Measuring Skills that Matter for STEM Practice

THE FUTURE NEEDS A PUSH

SUMMER 2024

FEATURED

WHAT WE DID

EQUITABLE MEASUREMENT

KEY LEARNINGS

www.stempushnetwork.org

The STEM PUSH Networked Improvement Community, or NIC, is our learning engine. In the NIC, pre-college STEM programs (PCSPs) test small changes to gather data and continuously improve programming.

STEM PUSH programs engage in two improvement cycles each year to test high-leverage ideas to help us achieve our goal of broadening participation in STEM. Programs share their learning with the Network at the end of each cycle so the Network can spread and accelerate change. Collective learning is the power of the STEM PUSH Network.

From March 2023 to September 2024, 31 pre-college STEM programs tested a change idea on the topic of *equitable measurement of skills that matter for the practice of STEM.*

Equitable measurement of skills that matter builds pre-college programs' capacity to serve Black, Latina/o/e and Indigenous students, thus moving us towards our collective aim of increasing STEM undergraduate enrollment and persistence.

In this newsletter, we will share what we have learned during the improvement cycle exploring how to *equitably measure skills that matter for STEM practice*.

STEM PUSH NETWORK

Improvement Cycle: Equitable Measurement of Skills that Matter for the Practice of STEM

Our Focus & What We Did

To expand the pathway to STEM undergraduate study for more Black, Latina/o/e, and Indigenous students, it is important for students to leave PCSPs prepared with competencies that matter for the practice of STEM.

Developing competencies that matter for the practice of STEM is a primary driver from our Theory of Improvement - the set of STEM PUSH hypotheses about how we get to meaningful collective impact on our shared problem, in order to broaden participation in STEM.

Essentially, the Theory of Improvement combines our understanding of the system creating the problem with our "best bets" about the most high-leverage areas we can target to achieve our aim.

When programs nurture and grow STEM competencies, students are better positioned to succeed in institutions of higher education, as well as in their STEM futures. By learning to more equitably measure progress on this driver, pre-college STEM programs can better support students in developing and recognizing their own STEM strengths and assets.

STEM PUSH focused on three competency areas that matter in the practice of STEM and will serve students in their post-secondary experiences as well as future careers. These three areas were science communication skills, critical thinking skills, and discipline-specific research skills.

Science Communication Skills include the ability to communicate thought processes, understanding, and/or scientific ideas through oral presentation, writing, narrative, and storytelling.

Critical Thinking Skills include things like problem-solving skills, scientific reasoning skills, the ability to make connections across and between ideas, and/or the ability to make connections between STEM content and real-world issues.

Research Skills include things like field work, lab skills, and research design such as experimental design and the engineering design process.

Equitable Measurement

Why is it Important?

Programs within the NIC explored more equitable approaches to document students' growth and performance. Strengthening these measurement methods are important because they help programs:

- Assess the way in which they support students' skill growth and development;
- Enhance students' ability to recognize their own growth and development; and
- Communicate the value of students' program experiences to colleges.

"Engaging in the Equitable Measurement Group for Science Communication helped me frame the way I present our students opportunities to evaluate themselves, and how to gather that data. It has made me think further about the way we engage the students in their own "grading" and how important it is to self-reflect."

Valentina London, Oregon MESA

Programs explored a number of STEM competencies within scientific communication, critical thinking, and research skills. Specific skills measured and tested during the improvement cycle include:

Technical Communication: Measuring students' ability to explain what they are doing to non technical audiences (such as their families) in writing and verbally, as well as more technical audiences like subject matter experts.

Measurement of Storytelling, Feedback, Growth and Confidence: This included evaluating the tone and language used in giving feedback, as well as the context and offering of ways in which students can improve. Additionally, measuring students' confidence as well as their ability to effectively communicate through storytelling.

Communicating Across Different Mediums: Programs measured students' ability to communicate complex ideas through different mediums such as formal presentations, pitches, and writing (e.g., abstracts).

Data Analysis: With a focus on critical thinking, programs measured student's ability to interpret, analyze, and reason.

