Broadening Access to STEM Learning through Out-of-School Learning Environments

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For nearly thirty years, researchers and policymakers been working to understand and develop strategies and policies to address the persistent underrepresentation of women and girls, youth from low socioeconomic status (SES) communities, and those from particular racial/ethnic minority backgrounds (Hispanic, African-American, and Native American) in science, technology, engineering, and mathematics (STEM) studies and in key STEM career fields. The majority of this work has been focused on improving K-20 classroom dynamics and higher education recruitment and retention strategies (Lee, 2010, 2011; Hill, Corbett, & St. Rose, 2009; Byars-Winston, A., Estrada, Y., Howard, C., Davis, D., & Zalapa, J., 2010). Outcomes of this research include identification of evidence-based instructional strategies for improving academic outcomes as well as consideration of environmental and structural challenges contributing to these gaps. Interestingly, the findings of these studies point to pedagogical practices long considered canon in out-of-school (OST) learning environments, including hands-on learning experiences, inquiry-based pedagogy, and contextualized content (Dierking, 2007; Lee, 2011; Hill, et al, 2009; National Research Council, 2009). In fact, over the same thirty years, there have been a number of successful efforts by OST providers to engage youth from these underrepresented demographics in STEM learning, many of which produced significant positive results not only in the STEM achievement of participating youth, but in their overall academic success (Grack Nelson & Ostgaard, 2011, Fadigan & Hammrich, 2004; Center for Aquatic Sciences, n.d.; Techbridge, n.d.). Additionally, OST STEM programs have developed rigorous recruitment and retention strategies for their programs, relying on deep relationship building with youth, parents, schools, and other community partners (Coalition for Science After School, 2014; Sneider & Burke, 2010; Intercultural Center for Research in Education, 2005). This paper will explore evidence-based strategies developed in OST STEM programs for successfully engaging youth from underrepresented demographics in STEM learning.

Serving Youth in Low SES Communities

According to the latest figures from the National Center for Education Statistics (2014), 21 percent of school-aged children are living in poverty – a 23.5 percent increase in two decades. This number is significant not only due to its magnitude, but because it is consistent across geographies (urban/rural/suburban), and because of the effects of low SES on youth, families, and communities. Youth from low SES communities face a variety of structural challenges to STEM success, including a higher likelihood of attending schools with lower funding levels, resulting in lack of basic educational materials, including science learning materials, and training for teachers (Nasir et al, 2011); and families have fewer financial resources and/or time to provide overall academic support (Orr, 2003). In considering the various consequences low SES has for academic achievement, Aikens and Barbarines (2008.) indicate that the school environment (lack of materials, high turnover, lack of well-qualified teachers) has a greater impact than any family characteristics (single-parent home, native language, etc.). In addition to these structural challenges, youth from low SES communities who self-identify or feel they are associated with a lower SES class identity are likely to feel stereotype threat around academic achievement in general – and STEM achievement in particular (Harrison, Stevens, Monty, & Coakley, 2006) – as well as feeling stress due to family financial constraints (Mistry, Benner, Tan, & Kim, 2009).

Despite these considerable challenges, there have been successful efforts by OST educators to serve youth from low SES communities in STEM learning. One successful program model from the science center field is the service learning model pioneered through *YouthALIVE!*, a decade-long initiative of the Association of Science-Technology Centers (ASTC). *YouthALIVE!* supported the development of youth employment/volunteerism programs targeting minority youth ages 10 – 17 from low income communities at more than seventy science centers across the United States. Nearly fifteen years after the end of initiative funding, 41 percent of the original *YouthALIVE!* sites still have some flavor of youth program in place, and currently, youth employment and volunteerism programs are commonplace across the science center sector (Sneider & Burke, 2010). The longevity and success of this program model can be attributed to its intense focus on professional development for program leaders on cultural competence, positive youth development, and community outreach strategies, as well as inclusion of youth as equal participants in the network convenings (Association of Science-Technology Centers, n.d.). The STEM-focused youth employment and volunteerism programs developed as part of *YouthALIVE!* directly address both material and emotional challenges to STEM achievement for youth from low SES communities: training and support provided through these programs improves STEM self-efficacy for participants and the income earned (in those programs that are employment-based) assists in alleviating financial stresses. The CAUSE program at the Center for Aquatic Sciences in Camden, New Jersey, which originated as a *YouthALIVE!* youth employment program, reports:

