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Development of Out-of-School Time STEM Program Quality Standards for Broadening Participation

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ABSTRACT: This article details the methodology used by a team of researchers at the University of Pittsburgh to develop a set of evidence-based quality standards for pre-college STEM programs that center equity and justice to drive programs to broaden participation of racially/ethnically minoritized groups in STEM. With support from a National Science Foundation Eddie Bernice Johnson Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (INCLUDES) Design and Development Launch Pilot (DDLP) grant, researchers engaged in a five-stage development process that tapped field knowledge about engaging and serving minoritized communities, leveraged frameworks for accrediting educational organizations, and built on existing approaches to evaluating out-of-school programming to derive critical qualities of programs successful in broadening participation. This article details the development methodology and presents the evidence-based quality standards for broadening participation that can be used to focus STEM program improvement efforts. It further describes how these standards are being used within the STEM Pathways for Underrepresented Students to HigherEd (STEM PUSH) Network, an NSF-funded Alliance that brings precollege STEM programs from seven cities together to better serve racially/ethnically minoritized students.

INTRODUCTION

In the United States, significant disparities in STEM fields persist along racial/ethnic and gender lines, particularly evident in postsecondary attainment and career trajectories. Data from the National Center for Science and Engineering Statistics indicate that underrepresented minorities—such as Black, Hispanic, and Native American individuals—receive a disproportionately lower percentage of STEM degrees compared to their representation in the U.S. population. For instance, while these groups constituted approximately 31% of the U.S. population in 2019, they earned only about 22% of the bachelor's degrees in STEM fields. Gender disparities are also pronounced, with women underrepresented in many STEM disciplines, particularly in engineering and computer sciences, where they earned about 22% and 19% of the respective bachelor's degrees in 2019. These disparities extend into the workforce, where women and Black, Hispanic, and Native American individuals often face lower employment rates and wage gaps in STEM careers compared to their white male counterparts (NSF, 2021).

Out-of-school time (OST) and informal learning experiences play a crucial role in enhancing students' interest, understanding, and proficiency in STEM. These programs, which occur outside the traditional classroom setting, include afterschool programs, summer camps, museum exhibits, and science clubs hosted by a range of organizations and institutions from universities to community-based organizations to museums. The history of informal STEM education dates to the early 20th century, with the establishment of science clubs and public science demonstrations. Over the years, the focus has expanded from mere exposure to actively engaging students in inquiry-based activities that complement formal education. Indeed, more targeted OST experiences such as precollege STEM programs (PCSPs) specifically seek to support students on a trajectory from high school to postsecondary STEM study (Delale-O'Connor et al., 2021). Research indicates that OST STEM programs significantly boost students' STEM interest and can lead to improved academic outcomes, including higher test scores and increased likelihood of pursuing STEM careers (National Research Council, 2009; Dabney et al., 2011). These programs can be particularly effective in reaching underserved populations, offering opportunities to engage with STEM subjects in flexible, culturally relevant, and contextually rich environments (Bevan et al., 2010).

Program leaders, researchers, and policymakers have long been interested in ways to assess the quality of these OST STEM programs to shed light on the program characteristics that might help in reducing disparities, and to support and drive the programs' continued improvement. As a result, there are a range of frameworks and tools available to assess OST program quality, with some specifically focused on STEM content (Middle States Association of Colleges and Schools, 2016; Accreditation Board for Engineering and Technology, 2019-2020; Cognia, 2020; National Institute for STEM Education, n.d). These tools, however, do not comprehensively infuse equity and justice nor do they function to drive programs to broaden participation of racially/ethnically minoritized groups. For the tools that do exist, most have not published the methodology for how the qualities or standards were identified and/or selected. Some offer literature reviews citing evidence for the standards (e.g., Cognia, 2020), but no transparency in the process used to derive what findings in the literature warrant inclusion as standards.

With support from a National Science Foundation Eddie Bernice Johnson Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (INCLUDES) Design and Development Launch Pilot (DDLP) grant, a team of researchers and pre-college STEM program leaders at the University of Pittsburgh embraced the challenge of developing evidence-based standards to assess the quality of pre-college STEM programs that integrate and elevate equity goals. These standards ultimately served as a guide for the subsequent NSF-funded work of the STEM Pathways for Underrepresented Students to HigherEd (STEM PUSH) Network, which seeks to bring together and support pre-college STEM programs to better serve racially/ethnically minoritized youth and ultimately improve their access to STEM postsecondary education. This document describes the methodology used to develop

Figure 1. Methodology for development of Quality Standards.

these evidence-based standards, the sources of evidence employed, the resulting standards, and current and anticipated uses.

