Smithsonian | SCIENCE *for the classroom*

Teaching Everyone

Addressing Diversity, Equity, Accessibility, and Inclusion in the STEM Classroom

Principal Hayes walks into a fifth-grade classroom to observe a lesson. After listening to small-group discussions for a few minutes, she checks her schedule. She thought she was going to observe a science lesson, but the students are sharing stories about family meals. She approaches the teacher, Mr. Amari, who is in the process of projecting a piece of artwork showing a mother and daughter working with dried corn. Mr. Amari explains that the class will be studying sugars and starches. He has set up the opening lesson so that students are grounding their research in their own experiences with corn as a food. Principal Hayes joins in the subsequent whole-class discussion and shares a story about helping her grandfather cook shrimp and grits.

Credit: "Drying Corn" by Carl Moon. Courtesy of Smithsonian American Art Museum, Gift of Florence O. R. Lang

Principal Hayes then joins a kindergarten class that has been investigating how pushes and pulls can change the speed and direction of objects. Students are talking about the new composting program in the school cafeteria. They have noticed a problem: not all students can easily get to and put their leftovers into the tall compost bins. One student suggests a solution using a shorter bin on wheels that students can push or pull to move around for compost collection. The teacher, Ms. Radigan, points out that this is a good place to think about inclusive design. She encourages the class to think of designs for the rolling bin that would enable all students to put their compost into the bin and to roll the bin around for others.

Taking an integrated approach to teaching STEM subjects is not only about bringing together science, technology, engineering, and math. We know that this integrated approach must serve all STEM learners along the continuum of human ability, cultural experience, and interest. How are Mr. Amari and Ms. Radigan serving all students? What research-based strategies should Principal Hayes be looking for in her school's STEM curriculum to ensure STEM is accessible to all students?

What Does DEAI Look Like in STEM Education?

One of the guiding principles of the National Research Council's *A Framework for K–12 Science Education* is promoting equity (NRC 2012). Under this principle, the *Framework* states:

Equity in science education requires that all students are provided with equitable opportunities to learn science and become engaged in science and engineering practices; with access to quality space, equipment, and teachers to support and motivate that learning and engagement; and adequate time spent on science. In addition, the issue of connecting to students' interests and experiences is particularly important for broadening participation in science.

While the *Framework* refers to *equity,* in discussions about serving all students in STEM classrooms, the words *diversity, equity, accessibility,* and *inclusion* (collectivized here under the acronym DEAI) are often used. For the purposes of this paper, we provide suggested definitions from the American Alliance of Museums for these words in the table shown.

Term	Definition
Diversity	All the ways that people are different and the same at the individual and group level
Equity	Fair and just treatment of all members
Accessibility	Giving equitable entry to everyone along the continuum of human ability and experience
Inclusion	Ensuring diverse individuals fully participate in all aspects of the work including decision making and engineering solutions

American Alliance of Museums 2018

Although each of these words can be distinguished, no single term stands alone and all four must be considered when designing high-quality opportunities for students to engage in significant science and engineering learning.

The Case for Implementing DEAI in the STEM Classroom

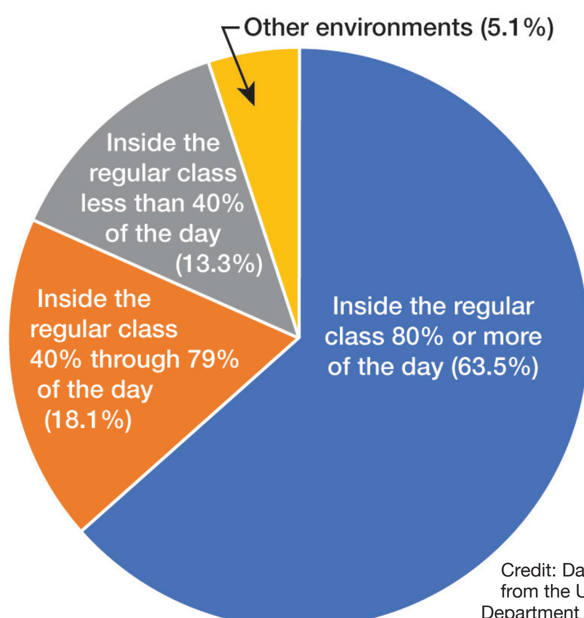
In the United States, students of color are expected to make up 56% of the student population by 2029 (see the graph, Page 3).

- Hispanic/Latinx students are the fastest growing demographic group in the K–12 public school population.
- An achievement gap in science persists between students across racial/ethnic identity lines (Hussar et al. 2020).