> "100% of CAUSE seniors graduated from high school (150 since 1993). This fact is particularly notable given all the high schools in Camden have dropout rates that exceed 50% and the fact that teens are recruited into the program *without regard for school performance*…100% of the CAUSE staff students have enrolled in college in the last four years. (Center for Aquatic Sciences, n.d.)"

The CAUSE program is able to achieve this level of positive outcomes for youth participants through a variety of strategies, including deep relationships with Camden schools and community-based organizations for recruitment and retention; frequent, in-person contact with parents; low youth to adult ratio; rigorous academic and workforce skill development curriculum for participants; and hands-on, research-focused STEM experiences.

Despite the successes in this space, there are still significant challenges to ensuring youth in low SES communities have equitable access to OST STEM learning opportunities, most of which revolve around issues of finances and funding. Many OST programs – including STEM-focused programs – are fee-based in some form (Dierking, 2007; Association of Science-Technology Centers, 2013). In the case of science center-based youth programming (not including youth-employment/volunteerism models), a majority offer some type of scholarship or discount for youth based on financial need for fee-based programs, but those spaces are limited and depend on external funding for support. Unfortunately, it is rare that these subsidized fees are sustained once external funding ends (Sneider & Burke, 2010). Even when the for OST STEM programming are nominal or nonexistent, participation still requires a significant amount of resource investment from families in terms of time and resources. Transportation is a particularly troublesome issue when programs are based at sites beyond the neighborhood. To lower the transportation barrier, a variety of OST programs – both school-based and community-based – are beginning efforts to integrate STEM programming into their offerings (Coalition for Science After School, 2014). Organizations like the Boys and Girls Clubs of America and 4-H, with long traditions of serving youth from low SES communities at sites situated in their neighborhoods, have developed national curricula around STEM content that are available to local entities to integrate into their general offerings.

While many OST programs (4-H clubs, Girls Scouts, science camps, etc.) work to ensure affordability, there is growth in high-profile and high-visibility robotics programs such as FIRST®, which require a buy-in cost in the thousands of dollars, and also require recruitment of multiple STEM professional volunteers, multiple adult coordinators, etc. – all structural requirements that are well outside the reach of most youth, but especially those in low SES communities. Some of these programs do offer discounts on physical materials or suggestions for fundraising, but these offerings cannot replace the additional social resources (adult mentors, volunteers, etc.) required for successful participation.

Serving Youth from Under-represented Demographic Groups

A second set of gaps in STEM achievement are related to race, ethnicity, and gender. It is important to acknowledge from the outset that issues of SES, race, ethnicity, and gender in STEM achievement do not exist in isolation from each other nor from other factors affecting STEM success. As we consider this second layer of demographic identities of youth, it is the convergence of these multiple identities (Latino, female, low SES or white, female, high SES) that impacts students' overall sense of competence and confidence with respect to STEM achievement (Byars-Winston, et.al. 2010). Overall, STEM performance levels for all youth have improved over the past twenty years, thanks to classroom policy and practice interventions (U.S. Department of Education, 2011; National Research Council, 2009). Despite these overall gains, when the data are disaggregated by race/ethnicity and gender, the picture is not quite as rosy. Interestingly, the gap in classroom achievement by gender has generally been closed, especially in the elementary grades, when all children are taking the same curriculum. In fact, there are some STEM areas in which girls are outperforming boys (Hill, et.al. 2010). However, once girls reach middle school and high school – where students have more choice and/or are tracked into particular courses of study, their participation in STEM classes drops steeply, regardless of their prior successful performance. For youth from certain racial/ethnic minority backgrounds, historical gaps continue to persist. Again, acknowledging that it is impossible to fully separate the dynamics of SES, gender, and race/ethnicity, this section will explore the nuances of serving girls and youth from underrepresented racial/ethnic backgrounds.