METHODOLOGY AND RESULTS

A group of researchers and program leaders at the University of Pittsburgh came together to create an evidence-based tool to assess pre-college STEM program capacities to support racially/ethnically minoritized (REM) students on a path to postsecondary STEM education. The development process tapped existing understandings and field knowledge about engaging and serving minoritized communities, frameworks for accrediting educational organizations, and approaches to evaluating the quality of OST programming. The work unfolded in five stages as noted in Figure 1 which are further described in the remainder of this section.

Literature Reviews. The research team drew on four bodies of literature (Figure 2) to identify potentially high leverage pre-college program qualities and capacities for supporting racially/ethnically minoritized students for equitable access to STEM postsecondary education:

1. First, published research around engaging minoritized communities in formal and non-formal learning environments was synthesized and published in 2021 (Delale-O'Connor et al., 2021).
2. Second, academic literature that identifies barriers and enablers for minoritized students in high school, in transition to postsecondary, and throughout postsecondary STEM education was reviewed.
3. Third, a broad array of accreditation models utilized within education spaces to determine program quality were identified and analyzed.
4. Fourth, existing tools for assessing OST program quality were identified and reviewed.

Table 1 provides a high-level summary of the demographic and contextual parameters for each data source,

Figure 2. Literature and landscape scans.

Table 1. *Demographic and contextual parameters for each data source.*

Source	Demographic characteristics of studied populations	Organizational context and grade levels of studied populations
Community engagement framework	66% of survey respondents from racially/ethnically minoritized backgrounds Literature review focused on racially-ethnically minoritized populations	Survey of 8th-12th grade students Literature review focused on K-12th grade experiences
Academic literature review	Populations underrepresented in STEM including women, low-income students and racially/ethnically minoritized groups	Grades 6-16
Accreditation model review	Not specific to student demographic characteristics	K-16 formal and informal education contexts
OST program quality tools	Not specific to student demographic characteristics	K-12 OST organizations

demonstrating that the data sources centered racially/ethnically minoritized students and attended to contexts including K-16 formal schooling and out-of-school time spaces. The remainder of this section provides more detail about each of the four data sources.

The work of the research project included the development of an evidence-based **Community Engagement Framework** intended to identify and communicate key practices for engaging minoritized communities with higher education institutions and in OST program recruitment, the results of which were used in the development of the quality standards. The Community Engagement Framework development involved a literature review of best practices for the recruitment and retention of minoritized students (n=20 publications focused on informal STEM learning outreach and community engagement), documentation of program practices around recruitment and retention and community connections for four participating STEM programs (surveys of 77 8th-12th grade youth from minoritized communities) and, a local needs assessment around STEM programming connected to college-going (interviews with leaders of four local STEM programs). This process resulted in a synthesis of equitable community engagement practices and was published in the National Science Teaching Association's Connected Science Learning publication (Delale-O'Connor et al., 2021). Key findings included the following three interrelated practices: Focus information sharing on racially/ethnically minoritized youths' lives and experiences; demonstrate program relevance to racially and ethnically minoritized youth, their families, and communities; and eliminate obstacles and barriers to participation for racially/ethnically minoritized youth.

Next, the research team conducted a **review of literature on enablers and barriers for minoritized students** on the

Table 2. *Undergraduate practices for attracting and retaining REM students in STEM fields.*

