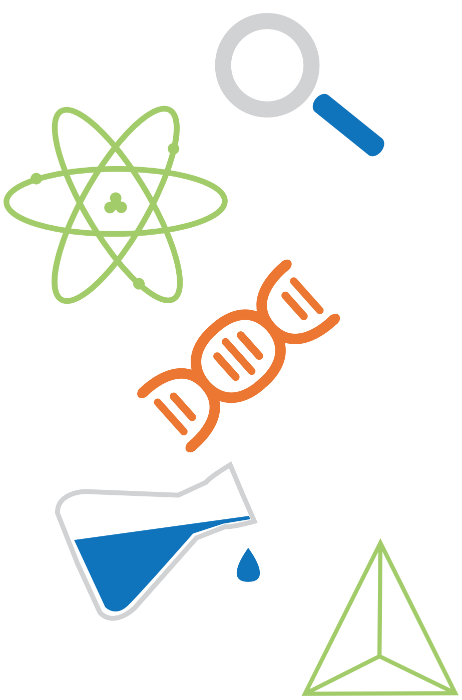
What Is the NSF INCLUDES Goal for Broadening Participation?

In 2016, the National Science Foundation (NSF) established the Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (INCLUDES) program to help address national challenges in broadening STEM participation. To make steady progress in efforts to broaden participation, NSF INCLUDES champions innovative approaches in scaling evidence-based best practices (James & Singer, 2016). The NSF INCLUDES National Network, a national movement to broaden participation in STEM with representation in every state and diverse STEM disciplines, is composed of partners from a wide range of organizations, including higher education, K-12, industry, government, non-profits, and research organizations. The NSF INCLUDES National Network, through its expansive collaborative infrastructure, is uniquely positioned to accelerate the scaling of identified, evidence-based broadening participation strategies.

What Will You Learn from This Brief?

This brief summarizes evidence-based strategies that can be used across different age ranges to encourage underrepresented racial and ethnic groups to participate and persist in STEM. We highlight strategies such as culturally relevant pedagogical practices, family support, hands-on learning, summer bridge programs, research experiences, counterspaces, and mentoring. The list is not exhaustive; we only cited published work within the last five years and that we believe relates to the context of INCLUDES. This is one of a series of briefs that will feature promising approaches for targeted groups underrepresented in STEM. This summary focuses primarily on student-centered practices at various academic levels (elementary through graduate education). We hope the findings will spark conversations among Network members, key stakeholders, and the broader STEM community about how to utilize collaborative approaches and shared resources to implement evidence-based strategies that can build a more inclusive STEM workforce. As you review the practices in this brief, please think about whether they are similar to approaches you have tried and whether there are other strategies you would recommend.

What are Some Effective Strategies to Broaden Participation in STEM?



Culturally Responsive Pedagogical Practices:
The practice of infusing cultural knowledge and real-life experiences into teaching and learning practices;

Family Support:
Engaging family members to encourage and support students to enter and stay in STEM educational experiences;

Hands-on Learning:
Experiential learning in which students are encouraged to participate in STEM fields through a variety of activities;

Summer Bridge Programs:
Academic programs that focus on including underrepresented groups for participation, with the aim to increase STEM education and workforce recruitment;

Research Experiences:
Undergraduate students' immersion in meaningful research experiences, which often is associated with increased interest in STEM careers;

Counterspaces/Safe Spaces:
Supportive environments that provide safe and inclusive experiences that promote belonging;

Mentoring:
The process by which more experienced researchers guide, advise, and establish long-term relationships that benefit a mentee's educational and career development.

Culturally Responsive Pedagogical Practices

Considering the forecasted growth and shifts in ethnic, racial, and cultural demographics in U.S. classrooms, it is critical for educators, scholars, and professionals to understand the value of culturally responsive pedagogy (Furuto, 2014) to better serve the needs of students, especially in STEM disciplines.

