CADRE Brief

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Partnership Building as a Broadening-Participation Strategy: Helping Researchers and Developers Bridge the Gaps in STEM Education

THE PROBLEM

The United States is undergoing a dramatic demographic shift. The U.S. Census Bureau projects that by 2044, over 50 percent of the population will comprise people of color. By these estimates, no one race or ethnic group will hold a majority, making the United States a truly pluralistic society for the first time in its history.[1] During this same period, the United States is anticipating significant job growth in the fields of science, technology, engineering, and mathematics (STEM). Historically, African Americans, Latinos, Native Americans, and women of all racial and ethnic backgrounds have been severely underrepresented in STEM educational and professional fields. With demand for STEM professionals high and supply dwindling as demographics shift, broadening the participation of underrepresented groups in STEM education and professions has been a focal point for policymakers. To expand STEM educational and professional opportunities, stakeholders at the local, state, and national levels have developed initiatives to broaden participation in STEM, with particular attention to increasing racial, ethnic, and gender diversity.[2] Yet, despite over a decade of initiatives devoted to broadening participation, these fields are no more diverse than they were previously.[3] This brief explores this continued underrepresentation, assesses the limitations of common broadening-participation strategies, and offers insight into how establishing strategic partnerships can help researchers and developers bridge the gaps in STEM fields.

UNDERREPRESENTATION IN STEM

Notable progress has been made in terms of understanding how different students learn and how teachers can adapt curricula and improve instruction to appeal to increasingly diverse student bodies.[4] Still, even with these new initiatives and the insights gained, participation of historically underrepresented groups remains low. Underrepresentation is often associated with a lack of interest among members of these groups,[5] resulting

in broadening-participation efforts that are driven by questions such as, "How can we motivate students to choose STEM fields?" But, Byars-Winston[6] explains that even when levels of interest are high, many students from underrepresented groups become "systematically disconnected" from STEM fields over time. For instance, in 2009, 36 percent of the students from underrepresented groups did not pursue a job or graduate degree in a STEM field after earning a STEM bachelor's degree.[7] The reasons for this are no doubt varied and complex, but some researchers have suggested that perhaps the culture of STEM itself it a contributing factor.[8,9,10]

The underrepresentation of women and racial/ethnic minorities in STEM fields has been attributed to a number of factors, including different professional interests and goals, variations in education and career paths, and a lack of STEM identity.[11]

Professional Interests and Goals

Members of underrepresented groups report not being encouraged to pursue STEM fields. Despite high levels of interest and motivation, many of these individuals have limited knowledge of the multitude of STEM educational and professional opportunities and how those relate to their own interests, values, or goals.[12] For instance, girls typically report greater interest in careers that allow them to "help others and make the world a better place." Because of this, they tend to gravitate toward careers that allow them to work with people directly rather than toward STEM fields.[13] In a study of successful women of color in science, respondents cited an "interest in humanity" and "altruistic career goals" as their motivation for pursing science. By framing science as a vehicle for serving humanity, these women were able to establish their own identities as STEM professionals that linked to their values and career goals.[14] Similarly, people of color often display greater interest in pursuing careers that allow them to remain connected to their communities.[15] Having a greater understanding of the ways in which STEM subjects can connect them with people and contribute to community well-being may encourage more people from underrepresented groups to pursue STEM fields.

Educational and Career Pathways

Fealing and Myers[16] argue that regardless of where points of intervention lie, broadening-participation initiatives are typically designed under the assumption that there exists a "dominant pipeline" toward STEM careers. So far, though, increasing the number of underrepresented students going into this "dominant pipeline" has not translated into increased diversity in the field. This assumption fails to acknowledge the variety of pathways that lead students to STEM fields. The authors explain that there are pathways to participation in STEM, such as attending minority-serving institutions (MSIs) or community colleges, which are disproportionately pursued by members of underrepresented groups. "There are multiple routes towards the required training for science careers and . . . the underlying problem is not the under-supply of graduates in science but barriers that undervalue these alternative routes taken by women and minorities."[18] Validating all career pathways, as well as building support systems that meet students where they are, are crucial steps in opening STEM fields to more diversity.

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STEM Identity

Some scholars have argued that the traditional model of STEM education promotes a "competitive, 'survival of the fittest' mentality,"[19] which might be off-putting for students from cultures that prioritize collective over individual identity. For example, meritocratic ideology, competitive weed-out courses, and unsupportive faculty[20] are often used to ensure that only "the best and the brightest" enter the STEM pipeline. This means there is more focus on searching for STEM

talent rather than developing it.[21] The problem with this approach is that it assumes all students are given equal opportunity to succeed in STEM from the outset and ignores the reality of opportunity gaps.