Key themes from literature: Undergraduate practices for attracting and retaining REM students in STEM fields	
Theme and Sources	**Findings**
Offer summer bridge program to prepare students and support transition (Estrada et al., 2016; National Academy of Engineering, 2014).	• Preparatory instruction in core classes such as Calculus, biology, and chemistry • Practices that improve spatial skills for students in engineering studies • Study skills, navigating campus resources, and self-advocacy
Provide early research opportunities (Estrada et al., 2016; Perna et al., 2010; Harper, 2010; National Academy of Engineering, 2014).	• Undergraduate research opportunities • Summer research opportunities
After college matriculation, provide proactive advising and mentoring with supportive faculty, and interventions to address imposter syndrome and stereotype threat (Clance and O'Toole, 1988; Estrada et al., 2016; Harper, 2010; Ladonna et al., 2017; Landhuis, 2017; Langford and Clance,, 1993; National Academy of Engineering, 2014; Perna et al., 2010; Steele, 2011).	• Ensure staff and faculty intervene early if student begins to go off track • Provide models of successful REM STEM professionals • Identify structural and cultural biases in the institution that reinforce or uphold stereotypes and communicate messages that certain students don't belong • Study institutional data on disparities with faculty • Normalize struggle and adopt growth mindset • Talk with students about stereotype threat and encourage them to think about how to respond to it • Challenge beliefs underlying imposter syndrome and stereotype threat, identify bias in systems that reinforce stereotypes and imposter syndrome, and introduce alternatives
Provide adequate financial support (Estrada et al., 2016; National Academy of Engineering, 2014; Perna et al., 2010).	• Scholarships • Paid summer internships • Cost of experiential learning opportunities such as applied research and study abroad
Make science content personal and relatable and reflective of students' cultural knowledge (Estrada et al., 2016; McGee and Bentley, 2017; National Academy of Engineering, 2014; National Research Council, 2003).	• Tether STEM content to how it affects REM communities • Hire faculty with industry experiences • Hire faculty from minoritized racial/ethnic groups • Orient STEM content foci to equity and justice purposes, economic development, and sustainability • Identify and incorporate the assets that REM students bring to STEM spaces
Nurture a supportive peer culture (Harper, 2010; Perna et al., 2010).	• Foreground cooperation and collaboration over competition • Structure peer experiences to nurture a sense of belonging in STEM field • Host student organizations that connect REM students to other REM STEM students and professionals
Provide more scaffolding and support in introductory classes (National Academy of Engineering, 2014; Perna et al., 2010).	• Orient away from "weed out" approach to developmental frame • Offer bilingual courses • Include self-paced instruction • Make remedial courses more flexible and tied to individual strengths and weaknesses
Provide robust access to career development (National Academy of Engineering, 2014).	• Examples of professionals in a range of careers who are from racially/ethnically minoritized groups • Connections to supportive professional networks • Access to internships

Table 3. *OST practices supportive of REM students pursuing STEM fields.*

Key themes from literature: OST practices supportive of REM students pursuing STEM fields	
Theme and Sources	**Findings**
Offer STEM focused employment and volunteering experience (Migus, n.d.).	• Helps build student confidence • Ease financial difficulties
Provide skills and authentic experiences (Lyon et al., 2012; Migus, n.d.)	• Hands-on, inquiry based and open-ended learning • Opportunities to explore a broad range of scientific disciplines and career options • Leadership opportunities • Evidence-based youth development practices
Provide mentorship and connection (Lyon et al., 2012; Migus, n.d.)	• Access to the role models and mentors: Staffs or speakers • Long term relationship with caring adults: Staffs and speakers • Content will be taught by STEM professionals
Build tight, supportive network between students, staffs, and the family (Lyon et al., 2012; Migus, n.d.)	• Small youth to adult ratio to provide more one-on-one attention • Nurture positive peer relationships • Provide support to families
Ease logistic difficulties (Migus, n.d.; National Academy of Engineering, 2014).	• Transportation • Low or no program fees • Cover the cost of room and board, food, and supplies
Make content relatable to family and cultural background (Lyon et al., 2012; Migus, n.d.)	• Tie back to the distinct backgrounds of the students • Link to cultural values and assets • Make the content meaningful to the students • Focus on youth development within the STEM content

following dimensions: practices at colleges that are supportive of attracting and retaining minoritized students in STEM fields, practices in OST spaces that are supportive of minoritized students' pursuit of STEM fields, and key barriers that minoritized students experience in considering or persisting in STEM education and careers. The result was a set of evidence-based practices for supporting minoritized students at the high school (see Table 2) and college (see Table 3) levels along with a list of key barriers (see Table 4).