Funded by the National Science Foundation and U.S. Department of Education, the Ethnomathematics Institute offers professional development workshops and a one-week summer institute focused on infusing cultural knowledge into mathematics teaching to teachers in the State of Hawaiʻi. The teachers were provided with strategies to plan and implement culturally responsive mathematics pedagogy and connect classroom teaching to context-specific scenarios (Furuto, 2014). Over a five-year period, the project doubled the number of Native Hawaiian and Pacific Islander students in mathematics courses; added more mathematics courses and a degree program to meet the growing demand; and increased student performance.

Furthermore, Stevens, Andrade, and Pans (2016) suggest that contextualizing STEM learning from an early age stimulates students' interest and has the potential to increase their pursuit of STEM education. The successful engagement and retention of Native American elementary and middle school students in STEM education was attributed to a project that integrated in-school mentoring with out-of-school STEM activities (Stevens et al., 2016). The out-of-school STEM activities incorporated historical viewpoints with students' cultural knowledge and lived experiences, therefore making abstract science concepts relatable. The project, funded by the National Science Foundation, is a partnership between the University of Arizona, Strength Building Partners (a youth mentoring program), the Pascua Yaqui Tribe, and public schools that predominately serve Native American and Hispanic/Latino youth near the U.S.-Mexico border. In their study, Charleston, Charleston, and Jackson (2014) found culturally relevant interactions were instrumental in the pursuit and persistence of African Americans in computing sciences.

Family Support

Familial support and engagement are critical to underrepresented minorities' interest and persistence in STEM education (Henriquez, 2017). Encouraging students to discuss STEM topics with family and friends helps foster community interest and honors family knowledge. While there is no monolithic approach to engaging underrepresented minority families in STEM education, research supports that family and community involvement leads to children staying in school longer, performing better academically, and having a better school experience (Henriquez, 2017).

One study of 3rd-8th grade Native American students found that exposing them to local STEM educational experiences and industries and further inviting their families to these opportunities, helped increase interest in STEM (Stevens, Andrade, & Page, 2016). For many Latino students, families are deeply involved in the decision to go to college (Oseguera, 2017).

It is important to inform and engage these families during every step of the process from college preparation and planning to enrollment and attainment, as this creates a supportive environment to help students eventually graduate from college (Gutierrez, 2017). Once a student is enrolled in college, families can act as a network for support, regardless of their education level or ability to provide academic help (Foltz, Gannon, and Kirschmann, 2014). Furthermore, a study of Black males in engineering found that a combination of high parental expectations, firmness, encouragement, support, and continuous follow-up was vital in helping these students through the educational pipeline (Flowers, 2015). This research demonstrates that strategies to diversify the STEM workforce must go beyond the classroom; broadening participation is a holistic endeavor that also engages students' homelife.

Hands-on Learning

An increasing number of studies documented the importance of a hands-on learning approach to develop creativity and interest in STEM fields. LaMotte (2016), for instance, identified that hands-on learning practices have strengthened the interest of girls in learning STEM fields. Using the experiences of the STEM Collaborative Project at California State University, Kezar and Holcombe (2018) have shown the value of providing hands-on experiences—whether it is a field trip or a simulated experience of the task—in creating interest and maintaining students' motivation in STEM fields.

Beyond building students' interest in STEM, hands-on learning contributes to building students' learning and agency, thereby setting students on a growth trajectory. Hands-on learning also builds students' research capacity. Using a case from the NSF Research Experience for Undergraduates' program (REU), Yang et al., (2019) documented how underrepresented students built their research skills and positive experiences through hands-on learning activities designed through a summer REU site program focused on cybersecurity.

Summer Bridge Programs

Numerous studies have documented the importance of summer bridge programs in diversifying STEM education and workforce (Ashley, Cooper, Cala, & Brownell, 2017; Bruno et al., 2016; Tomasko, Ridgway, Waller, & Olesik, 2016; Wolfe & Riggs, 2017). A joint effort between the University of Hawai'i at Mānoa's Native and Kapi'olani Community College offered a one-week summer program to the community college students to foster their transfer to geoscience degree programs at the four-year university (Bruno et al., 2016). During this week, students were exposed to information about geoscience degrees and careers; went on field trips to geological sites and the ocean (research vessel); and connected with alumni, advisors, and faculty. The summer bridge program was credited for increasing the enrollment of Native Hawaiians and other minority students in geoscience majors. Five program alumni who had not expressed interest in geosciences prior to participating in the program went on to pursue the major at the university.