Under-represented Racial and Ethnic Minority Groups

Not all racial or ethnic minority groups are under-represented in STEM achievement. According to the National Science Foundation (2013), there are disproportionately low percentages of African American (8.7 percent vs. 12.6 percent of general U.S. population), Native American (.6 percent vs. .9 percent), and Hispanic backgrounds (10.3 percent vs. 16.3 percent) students completing STEM undergraduate degrees and a disproportionately high percentage of Asian (9.7 percent vs. 3.6 percent) students completing STEM undergraduate degrees. Standardized assessments also show lower performance levels in science and mathematics for the same underrepresented populations in K-12. Why, if overall performance has improved for all students, do youth from these populations still underperform when compared to white students and other racial/ethnic minority groups? As with students from low SES communities, youth from these demographic groups face both structural and psychological barriers to STEM success. In fact, it is essential to acknowledge and become versed in the impacts of the legacy of structural discrimination and marginalization – especially with respect to economic and educational opportunity – faced historically (and presently) by youth from these communities in order to fully embrace approaches for effectively supporting their positive engagement in STEM learning (Lee, 2010, 2011).

Another significant challenge to engagement in STEM learning is the cultural divide between the lived experiences of youth from these backgrounds and the cultural lens through which STEM content is traditionally presented. As discussed extensively in *Learning Science in Informal Environments* (2009), science is a culture unto itself, with its own rituals, behavioral norms, values, and language. When the science is presented to students, it is often with the expectation for students to assimilate to the norms of science culture and situates science as historically an endeavor of Western European white males (Lee, 2011; National Research Council, 2009). This cultural bias is problematic for leveraging youth's existing funds of knowledge and lived experiences for advancing STEM learning in the classroom. The combination of the cultural bias of traditional STEM instruction and sociopolitical history results in many youth from these backgrounds feeling as though they don't belong in STEM careers (Quality Education for Minorities Network, 2010).

There are a number of OST STEM programs that offer excellent models for addressing the issues outlined above directly. *Acceso a la Ciencia*, a collaboration between Washington State University, the Pacific Science Center, and the Yakima Valley/Tri Cities MESA program, developed a suite of traveling exhibitions and professional development materials to serve rural Latino families. In order to ensure sustainable impact of the project, the partners developed content that reflected the everyday context of these families (agriculture and environmental issues) and connected them to the classroom curriculum; linguistically accessible materials (all materials were English/Spanish bilingual); and training for local community members to implement activities. Additionally, the entire project was grounded in the cultural values of this Latino population, which is reflected in the orientation of all activities as family activities. *Native Field Schools*, a program developed by Hopa Mountain and Blackfeet Community College, addresses directly the cultural bias of traditional Western approaches to STEM engagement. In this program, Native youth engaged in citizen science environmental observations in their own communities, learning empirical observation and recording techniques as well as tribal traditions related to the natural environment. The pioneering approach developed through the *Native*

Science Field Schools program helped participating youth build STEM self-efficacy and confirmed the value of the cultural knowledge of their communities, as evidenced by the high retention rate during the program and high return rate for subsequent years (Porticella, et al, 2013).