The team then identified and reviewed four existing **educational accreditation and certification frameworks** to understand the capacities they measure, as well as the processes used to structure the accreditation experience. In particular, the team reviewed publicly available information for Middle States Association Learning Service Providers (Middle States Association of Colleges and Schools, 2016), Accreditation Board for Engineering and Technology (Accreditation Board for Engineering and Technology, 2019-2020), Cognia's STEM certification (Cognia, 2020), and the National Institute for STEM Education's teacher certification standards (National Institute for STEM Education, n.d.). Table 5 provides a high-level overview of the key assessment dimensions for each of the four models that were reviewed. For the analysis, the full accreditation models with corresponding standards, indicators, and self-assessment tools were reviewed and analyzed.

The Middle States Association (MSA) Learning Service Provider (LSP) framework was the most comprehensive in

Table 4. *Key barriers for REM students in pursuing STEM education and careers.*

Key themes from literature: Barriers for REM students in pursuing STEM education and careers	
Theme and Sources	**Findings**
Imposter syndrome (Clance, 1988; Estrada et al., 2016; Ladonna et al., 2017; Langford and Clance, 1993; Migus, n.d.; Perna et al., 2010) and stereotype threat (Migus, n.d.; National Academy of Engineering, 2014; Steele, 2011).	• Cultural messages around gender and race/ethnicity in scientific fields manifest as imposter syndrome and stereotype threat
Economic disparities and challenges (Estrada et al., 2016; Lyon et al., 2012; Migus, n.d.; National Academy of Engineering, 2014; Perna et al., 2010).	• Many URM students are from low-income families which make paying for higher education and extracurricular activities difficult and may result in the student having to work while in postsecondary • FAFSA form can be complicated and can cause URM students not to file for financial aid • College application fees • Rising tuition in higher education • Registration fees
Lack of resources and/or support (Harper, 2010; Lyon et al., 2012; McGee and Bentley, 2017; Migus, n.d.; National Academy of Engineering, 2014).	• Disparities in K-12 access to high-level STEM courses, equipment, and technology • Inadequate access to academic support to navigate college and career planning • Inequitable access to enrichment experiences
Not enough connection to mentors that can guide the students toward STEM (Migus, n.d.).	• Access to mentors • Access to mentors who are also from minoritized groups
High stakes standardized testing (National Academy of Engineering, 2014; Santelices and Wilson, 2015; Stern, 2005). • Cumulative effects of inequitable public education system	• Inequitable access to preparation programs • Cultural bias within the test content
Lack of representation and cultural homogeneity in STEM fields (Lyon et al., 2012; McGee and Bentley, 2017).	• STEM careers not marketed as a service-oriented career field which is often a draw for REM students • STEM emphasis is often on more economic and individualistic values • Lack of representation of REM people in STEM fields makes it difficult for REM students to see themselves working in a scientific profession

Table 5. *Summary of accreditation model key dimensions.*

Accreditation Model	Middle States Standards for Accreditation- Learning Services Provider	Accreditation Board for Engineering and Technology- Computing Accreditation	Cognia STEM Certification	National Institute for STEM Education- Certificate for STEM Teaching
Accreditation Target	**Organizations**	**College or University program**	**K-12 schools and programs**	**STEM Educators**
Accreditation Dimensions	Mission			
	Governance and leadership			
	Improvement planning	Continuous improvement		
	Finances			
	Facilities	Facilities		
	Climate and organization	Faculty Institutional support	STEM community	
	Health and safety			
	Educational program	Program educational objectives Curriculum	STEM learning culture STEM experiences	Creating an environment for learning Building scientific understanding Engaging students in science and engineering practices
	Assessment and evidence of student learning	Student outcomes	STEM outcomes	
	Student services	Students		
	Student life and activities			
	Information resources			

the dimensions that it assesses. This accreditation model is intended to be used with educational organizations that provide services to students and thus, its accreditation seeks to ensure that the provider has organizational resources, capacities, and leadership to provide a safe educational program. The MSA framework is not STEM-specific and does not have equity and broadening participation goals embedded throughout its standards.

The Accreditation Board for Engineering and Technology (ABET) Computing Accreditation Commission framework examines eight dimensions of college or university programs in computing. This framework mirrors many of the MSA LSP dimensions, although organized differently. The ABET standards are also not inherently STEM-specific and do not have explicit equity and broadening participation goals.