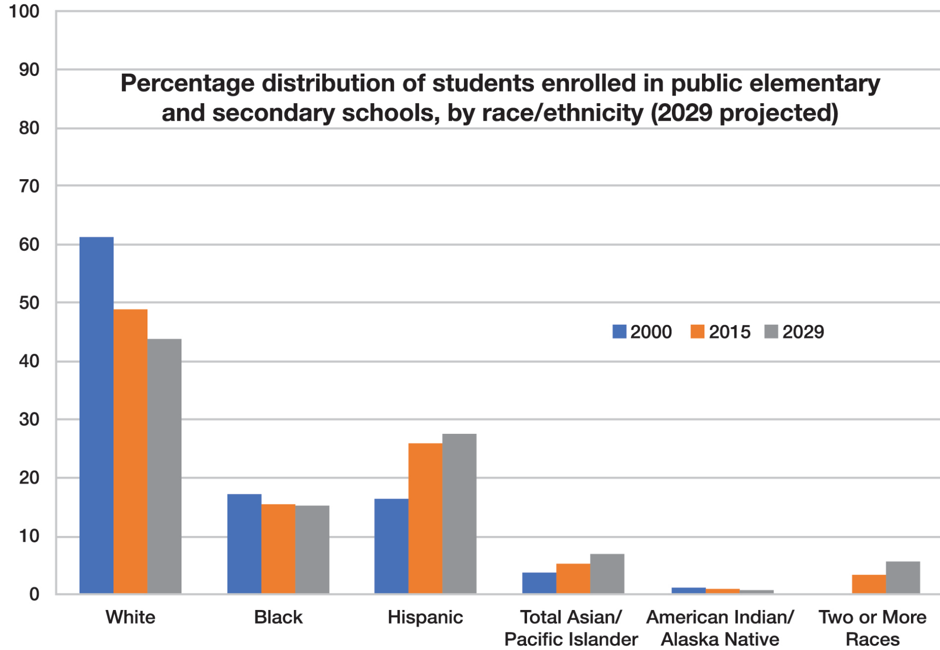
The elementary and secondary educator workforce in public schools is overwhelmingly white (79%). Black males make up 2% of the teaching workforce nationwide (US Department of Education 2016). As a result, many students of color do not see teachers who look like them or share cultural backgrounds with them.

In 2017, 9.3% of the US population ages 6 through 21 in 49 reporting states were served under federal programs for students with disabilities. More than 63% of children with disabilities are in general education classrooms for more than three-quarters of their school day (US Department of Education 2020).

Percentage of Students Ages 6 through 21 Served Under Individuals with Disabilities Education Act by Educational Environment, Fall 2017



Credit: Data from the US Department of Education 2020



Credit: Data from the US Department of Education 2020

Research indicates that special education coursework has "a positive impact on preservice teachers' disposition towards inclusion" (Hadadian and Chiang 2007). In the US, approximately 70% of teacher preparation programs require a course or coursework in special education in their general education curriculum. Less than a third of programs require general education preservice teachers to work with students with disabilities (Blanton, Pugach, and Florian 2011). In addition, little research has been done on how students with disabilities learn science concepts (Anderson and Nash 2016). As recently as 2015, 82% of fourth-grade students with disabilities in the US performed at or below the basic level on the National Assessment of Educational Progress science assessment (NAEP 2015).

In addition to students from major racial and ethnic groups and students with disabilities, other groups of students within US schools should be considered when looking at the state of the STEM classroom. These groups include students in economically disadvantaged families, students with limited English proficiency, girls, students in alternative-education programs, and students identified as gifted and talented. According to the 2018 Digest of Education Statistics, 52% of US elementary and secondary students are eligible for free/reduced-price lunch, 10% participate in programs for English learners, and almost 7% participate in gifted/talented programs (Snyder, de Brey, and Dillow 2019). Although definitions for alternative-education programs vary among states, over 600,000 students in the US are identified as attending such programs (Porowski, O'Conner, and Luo 2014). Given these statistics, it is important to identify STEM curriculum that ensures all students have the opportunity to learn science, technology, engineering, and math.

> "... academic performance of students with disabilities is significantly below that of other students—even for students whose disabilities should not prevent them from learning alongside their peers and achieving similar academic outcomes."
>
> (Blanton, Pugach, and Florian 2011)

Desired State of DEAI in the STEM Classroom

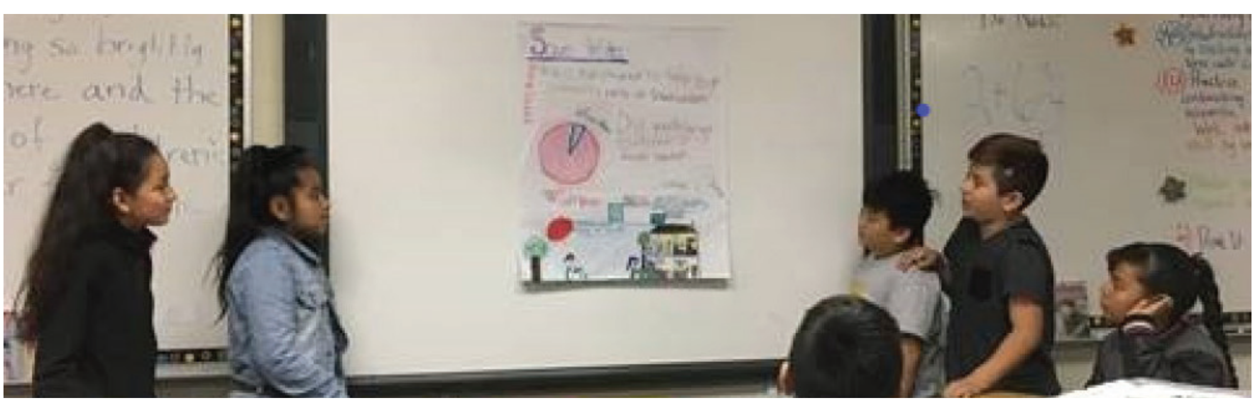
What should Principal Hayes look for in STEM classrooms? What curricular resources might support diversity, equity, accessibility, and inclusion in the STEM classroom?

