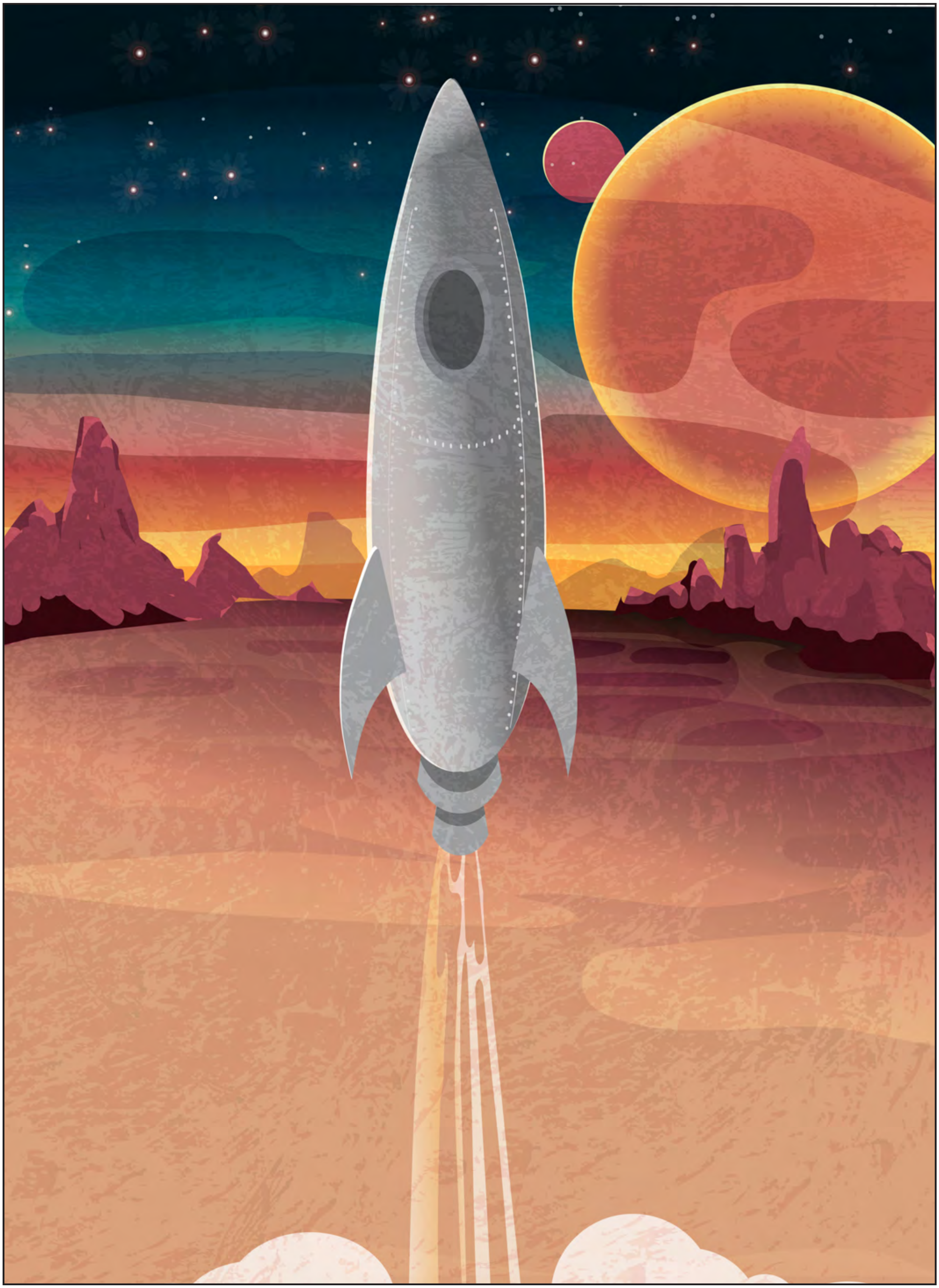


Advancing Science Instruction

State boards can lean into efforts to boost K-12 science literacy and beef up access to high-quality, inquiry-based education.