Cognia's STEM certification organizes its 16 standards in four dimensions that are explicitly STEM-focused and intended to be applied to K-12 schools and districts. The four dimensions include STEM community, STEM learning culture, STEM experiences, and STEM outcomes. These standards do include some explicit marking of equity in two of the sixteen standards but since these are intended to be applied in formal school settings, they do not address barriers to access that are critical for out-of-school time programming. In addition, the standards do not specifically address culturally sustaining pedagogical practices.

The National Institute for STEM Education's teacher certification standards focused deeply on classroom instruction in STEM, providing much more guidance around pedagogical practices without corresponding organizational level conditions. The 15 practices are clustered into three domains: Creating an environment for learning; Building scientific understanding; and, engaging students in science and engineering practices. Publicly available information on the domains and teacher actions do not explicitly mark equity or culturally sustaining practices and these practices are all intended for in-school rather than OST spaces.

Each of these accreditation models offers important dimensions known to matter for providing high quality educational programming but none fully achieve what the research team's goal of providing evidence-based standards for OST STEM programs that can broadening participation in the STEM pathway.

Finally, the team reviewed two existing **tools for assessing quality of OST programs**. The key tools reviewed included the Partnerships in Education and Resilience (PEAR) Institute's Dimensions of Success (DoS) (n.d.) and the Pennsylvania Statewide Afterschool Youth Development Network (PSAYDN) Quality Campaign self-assessment (n.d.). The DoS tool evaluates 12 dimensions of success in four broad domains: (1) features of the learning environment, (2) activity engagement, (3) STEM knowledge and practices, and (4) youth development in STEM. Like some of the accreditation models, this framework focuses on specific design and instructional aspects of STEM-focused programming but is much better suited to OST spaces because it does not adopt a formal schooling frame. It also incorporates elements crucial to equity such as foregrounding youth voice and relevance of content. However, this tool is intended to focus on specific STEM activities in OST spaces rather than whole programs and, therefore, does not include aspects related to program recruitment, reducing barriers to participation, and measurement of outcomes.

The PSAYDN Quality Campaign details a collaborative process for OST STEM programs to self-assess along four elements of quality programming: safety and health, structure and management, activities, and relationships. These are general dimensions for OST programs and do not offer STEM-specific guidance. Several of the standards are equity-focused, including mention of program staff representing the communities served, promoting understanding and respect for youth's cultures and centering youth's interests. Combined, dimensions from the DoS and PSAYDN Quality Campaign were considered as inputs to the quality standards for broadening participation in STEM.

Analysis and Identification. The analyses of the four data sources were conducted individually and then merged systematically. Figure 3 shows the high-level analytic flow in which each of the four data sources underwent qualitative coding and thematic analysis (Braun and Clarke, 2012) to yield sets of critical program qualities, evidence-based practices, and challenges and barriers to STEM education access and persistence. Because two of the literature reviews focused explicitly on experiences and needs of minoritized students and communities, the aggregation process exposed gaps in the existing sets of capacities surfaced in the reviews of accreditation and assessment instruments. Next, the findings from each of the four data sources were then synthesized using affinity clustering (Beyer and Holtzblatt, 1998) to yield a single set of categories with evidence-based capacities and needs for effectively serving racially/ethnically minoritized youth.

The result was a comprehensive set of quality standards organized into six domains that intentionally addressed these gaps: program goals, student recruitment, program design and implementation, student services, assessment and evidence of performance, and college pathways. Each of these six quality standard areas served as umbrella categories for individual critical qualities which became standard statements. In sum, through thematic analysis and affinity clustering of the four literature reviews, a comprehensive set of standards organized into six areas was constructed to embody the research base for practices critical to identifying, recruiting, and supporting racially and ethnically minoritized youth in STEM.

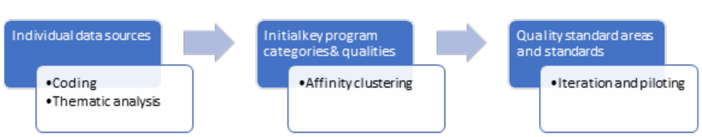

Figure 3. Analytic approach across four data sources.

Iterative Review and Refinement. Once the research team drafted a comprehensive set of evidence-based quality standards for broadening participation in STEM, they began an iterative process of review and refinement. First, all team members – representing a range of disciplinary expertise and experience in STEM, learning sciences, evaluation, equity and social justice, and youth development –conducted individual reviews providing critical feedback, questions, and suggestions. Next, the research team engaged the DDLP advisory council which included high level administrators from two universities, university admissions representatives, a state department of education STEM administrator, Diversity, Equity and Inclusion administrators, a learning scientist, administrators and professors from STEM departments at three universities, university-based STEM outreach directors, a public school outreach director, and an administrator from a college access community-based organization. These advisory council members reviewed the draft quality standards, provided critical feedback, questions, and suggestions which led to further revision.