African American undergraduates who participated in the Meyerhoff Scholars Program, a summer bridge for prospective undergraduate students at the University of Maryland, were found to be almost five times likely to complete STEM doctorates than their counterparts who were accepted into the program but declined the offer (Maton et al., 2016). Study findings suggest that the sense of community experienced by participants in the summer program was paramount in enhancing their science identity and research science efficacy, and subsequently their success in attaining advanced degrees in STEM.

Research Experiences

The benefit of hands-on student research experience has been well documented in increasing participation and improving key academic outcomes in STEM fields (Banks, Fresquez, Haeger, Quinones-Soto, & Hammersley, 2018; Yang, Xu, Yeh, & Fan, 2019). Several programs use different strategies in providing opportunities to students. For instance, in an effort to expand and diversify Hawai‘i's undergraduate geoscience enrollment, the School of Ocean and Earth Science and Technology has invested considerably in building the research experience of undergraduate students through summer-long paid opportunities to conduct undergraduate research. The research experience was embedded within oceanography field trips, where students met with scientists to learn more about maritime studies (Bruno et al., 2016).

Another recent andinnovative approach uses photovoice in education fields. Photovoice is a participatory action research method that enables participants to construct learning through their own experiences and individual ideas. Photovoice first started in the health field, yet it is now expanding to education fields. Photovoice also empowers voices from marginalized communities. Photovoice enables students to co-create and participate in research methods by thinking and reflecting on their experiences. Expanding on this concept, photo-elicitation can give more voice to participants—enhancing how they can provide a more in-depth description and narration of their experiences. Adding to this work, Chelberg and Bosman (2019) cited photo-elicitation and photovoice as innovative approaches when mentoring students from historically underrepresented groups.

Based on his work on community college partnerships, Oseguera (2017) found that authentic undergraduate research experiences are key factors in maintaining interest in STEM as well as increased degree completion. Hewlett (2018) documented the success of the Community College Undergraduate Research Initiative (CCURI), a national network of 115 community colleges in more than 30 states, in fostering research experiences for two-year programs. A unique aspect of the CCURI model is that it mitigates barriers to integrating student research experiences by training professionals at participating community colleges to develop strategic plans that seek to change institutional culture (Hewlett, 2018).

Counterspaces/Safe Spaces

Endeavors geared toward retaining underrepresented minorities in STEM should pay more attention to safe social spaces, or counterspaces, which offer supportive environments and enhance feelings of belonging in STEM (Alonso, 2015; Ong, Smith, & Ko, 2018). Lane (2016) explored the role of undergraduate research sites at a predominantly White institution in developing and strengthening science identity among Black students in STEM. In this case study, the research environments served as counterspaces that affirmed and validated students' identities as budding Black scientists and engineers. In these spaces, Black students were provided with the opportunity to fully exhibit their intellectual prowess "without being judged," and many reported experiencing heightened confidence in their ability to engage in scientific practices and contribute to the advancement of the knowledge base.

The findings suggest that exposing Black students to STEM research conditions that affirm their racial and disciplinary identities is associated with positive academic outcomes. The research sites functioned as counterspaces for students, where being Black was congruent with being scientists or engineers.

In a study with women of color in STEM, participation in counterspaces was found to contribute to their persistence and success in STEM (Ong, Smith, & Ko, 2018). Study participants identified a range of interactions at counterspaces outside of their STEM departments that offered opportunities and networks that advanced their persistence: 1) peer-to-peer relationships; 2) mentoring relationships; 3) STEM diversity conferences; and 4) STEM and non-STEM campus student groups.