Application of Skills: Programs measured student application of specific skills, like coding, lab skills, research or math.

Critical Thinking: Programs reviewed a number of areas aligned with critical thinking, such as problem-solving, analytical thinking, logical reasoning and creative thinking.

Measuring Communication Skills

Here are some examples of the customized STEM skills measured and tested during the learning improvement cycle.

Communication with The Citizen Science Lab - Ice-T Project

Focusing on measuring technical communication, The Ice-T Project at The Citizen Science Lab adapted the SCALE rubric ("Effective Communication Rubric (Grade 9-12)" by Envision Schools to measure students' ability to:

- Explain what they are doing to non technical audiences (such as their families) in writing and verbally;
- Answer questions clearly and concisely;
- Ask questions to subject matter experts, and seek more information if the question wasn't answered adequately; and
- Provide concise and appropriate answers to questions about their projects.

"By looking at these harder to measure (communication) skills, we can change our teaching to help develop them further in our students. These communication skills will be the ones that help students in college applications, job interviews, and other hard to measure communication scenarios." Chris Wandell, The Ice-T Project

During the improvement cycle, leaders learned that the "informal" nature of the rubric was helpful to collect data in a more natural way. They also found that while staff are generally scientists, they don't always get training on how to communicate or how to teach. The Ice-T Project plans to implement new training protocols for staff to develop:

- Skills and strategies for getting students to volunteer their thoughts and information;
- The ability to answer questions that encourage curiosity; and
- Comfort in saying "I don't know" to find answers together with students.

Communication with Pittsburgh Parks Conservancy Young Naturalists

Young Naturalists added more opportunities for students to practice science communication to further solidify the knowledge and learning taken from the program. During the improvement cycle, the program had students explain a science concept from an article and identify the types of information or strategies that helped explain the article's content. Through games, self-evaluations, a rubric and surveys, Young Naturalists measured the ability of students to demonstrate mastery of science communication tactics.

The program found that the rubric, while likely too formal for the environment, highlighted relevant learning that would help tailor student project guidelines.

"Giving students a rubric creates more pressure and anxiety... It really doesn't fit the vibe of the program, which is less formal and designed to not 'feel like school.'

We are more likely to adopt the rubric for internal/staff purposes... our team could use the rubric as context for planning the assessment projects and still emphasize a section of the rubric during individual weeks."

Stephen Bucklin and Ellen Conrad, Young Naturalists

Measuring Critical Thinking Skills

HIT in the CLE

HIT in the CLE helps bolster students' critical thinking skills as a vital part of coding. Working with students with little to no experience in coding, HIT in the CLE engages students in learning to code in multiple languages by program completion. Program leaders gave students a clear definition of what critical thinking is, how they would be improving the skill set in the program, and shared details of how the skills would be necessary for post-secondary, career and future success. By integrating exercises to test critical thinking skills into existing programming and creating a peer review structure, HIT in the CLE measured students' critical thinking skills. Program leaders learned:

- The importance of skill definition; critical thinking can be a subjective characteristic and ensuring student understanding is important for their learning and measuring progress.
- Peer reviews incorporated student voice into the process and built a degree of compassion and empathy among students. Youth learned to appreciate different ways to approach a problem.
- Establishing a baseline (e.g., pre-test.) will give clear metrics that can be compared to post-program proficiency.

"We often jump right into the tech, without giving the students more context as to 'why' they are learning to code and what skills we hope to help them grow. I think that small assessments will go a long way in demonstrating student growth of critical thinking and other skills."

Grady Burrows, HIT in the CLE

MESA Programs at the University of Southern California and California State University East Bay

Starting with student focus groups, MESA programs learned more about the language students use to define critical thinking and the connection to annual student projects. Program staff used this information to draft a survey that allowed students to rate their critical thinking skills. Then, using an assessment crafted using The Foundation for Critical Thinking and using Bloom's Taxonomy of analyzing, evaluating, and creating/synthesizing/inferencing, MESA staff asked students to assess California-based MESA competitions. MESA leaders learned:

- The student focus group was powerful and kept students engaged as they challenged/supported ideas and were able to articulate skills within each competition. Students also appreciated the space to have a dialogue about critical thinking.
- A common definition of critical thinking is important as students learn and assess their progress.
- Highlighting the specific skills students are learning along the way are important. By explicitly outlining skills, students can more actively stop to reflect on the skills they are learning within the program. An observation rubric would be useful to have to guide student reflection.