Adaptation to Self-study Tool. The original intent of the quality standards was to have a tool to support continuous improvement and to lay the foundation for an evaluation or accreditation process that could certify the capacity of precollege STEM programs to broaden participation in STEM. To achieve this, the team constructed a self-assessment tool around the standards that included a categorical rating ("not met," "making progress," "met," or "exceeds") and qualitative justification. Staff from precollege programs would reflect on their practices, assign a consensus rating for each standard, and then provide evidence for the rating by describing practices and reporting relevant data.

The prototype self-assessment tool was piloted by four University of Pittsburgh precollege STEM programs. Program leaders completed the prototype self-study assessment in 2018 and then completed a reflective survey about the process and the tool. Their reflections highlighted areas in which there was overlap, lack of clarity/definition, and gaps. Team researchers analyzed the pilot responses to understand whether the structure was eliciting supporting evidence at a useable level of detail. Based on this pilot, the research team made significant modifications to both the standards themselves within each of the six standard areas, and to the structure of the self-study tool. The most significant changes included elimination and consolidation of overlapping standards, reduction of the number of qualitative response areas, and revised definitions for each of the self-rating levels.

Testing and Revision. After the DDLP grant, the team of researchers, along with an expanded set of partners, was awarded an NSF INCLUDES Alliance grant (INCLUDES #1930990) to form the STEM PUSH Network (STEM Pathways for Underrepresented Students to HigherEd). By 2024 this network brought together 45 pre-college STEM programs from 8 urban areas to strengthen their capacities to support racially/ethnically minoritized students on a pathway to STEM postsecondary education and innovate new, more equitable communication mechanisms between these programs and undergraduate admissions. A significant component of the STEM PUSH Network is the formation of a networked improvement community in which precollege STEM programs work in collaboration with one another, with researchers, and with equity experts to iteratively test and refine high leverage practices for better supporting racially/ethnically minoritized students aligned with the Quality Standard areas. In this context, the original Quality Standards were deployed, tested, and refined over a three-year period, resulting in the current set of Quality Standards depicted in Table 6.

When programs join the STEM PUSH Network, the self-study tool is used as a baseline reflective experience for program leaders, to support network leaders in providing focused support, and for network effectiveness monitoring. Programs complete the self-study tool upon entry to the network and report that completion takes an average of eight hours with a range of 4-24 hours. Programs use their individual self-study data to help focus their efforts within the network and join improvement groups aligned with the Quality Standards for which they identify the most need to improve. For example, a program may examine their self-study results and recognize that recruitment of racially/ethnically minoritized youth is an area of weakness and then join an improvement group to work with other programs on identifying and testing new approaches for equitable recruitment (Quality Standard Area 2). Network leaders also use the aggregated self-study data to strategically focus network-wide professional learning experiences toward capacities with the greatest collective need and to identify and leverage areas of expertise and strength within the network. For example, early data from the first program cohort revealed that equitable measurement and evaluation were weaker program qualities across most programs (Standard Area 5). As a result, the network leadership focused significant whole network professional development and improvement work to providing information, resources, and supporting application of equitable measurement, specific measurement tools, and evaluation frameworks.

The self-study tool has been used with the three cohorts of STEM PUSH Network pre-college STEM programs (a total of 45 programs) and has resulted in program self-reported change in individual thinking and understanding of Quality Standards they have focused on, increased program attention to the areas identified as in need of improvement and changes to concrete practices related to the Quality Standards on which they have focused improvement effort. For example, for equitable recruitment practices, 13 programs engaged in direct improvement work in network-sponsored improvement groups and all reported increases in their own understanding of equitable recruitment practices, that their programs had dedicated increased attention to how it designs and implements recruitment, and that concrete changes were made to strengthen practices for recruitment racially/ethnically minoritized students.