Findings from Alonso (2015) revealed that the Society of Hispanic Professional Engineers (SHPE) acted as an academic, social, and professional counterspace for students, which cultivated the development of Latina/o undergraduates' engineering identities. Through SHPE, students engaged in community outreach, were exposed to role models who looked like them, and were nurtured by a network of engineers—solidifying their identity as engineers. Students regarded becoming an engineer as a collective accomplishment rather than just individual success.

Mentoring

Mentoring is well-documented as an integral element in the persistence of underrepresented minorities in STEM and in efforts aimed at increasing their participation (Charleston, Charleston, & Jackson, 2014; Estrada, Hernandez, & Schultz, 2018; Metevier, Seagroves, Shaw, & Hunter, 2015; and Zaniewski & Reinholz, 2016). Burt, Williams, and Palmer (2018) found a positive relationship between mentoring and the persistence of Black men in engineering graduate degrees. The study described how the students' graduate experiences were shaped by the sustained effects of undergraduate mentoring. Black men reported drawing from lessons imparted to them by their undergraduate mentors to navigate graduate studies.

Among successful Latina scientists and engineers, mentoring was found to have contributed positively to their career success (Miguel & Kim, 2015). In particular,access to multiple mentors, a mix of mentoring approaches, supportive and encouraging mentors, and having a shared understanding (mentor-mentee) of the mentoring relationship were essential ingredients to this group's career development and success.

Metevier, et al. (2015) described a rigorous mentoring endeavor in Hawaiʻi through the Akamai internship program that incorporates inquiry, equity and inclusion, and assessment. The program's mentoring efforts have been linked to broadened access of Native Hawaiians, especially in engineering fields and enhanced persistence in STEM (81% of alumni persisted in STEM pathways).

Estrada, Hernandez, and Schultz (2018) found that effective undergraduate mentorship fostered science self-efficacy, identity, and values of underrepresented minorities. Study participants reported experiencing a sense of belonging and believed they would complete their degrees and become successful STEM professionals. Strong peer support has also been found to help students underrepresented in STEM strengthen their identity and sense of belonging, and ultimately increase retention and career aspirations (Dennehy & Dasgupta, 2017; Zaniewski & Reinholz, 2016).

KEY TAKEAWAYS

The strategies described above, embedded in each project and program, show the divergence of approaches used across the STEM fields, yet provide considerable evidence for positive results for both students and the research community. Looking across these evidence-based strategies, we note the following approaches may support program success:

Design for local needs. Although the strategies featured in this brief have evidence of success in varied contexts, no single solution works in all contexts.

The role of partnerships. Most evidence for success in this brief arose in projects structured as partnerships, for example among school districts and local higher education institutions, two-year and four-year colleges, in-school and out-of-school entities, and undergraduate and graduate programs.

Multicomponent approach. Many of the featured studies integrated multiple strategies at the same time to advance participation in STEM fields.

Next Steps

The aim of this review is to stimulate conversations about successful approaches to achieving diversity and inclusion in STEM, as well as the value for action-oriented collaborations to broaden participation in STEM. We will follow up with network-wide conversations to elicit feedback about how your INCLUDES work might align with these strategies. We also want to use this platform to learn about other strategies that have been found effective in increasing the participation of groups underrepresented in STEM.

You can contribute to these discussions at www.includesnetwork.org.

Here are several questions to spark conversation:

» **Have you successfully implemented any of the strategies discussed? Would you like to share your experiences, lessons learned, and types of outcomes achieved with the INCLUDES Network?**

» **What other strategies have you found effective in increasing the number of underrepresented students in STEM?**

To access this, and other resources to support your DEI and broadening participation efforts, please join the INCLUDES National Network at www.includesnetwork.org.

Suggested citation
NSF INCLUDES Coordination Hub (2020). Broadening Participation in STEM: Evidence-based Strategies for Improving Equity and Inclusion of Individuals in Underrepresented Racial and Ethnic Groups (Research Brief No. 1). Available at https://www.includesnetwork.org/viewdocument/coordination-hub-research-brief-im?CommunityKey=5e902dcd-362e-47be-a076-16bc71e2f038&tab=librarydocuments.

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