Once students embark on a STEM educational or career path, they report encountering obstacles as well, including negative stereotypes that reinforce the white male status quo in STEM,[22] overt racism and/or more covert microaggressions,[23] and lack of support for diverse research interests,[24] all of which can lead to feelings of isolation and invisibility. The lack of advisors, mentors, and colleagues who can empathize with this experience and advocate for these individuals only serves to exacerbate the problem. According to Malcom and Malcom-Piqueux, broadening participation and sustaining diversity requires "a welcoming environment, supportive mentors, and the construction of a supportive research community."[25] Failure to identify and nurture STEM potential and ensure that STEM environments are accommodating for diverse groups can hinder underrepresented students' sense of belonging, thus dissuading their interest in STEM fields and their self-identity as a STEM professional.[26]

HOW STRATEGIC PARTNERSHIPS CAN HELP

Some STEM researchers and developers have expressed concern that they do not have the expertise necessary to adequately engage students from underrepresented groups to which they themselves do not belong.[27] Because underrepresentation in STEM is such a complex issue, researchers alone are not necessarily the most effective designers of broadening-participation programs. Jakita Thomas from Spelman College is the principal investigator (PI) on the National Science Foundation (NSF) Discovery Research PreK–12 (DR K–12) project CAREER: Supporting Computational Algorithmic Thinking (SCAT)—Exploring the Development of Computational Algorithmic Thinking Capabilities in African-American Middle School Girls. She explains that researchers must learn to accept that when it comes to broadening participation, their expertise is limited and they must reposition themselves within these efforts. For her, combining expertise can be "powerful" (J. Thomas, personal communication, September 24, 2015). Establishing partnerships is one way to combine expertise. Having input from additional stakeholders can expose researchers and developers to a variety of professional interests and educational and career pathways, offer insight into the challenges and barriers experienced by members of underrepresented groups, and inform project design that addresses these issues directly. Partnerships can take various forms, but stakeholders such as social science academic departments, minority-serving institutions (MSIs), community colleges, school districts, and community organizations are particularly relevant for broadening participation.

Interdepartmental Partnerships

For broadening participation to become central, STEM researchers and developers must give proper consideration to the broader impacts of their work from the earliest stages of proposal development and ensure that design, implementation, and evaluation all support broadening-participation efforts.[28] This is an area in which combining expertise through partnerships can offer significant benefits. According to NSF, social science is an often underutilized resource in STEM research and development. Partnering with social science departments within your institution or other institutions can provide additional expertise that will allow STEM researchers and developers to more thoroughly understand the unique challenges faced by people from underrepresented groups and how to maximize the social impact of their work.[29] This insight can help STEM researchers and developers understand the root causes of underrepresentation and ensure that their work adequately engages members of these groups at every stage of the project.

Minority-Serving Institutions (MSIs) and Community College Partnerships

MSIs and community colleges are in a unique position to reach underrepresented groups. The majority of MSIs were established for the purpose of serving specific populations—African Americans, Latinos, Native Americans—and, as such, are more deeply connected to the experiences of these populations. In addition, access, affordability, and geographic proximity make community colleges attractive to many students from underrepresented groups.[30] For these reasons, MSIs and community colleges are viable pathways into STEM fields. According to a 2005 study, African American engineering students reported high STEM self-efficacy, interest, outcomes, and support in culturally supportive environments at historically black colleges and universities (HBCUs).[31] HBCUs, in particular, tend to prioritize student support and are better positioned to help underrepresented students integrate into STEM fields.[32] Partnering with MSIs and community colleges on projects helps build the research and development capacity of these institutions while, at the same time, helping predominately white institutions (PWIs) develop cultural competency that over time can help to make their institutions more inclusive and welcoming. Moreover, by working together, partner institutions can identify what training and support students from underrepresented groups need in order to succeed in STEM fields and how best to provide them with it.