These iterative pilot uses of the Quality Standards in the form of the self-study tool revealed both strengths and areas for improvement to the standards and the self-study process. Key changes to the standards included definitional clarifications within the standards text and more nuanced contextual information. During this pilot phase, the research team recognized challenges calibrating the self-study evaluation scale across programs and comparing evidence of ratings for each standard. Future iterations of the self-study tool will need to include expanded anchors for each of the rating levels in each standard area and vignettes to help users more deeply understand how the standards might look in practice.

DISCUSSION

The development steps described in prior sections resulted in the STEM PUSH Network Quality Standards, which are **a set of research- and practice-based principles that codify what high quality precollege STEM programs do to equitably engage and serve students from minoritized backgrounds**. Central to the work of the STEM PUSH Network, the Quality Standards provide the foundation for the self-study tool and serve as a compass for our improvement cycles and program accreditation process. They will also help the network communicate to postsecondary institutions the value of pre-college STEM programs and the promise, strengths, and assets of student-participants.

Currently, the STEM PUSH Network uses the Quality Standards and self-study tool to:

- Focus network improvement efforts;
- Support programs in reflecting on areas for improvement to better serve racially/ethnically minoritized students;
- Benchmark and report on program improvement over time; and,
- Support accreditation of pre-college STEM programs for broadening participation, in partnership with Middle States Association (Davis et al., in preparation).

Table 6. *Quality standards for broadening participation in STEM.*

Quality Standards Revised 2024

1. Program Goals

1.1 Intentional program goals include broadening participation of underrepresented minoritized students in STEM including in undergraduate college programs.

1.2 Program goals reflect an intentional focus on building students' connection to a STEM community

1.3 Program goals demonstrate a deliberate effort to develop students in STEM competencies & skills.

1.4 Program goals reflect exposure to and development of familiarity with college planning, college life and resources available on campuses.

2. Student Recruitment

2.1 The program intentionally and effectively recruits underrepresented minoritized students. (Overall assessment of recruitment practices.)

2.2 Recruitment strategies include community-aligned messages and methods that reach into spaces frequented by minoritized students in the program's feeder area.

2.3 Recruitment practices demonstrate STEM fields' relevance to minoritized students' interests, cultures, and identities.

2.4 Recruitment practices go beyond self-selection to include active identification and referral from organizations and individuals who have regular contact with the population of potential program participants (e.g., counselors, parents, community members, peers, schools, community groups).

3. Program Design and Implementation

3.1 The program utilizes well-trained, consistent staff and/or volunteers who demonstrate cultural competence and have appropriate expertise given the program goals.

3.2 There are measurement routines and tools in place for continuous program improvement efforts around areas such as recruitment, program implementation quality, student/parent satisfaction, and outcomes attainment.

3.3 Program has an articulated curriculum (activities and experiential STEM learning) driven by its established learning and equity goals for students.

- 3.3.1 Program is focused on developing students' STEM competencies & skills through rigorous STEM content.
- 3.3.2 Program content is reflective of advances in applicable STEM fields.

3.4 Program utilizes culturally sustaining practices and approaches that engage, energize and empower students in their own learning. (Overall assessment of culturally sustaining practices).

- 3.4.1 Program environment, activities and policies promote understanding of and respect for the cultural backgrounds of youth and their families.
- 3.4.2 Activities stimulate positive STEM identities and sense of belonging for racially minoritized students in the STEM community and/or on college campuses.

3.5 Program utilizes research-based instructional practices aligned with what is known about how people learn.

3.6 Program is implemented in ways that broaden students' understanding of and first-hand experience with college campus and culture, STEM careers, STEM professionals, and STEM workplaces.

3.7 Program implementation includes effective formation and sustaining of meaningful connections to students' families and communities.

3.8 Program sustains a network of peers and program alumni to serve as an ongoing STEM resource for student participants.

4. Student Services

4.1 Program utilizes practices that proactively identify and address barriers to participation (these may include transportation, cost of participation, meals, social-emotional, and/or other barriers).

4.2 Program includes responsive support for students based on needs identified at application and/or during program implementation (these may include tutoring for STEM content, study skills, professional communication skills, social-emotional support, etc.).

4.3 Program provides age-appropriate college advising and supports (these may include letters of recommendation, financial aid resources, application process, etc.).

5. Assessment and Evidence of Performance

5.1 Equitable assessment practices are consistently used to measure student growth of targeted STEM competencies & skills. (Please respond to this standard with respect to the outcomes you listed above—QS1.3).