"Start with student voice to develop an attitudinal survey - their insights, language, and questions will help to ground the surveys to make them more meaningful and approachable for students. Hosting a focus group allows students to share, reflect, and co-create."

Ben Louie, USC MESA and Janiene M. Langford, CSUEB MESA

Data Analysis with Science Career Continuum at Chicago Botanic Garden

The Science Career Continuum set out to measure students' critical thinking, specifically a student's ability to interpret, analyze, and reason. Adapting a "Envision K-12 Critical Thinking & Problem Solving" rubric from Catalina Foothills, the program focused on the analysis and discussion portion of the students project. Program leaders learned:

- Involving students in syllabus development to measure a student's critical thinking growth; and
- Giving students the opportunity to analyze data and asking them to relate it to their own real world experiences often helps them feel more confident in their knowledge.

"One size does not fit all! I thought I was going to be able to use the syllabus with all students, but quickly realized that younger students demonstrate critical thinking skills in much different ways than our Juniors and Seniors."

Karen Segura, Science Career Contiuum

Measuring Research Skills

SHINE - Summer High School Intensive in Next-Generation Engineering at the University of Southern California

Research skills provide students access to university-based research experiences at the same level as their peers, and helps elevate student confidence in STEM and sense of belonging as part of a scientific community. SHINE used a rubric, co-designed by SHINE alumni, to measure progress on students' research skills and ability to understand and communicate research concepts. Through weekly assessments and final presentations, SHINE staff provided regular feedback to students and measured their progress on important skills like explanation of impact, communication of ideas, methodology, connections to broad knowledge, data tables and visuals, as well as language and citations. Staff learned:

- Continual engagement and consistent feedback is critical.
- Getting input from others like STEM professionals, funders, and PhD students is critical to the evaluation process.

TEENS students researching

Teenagers Exploring and Explaining Nature and Science (TEENS) at the Peggy Notebaert Nature Museum of the Chicago Academy of Sciences

Students often have trouble articulating the skills they develop and demonstrate during the summer program, TEENS program staff created rubrics to define and measure skills developed/demonstrated through students' final projects and student self-assessments. TEENS staff learned:

- Distinguishing individual teen growth or mastery of discipline-specific skills through staff assessment of group-created artifacts (report, website, etc) is a challenge.
- It is important to utilize both teen self-assessments and staff assessments of teen projects.
- Having rubrics available to teens to review before their final projects is critical to ensuring deep skill development and success.

Developing competencies that matter in STEM are important for programs to nurture in students as they prepare for their futures. This is important for pre-college STEM programs and the youth they serve, as well as the larger system. STEM PUSH is testing key areas of improvement - like *equitably measuring skills that matter for the practice of STEM* - to position programs as providers of high-quality STEM learning experiences, in addition to giving admissions offices clear indications that students leaving the programs have the skills needed to succeed within their institutions.

These findings will continue to shift pre-college STEM programs in their practice. STEM PUSH's learning engine will also continue to test and share best practices to create larger systems change within the college admissions process. Proving programs' rigor also makes the case for **accreditation**, a trusted signal for admissions professionals during decision-making.

Continue to learn more with STEM PUSH at www.stempushnetwork.org
Learning, templates and best practices can be found on our learning engine page.

The STEM PUSH Network is funded by The National Science Foundation's (NSF) Eddie Bernice Johnson INCLUDES Initiative, a comprehensive national effort to enhance U.S. leadership in discoveries and innovations by focusing on diversity, inclusion and broadening participation in STEM at scale. STEM PUSH is also co-funded by the NSF Innovative Technology Experiences for Students and Teachers (ITEST) program and the Advancing Informal STEM Learning (AISL) program.