In 2012, MSIs enrolled 39% of all students of color.[32] Enrollment of students of color at community colleges is around 54%, and community colleges account for 57% of total female enrollment.[33]

CASE STUDY: ECSU-UNH Partnership

In 2002, the University of New Hampshire (UNH), a PWI, and Elizabeth City State University (ECSU), an HBCU, partnered to "expand scientific knowledge, enhance educational opportunities, and, over time, ultimately create a more diverse workforce."[35] This partnership was initiated by faculty members at UNH around a mutual research interest in earth science and a shared desire to expand STEM opportunities for underrepresented students. Both institutions possess unique strengths that provide mutual benefits: "ECSU excels in undergraduate education and student mentoring, while UNH excels in research and graduate education."[36] The partnership serves as a "learning organization" wherein scholars develop and implement collaborative projects around a shared vision and goals. This collaborative partnership operates under the following practices, which were identified by key stakeholders:

1. "institutional commitment and faculty engagement;
2. establishing mutual respect and shared time commitment;
3. identifying an engaged leader [someone who can effect change at all levels within the institution];
4. engaging critical change agents [including both internal (faculty and administrators) and external (from NSF and other agencies) change agents];
5. initiating difficult dialogues ([where] participants…identify the problem, discuss multiple perspectives, encourage careful listening rather than defensive reaction, foster respect when disagreeing, and commit to reaching a resolution); [and]
6. preparing for growth and evolution [including reviewing partnership principles, involving new change agents, and continually engaging in difficult but constructive dialogues]."[37]

Truly collaborative partnerships such as these take time. Developing mutual understanding and respect, which are absolutely essential for effective partnerships, is a long process that requires commitment from all participants. Faculty at ECSU and UNH spent 18 months in communication with one another prior to writing their first joint proposal. Through this, participants were able to learn valuable information about community culture, relative strengths and opportunities for growth, and the needs and priorities of each institution. This was key in building and sustaining such an effective ongoing partnership—a partnership that has resulted in collaborative proposals and projects for NSF and other federal agencies; joint professional development and experience sharing; and engaging over 400 students from both institutions in research activities.[38]

School Partnerships

Strategic partnerships with K–12 schools can do a lot to support broadening participation in STEM. Researchers and developers bring content knowledge, tools, and artifacts into the classroom and connect students directly to STEM fields.[39] For students from underrepresented groups especially, this connection to the real world can help mold a STEM identity and encourage further participation in STEM fields. Additionally, building solid relationships with teachers, administrators, and staff connects researchers and developers directly with the experiences of students and teachers in the classroom, which can provide them with a deeper understanding of their needs. DR K–12 PI M. Alejandra Sorto from Texas State University advises researchers not to enter into a partnership with their own agenda but rather to begin with input from teachers, students, administrators, and staff. Together, stakeholders can develop a well-informed plan that meets students where they are. "Practitioners are experts," Sorto says, "and it's important to let them know that" (M. A. Sorto, personal communication, September 10, 2015).

Sorto's project, CAREER: Mathematics Instruction for English Language Learners (MI-ELL), investigates the classroom factors and teacher characteristics that contribute to Latino English language learners' gains in mathematics learning. In discussing school partnerships, Sorto cited her own cultural background as a Latina and native Spanish speaker as an important factor that allows her to "understand nuances and connect with the teachers and students" with whom she works (M. A. Sorto, personal communication, September 10, 2015). Maritza Macdonald from the American Museum of Natural History is the PI on the DR K–12 project An Innovative Approach to Earth Science Teacher Preparation: Uniting Science, Informal Science Education, and Schools to Raise Student Achievement. She reinforces Sorto's point by advocating for project teams that reflect the diversity of the target communities (M. Macdonald, personal communication, August 20, 2015). Sorto describes partnerships as a "two-way street" and encourages researchers to take the time to develop trust among partners to allow for truly collaborative work that addresses the needs of all involved (M. A. Sorto, personal communication, September 10, 2015).

Community Partnerships

Partnerships with community institutions are especially promising for broadening participation in STEM. Museums, science centers, nonprofits, community centers, etc., are often involved with education and community outreach; therefore, these institutions can connect researchers and developers with target communities and, in doing so, help researchers achieve broader impacts goals.[40] Community partnerships also bring content knowledge, tools, and artifacts into the classroom.[41] Urban Advantage (UA) is one example. Launched in 2004, UA "is a standards-based partnership program designed to improve students' understanding of scientific inquiry through collaborations between urban public school systems and science cultural institutions."[42] These partnerships provide students "with opportunities to conduct hands-on investigations that engage them in science as a way of thinking and investigating rather than simply as a body of knowledge."[43] UA partners include the American Museum of Natural History, Brooklyn Botanic Garden, New York Botanical Garden, New York Hall of Science, Queens Botanical Garden, Staten Island Zoo, Wildlife Conservation Society's Bronx Zoo and New York Aquarium, and New York City Department of Education. It is understood that these institutions have different subject area expertise within the sciences and varying capacities to support different types of projects. Partner institutions bring this expertise and "work collaboratively to develop a shared vision of effective programming that emphasizes scientific investigations." This collaboration has resulted in increased inquiry-based learning in UA classrooms, more opportunities for hands-on investigations, greater mastery of science content for UA teachers and improved capacity to support students' investigations, a boost in students' confidence around science content, and increased attendance by school groups and families at participating cultural institutions.[44]