Girls

As mentioned above, there have been great strides in closing the academic achievement gender gap in K-12 STEM classrooms. There are corresponding improvements in the participation rates in certain science disciplines in which there is parity and even over-representation of women in higher education degrees, including the social sciences, biological sciences, and medical sciences. Despite these gains, there are still persistent gaps in participation by women in the physical sciences, engineering, and computer science. Again, if girls are performing at least as well as boys in STEM subjects in early grades, why are they making choices at the secondary level that will preclude them from pursuing certain STEM studies in higher education? Lackey et al (2007) indicates that consideration of the dynamics of girls' science identity, one's sense of self as affiliated with science and identifying as a scientist, is essential to answering this question. Key levers that affect the development of girl's science identity include sociocultural expectations of femininity (Lackey, 2007); the availability and consistency of positive STEM learning experiences (New York Hall of Science, 2011); family and school support for STEM learning (Aschbacher, et. al. 2010); access to a peer learning group (Lee, 2002); and level of intrinsic motivation (Simpkins et al, 2006).

Techbridge, originally a program of the Chabot Space & Science Center and now an independent entity, offers a suite of OST STEM activities to encourage girls from all backgrounds in pursuing STEM studies and careers. *Techbridge's* approach is grounded in building participants' science identities and sense of self-efficacy by creating hands-on learning experiences that focus on "developing technical skills and aptitudes; increasing self-confidence, persistence, and leadership skills; and promoting greater awareness and interest in [STEM] careers." (Techbridge, n.d.) A key part of *Techbridge's* approach is dedication to building networks of support for the girls participating in the program via role models and mentors, who in turn serve as networks of support and advocates for the program itself. The success of *Techbridge's* approach is clear from the results of a recent longitudinal study that indicating that the vast majority of participants reported increased levels of STEM self-efficacy (career interest, confidence, perceived career options) and higher than average rates of enrollment and academic achievement in key STEM courses in high school (Techbridge, n.d.).

Challenges

Challenges for OST STEM providers to serve youth from the groups discussed in this section mirror the challenges described for serving low SES communities, with some important additions. For girls and youth from under-represented minority backgrounds, strategies for developing a sense of "belonging" in STEM is of the utmost importance. Having access to program staff and role models that reflect their identity (-ies) and that are adequately trained to help youth negotiate and overcome social and psychological hurdles for developing positive science identity is critical. This means that not only would program staff ideally represent and reflect participating youth by gender and race/ethnicity, but that they would also be sufficiently trained in STEM content, positive youth development techniques, and have the facility to integrate cultural knowledge to create culturally relevant content. The lack of funding and generally low pay for OST program staff makes this scenario unlikely.

Design Features for Success

The OST STEM programs highlighted earlier in this paper reflect a number of evidence-based approaches to designing programs and experiences that successfully engage girls, youth from low SES communities, and youth from under-represented racial/ethnic minority backgrounds. The list below strives to condense and articulate the successful strategies and features of these programs.

Program Features

- Designed with the assets, needs, and challenges of youth in mind (youth-centered design)
- Learning is hands-on, inquiry-based, and open-ended
- Content is relevant to youths' lives and experiences
- Provides tangible technical skill-building
- Focus on career and college readiness
- Grounded in building positive peer relationships
- Provide access to role models and mentors
- Have a small (25:1) youth-to-adult ratio
- Providing opportunities for family support
- Offered on a long-term basis (not a single event)

Strategies

- Adequately trained and supported professional staff that reflect the lived experiences of youth participants.
- Diversified and sustainable revenue sources to support long-term program implementation
- Investment in building partnerships and networks of support with relevant organizations to support recruitment and implementation
- Material/physical access to participation directly addressed (i.e., transportation, registration fees, etc.)

In the vast majority of OST STEM programs, some subset of the program features and strategies listed above are implemented, but the most effective programs – such as those highlighted in this paper – implement all of them consistently and with impressive results. Youth who participate in these programs not only show improvements in self-confidence and self-esteem with regard to their identities as STEM learners, they also show improvements in overall academic performance, pursuit of STEM studies, and pursuit of STEM careers. And, perhaps most importantly, OST STEM programs can serve as the critical bridges that tie together school, family, mentors, and workforce preparation to create a network of access and opportunity for youth from underrepresented and under-resourced backgrounds to experience STEM success.

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