Good curriculum and instruction serve all students without providing a particular benefit to any specific group. The *Framework's* call for equity in science education can translate into supports for all students, including those who have not always been well served (Januszyk, Miller, and Lee 2016). M. Bang et al. introduce three principles that relate student sensemaking in the STEM classroom to culturally responsive instruction in support of all learners (Bang et al. 2017). In addition, they suggest that curriculum and instruction that emphasize student engagement in science and engineering practices has "the potential to shift science education toward more equitable, active, and engaged learning for all students." This potential can be met if teachers and students are encouraged to "push against prescriptive views of knowing and doing science" and allowed to integrate their diverse backgrounds into their practice of science. Mr. Amari's students were able to build their understanding of sugars and starches in plants around a food that is common to many of their home cultures.

High-quality instruction that is culturally responsive can be fostered through professional learning opportunities, and good curriculum can support such teaching. For example, students should have the chance to see their current and future selves represented in student-facing curriculum materials. This includes pictures but perhaps more importantly students must relate to the phenomena and problems designed to drive student learning. While every phenomenon or problem in a curriculum may not be relevant to every student or group, curricular materials can provide a variety of phenomena and problems across a discipline or grade. These can include caring-themed problems, locally focused environmental problems, or regional health issues such as the prevalence of black lung disease or lead poisoning. Curricular materials can also suggest prompts that help a teacher make a phenomenon culturally relevant, such as Mr. Amari's class discussion about corn in family meals.

Smithsonian fire protection engineers are featured in a grade 1 reading. Engineers Ajay Gulati, Josh Stewart, Jim Call, Tiffney Chen, Rychele Jones, and Nandeep Bahra provide role models for students to envision future selves.

Today, with technological advances and more diverse classrooms, it is increasingly possible for high-quality curricular materials to include multimodal/multisensory activities so that students can access STEM along a continuum of human ability and experiences. Other strategies to support DEAI in the STEM classroom include intentional planning for learner variability, flexible methods and experiences, and universal design for learning (UDL) approaches (Basham and Marino 2013).



Credit: Smithsonian Science Education Center

Students propose a solution to a water shortage problem.

UDL principles focus on ensuring equity in access through providing multiple ways of representing content (e.g., text to speech, audible passages), providing multiple ways for students to demonstrate their knowledge and skills (e.g., verbal, speech to text), and providing multiple strategies for student engagement (e.g., instructional choice). Curricular materials that provide multiple ways of presenting instruction allow students to make connections within and between concepts and facilitate the transfer of learning. Providing students with options such as speech to text and vice versa, making collages, and conducting and reporting on interviews allows them to express their learning in ways that reduce or eliminate barriers to showing what they know and can do.

Universal design is not just for teachers, however. Ms. Radigan introduced her students to universal (or inclusive) design practices as they were preparing to engineer solutions to problems, allowing her students to consider all students and all abilities in their school as they designed new compost bins.

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How the Smithsonian Science Education Center Supports DEAI in the STEM Classroom

The Smithsonian Science Education Center publishes high-quality curriculum that provides student/role model representation; introduces student-relevant problems and phenomena that drive learning; and are built around student use of science and engineering practices, allowing for multiple entry points for students from a range of communities.

Its curriculum series, Smithsonian Science for the Classroom, also includes sensemaking strategies and supports to help all students' ideas become more structured and coherent. These include the use of image-based vocabulary cards, STEM notebooks, and cross-curricular and digital extensions that provide additional multimodal activities for students with high interest and connect to a variety of topics, including arts and literacy, which have been shown to increase girls' engagement with science, and community/home, which has been shown to be effective in supporting students who are underrepresented in STEM careers (NRC 2012). In addition, relevant research-based English-learner strategies are embedded at the point of use, with recommendations such as pairing bilingual students and those with limited English ability so they can discuss a concept in their primary language first and then, together or individually, express their thoughts in English (Quinn, Lee, and Valdés 2012; Fathman and Crowther 2005).

Smithsonian Science Stories, the literacy series that accompanies Smithsonian Science for the Classroom, features scientists and engineers from diverse groups and incorporates topics that are culturally relevant, drawing on the Smithsonian's cultural expertise from the Smithsonian National Museum of the American Indian, Smithsonian Latino Center, Smithsonian Asian Pacific American Center, and Smithsonian National Museum of African American History and Culture. There are below-grade and Spanish versions of the reader available.

Smithsonian Science Education Center, in collaboration with its partners, also supports teachers and school leaders in context through DEAI professional services. To learn more, go to https://ssec.si.edu/STEM-diversity.

Carolina Biological Supply Company. www.carolina.com/ssftc
Email: curriculum@carolina.com