One of the most important findings from this collaboration is that schools participating in UA show improved achievement on the eighth-grade science exam in New York State.[45]

The Algebra Project is another example of a community partnership. The Algebra Project is "a national mathematics literacy effort aimed at helping low income students and students of color successfully acquire mathematical skills that are a prerequisite for a college preparatory mathematics sequence in high school and full citizenship in today's technological society."[46] This nonprofit organization focuses on using mathematics as an "organizing tool to ensure quality public school education for every child in America,"[47] which is achieved in part by "building coalitions of stakeholders within the local communities, particularly the historically underserved population."[48] These strategic partnerships involve school districts, universities, research institutes, nonprofits, and foundations, and are designed to achieve specific objectives such as designing teacher training and certification programs, recruiting and training participants, exploring opportunities for implementation, hosting conferences and workshops, building nationwide coalitions, developing and advocating for national education policy initiatives, collaborating on NSF and other projects, and carrying out community development efforts.[49]

By partnering with community institutions, STEM researchers and developers acknowledge that broadening participation is a multifaceted endeavor. These community partnerships, and others like them, demonstrate the power of combining expertise in working toward the shared goal of broadening participation in STEM.

SUMMARY AND RECOMMENDATIONS

The problem of underrepresentation in STEM is a complex one, and the root causes vary from group to group and even individual to individual. Because of this, appropriate solutions are equally varied. NSF suggests focusing on lack of diversity as a "human capability realization problem, rather than as a STEM capacity building problem."[50] In other words, broadening participation requires transforming STEM disciplines so that they are better able to accommodate and benefit from diversity rather than attempting to fit diverse groups of students and professionals into existing molds. Part of the solution lies in the ability of STEM researchers and developers to understand the professional interests and educational and career pathways of students from underrepresented groups as well as the discriminatory barriers that keep diversity in these fields low.

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While this brief addresses just a few of the critical issues regarding underrepresentation in STEM, it does provide a foundation for getting started that can be applied more broadly. It was also written to stimulate thinking about different strategies for bridging the gaps in STEM fields and what can be gained by doing so. Whether you are interested in bridging the gaps in gender, race, ethnicity, ability, or socioeconomic status, building relationships that offer necessary insight into what these communities want and need, as well as how best to serve them, is the first step in broadening participation. With whom you choose to partner and the nature of those collaborations will vary depending on the type, scope, and objectives of your project, but building partnerships with stakeholders who are connected to these populations is a key strategy for developing that understanding and designing interventions that broaden participation and sustain diversity in STEM.

Consider the following when proposing broadening-participation efforts:

- Explore what STEM work is being done in your geographic region or within your area of interest to identify potential partners. Consult resources such as Pathways to Science to find out more about community

programs or CADRE's Broadening Participation Spotlight to learn about STEM programs at MSIs.

- Establish partnerships from the start in order to identify the needs of the target group. At the same time, remember that true collaboration takes time to develop and be willing to put in the time and energy required to build trust. Recognize the expertise of all stakeholders and use that to inform the direction of the project.
- Once you have identified potential partners and begun to build those relationships, explore resources, such as CADRE's *Education R&D Partnership Tool*, that offer strategies for establishing and sustaining mutually beneficial collaborations.
- Build broadening participation into the proposal from the outset and make certain that adequate supports are in place throughout each phase of the project.
- Draw from the knowledge of social science and other experts when writing your proposal, and consult with them as needed throughout the duration of the project.
- Represent the diversity of your target community on your project team.
- From the initiation of the effort, consult with partners to develop a dissemination strategy that will reach underrepresented communities.
- Conduct research on broadening participation approaches, and take advantage of training opportunities to develop/strengthen your cultural competency.
- Remember that underrepresentation in STEM is a deeply rooted, multifaceted social justice issue; therefore, broadening participation is a complex process. Try not to feel overwhelmed. Each individual has a role to play. Focus on what strengths you bring to the table, allow other experts to assume leadership roles, and be responsive when you identify opportunities for your own professional and personal growth.

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