5.2 Program can demonstrate meaningful student growth on at least one STEM competency and/or skill for at least three of the last five years. (Please respond to this standard with respect to the outcomes you listed above—QS1.3).

5.3 Program has a method to track alumni college enrollment, persistence and attainment and, specifically, rates for racially minoritized students and STEM majors.

5.4 Program can demonstrate improvement trends in college enrollment in STEM fields by racially minoritized program alumni over three or more program years or cohorts of students.

6. College Pathways

6.1 Program has established methods to engage parents/guardians in ways that provide support, guidance, and/or access to resources with regard to college pathways.

6.2 Program has established pathways to other experiences and/or programming that act as a bridge to STEM college opportunities (e.g., internship with STEM employer, preference for admission to another STEM precollege program, etc.).

6.3 For programs serving high school students, there is an established relationship with at least one college admissions department that provides some benefit to program alumni in the admissions process.

In addition, an adapted version of the self-study tool has been disseminated for broader use outside the STEM PUSH Network (Davis et al., 2024). This tool helps organizational leaders consider and apply the quality standards to potential or existing programs to focus design and improvement efforts in ways that will help broadening participation in STEM. The tool includes a spreadsheet that leaders can clone and fill in with their own data.

In the future, the STEM PUSH research team anticipates using the Quality Standards and self-study data for the 45 programs to link to student postsecondary persistence and attainment data to better understand how specific program capacities influence student outcomes. This study will connect individual program's most recent self-study and change scores over time to their program alumni National Student Clearinghouse data to begin to explore whether and in what ways program strength in particular standard areas is linked to better student postsecondary STEM outcomes. Additionally, the STEM PUSH Network is building out a library of implementation models, tools and routines to effectively meet each standard in what we call "Change Packages" (these are available on the STEM PUSH Network website). Ideally, STEM PUSH along with other partners committed to equitable STEM OST experiences, can develop a robust library of tested approaches to support a range of OST programs in strengthening their capacities to meet the Quality Standards.

The Quality Standards and their activation within the self-study face some challenges. Firstly, while the tools work well for individual driving and focusing program improvement in ways that align with literature on effectively supporting racially/ethnically minoritized students, there are more challenges in using the self-study ratings to compare across programs and to compare a single program over time. Currently, the rating scale does not include strong anchors to assist users in calibrating their self-ratings to a defined level, leaving these ratings susceptible to individual interpretation. In addition, when precollege programs experience staff turnover between the completion of the self-study and the second benchmarking use of the self-study tool, we find that new staff have different understandings and may rate differently based on their institutional knowledge and positionality. These weaknesses might be attenuated with strong rating scale anchors and vignettes for each standard that elucidate the intended qualities in concrete ways.

As other programs and leaders consider use of the Quality Standards and corresponding self-study, it is important to note that these were developed with the high school to postsecondary transition in mind. Although the researchers hypothesize that the Quality Standards, with some specific exceptions, are more broadly applicable across OST STEM contexts and with other grade levels of student participants, this has not yet been tested empirically. It is likely that users outside of the precollege STEM program context will need to review the standard areas and specific standards to first determine relevance to their program context and then use only those that have applicability. For example, for elementary school-age focused OST program, Standard Area 6 College Pathways may have limited relevance).

Despite these challenges, we expect that these evidence-based Quality Standards and self-study tool can, over time, contribute to larger scale broadening participation in STEM in the U.S. Their intentional grounding in evidence-based insights and practices for equitable inclusion in STEM positions them to drive equitable improvement within the organizations and programs that engage with them meaningfully. We expect to continue to learn and iterate of both the standards and the tools as more programs use them and report on accessibility, utility, and efficacy.

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ABBREVIATIONS

ABET: Accreditation Board for Engineering and Technology; DDLP: Design and Development Launch Pilot; DoS: Dimensions of Success; INCLUDES: Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science; LSP: Learning Service Provider; MSA: Middle States Association; OST: Out-of-school Time; PCSPs: Precollege STEM Programs; PEAR: Partnerships in Education and Resilience; PSAYDN: Pennsylvania Statewide Afterschool Youth Development

Network; REM: Racially/Ethnically Minoritized; STEM PUSH: STEM Pathways for Underrepresented Students to HigherEd

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