Bobbi Newman

America's future depends upon its citizens' basic science literacy. Soon the country will be relying on students in classrooms today to spur the discoveries needed to save lives, stave off disease, and protect the planet and to join the wide swath of professions that once did not require such knowledge and skills but now do. All students deserve the urgent efforts of educators and policymakers, state boards of education included, to strengthen science education. Without improved K-12 science performance and universal access to effective science teachers and high-quality science instructional resources, the states and the nation will struggle.

In 2021, the National Academies issued *A Call to Action for Science Education: Building Opportunity for the Future.*[1] Its authors lay out a vision in which all students develop "scientific literacy they need for personal and professional success" and are prepared to enter a competitive workforce that demands a wide range of science, technology, engineering, and math skills. For all students to have access to high-quality science education, they need to start early. In addition, struggling students and diverse students in groups underrepresented in the current STEM workforce will require greater support.

While students also need preparation in science from postsecondary institutions and through workforce opportunities, they must first develop a strong foundation before they graduate from high school. Too many have not.

Science Achievement Pre-Pandemic

Before the pandemic, U.S. science achievement already showed troubling lags. The National Assessment of Educational Progress (NAEP)—"the nation's report card"—last administered its science assessment to a nationally representative sample of fourth-, eighth-, and twelfth-grade students in early 2019 (see box). According to the 2019 results, 69 percent of Black students, 56 percent of Hispanic students, and 71 percent of students with disabilities scored below basic on the NAEP in grade 12 science, compared with 28 percent of White and 28 percent of Asian-American Pacific Islander students.[2] More than a quarter of the nation's fourth graders are below basic (27 percent), worse than the 24 percent in 2015 in science. There was little change overall from the 2015 administration, but students at the bottom of the score distribution fell even further behind in 2019.

The NAEP's student questionnaire offers a glimpse into students' science learning experiences, participation in scientific inquiry–related classroom activities, access to resources for science instruction, course taking, and interest in a science career. Less than half of 12th graders reported they were somewhat or more likely to pursue a career in science.

Teachers' attitudes as expressed in recent surveys are also cause for alarm. According to the 2018 National Survey of Science and Mathematics Education, teachers reported feeling unprepared to teach science. In addition, the survey found that very few elementary teachers have college or graduate degrees in science. In its science and engineering indicators report for 2020, the National Science Board found that science teachers with fewer years of teaching experience were more often teaching at U.S. schools with high-minority and high-poverty enrollment (figure 1).[3] There was also regional variation, with 20 percent of science teachers in the South having three years or fewer of teaching experience, compared with 10 percent in the Northeast, 14 percent in the Midwest, and 15 percent in the West. In a separate

Box 1. Changes Ahead

The Program for International Student Assessment (PISA) is being revised.[a] A working group has identified three dimensions that describe what all 15-year-olds should achieve: scientific knowledge, scientific competencies, and scientific identity. It also recommended three new knowledge areas: socioenvironmental systems and sustainability, the development and misuse of scientific knowledge, and informatics.[b] The old PISA framework emphasizes the traditional disciplinary framework but without the essential crosscutting, contextual, and interdisciplinary approaches that the new framework proposes.

In addition, the National Assessment Governing Board began soliciting public comment in 2021 on an updated assessment framework for the 2028 NAEP in science. NAEP frameworks guide the development of content-area assessments that are valid, reliable, and reflective of widely accepted professional standards. Any changes to the NAEP science framework will provide states with a signal for what will be assessed and reported in a NAEP science assessment.

[a] In PISA 2024 Strategic Vision and Direction for Science: A Vision for What Young People Should Know about Science and Be Able to Do with Science in the Future (March 2020), the Organization for Economic Cooperation and Development shares a vision for a future PISA framework.
[b] Informatics is the study of the data, structure, and behavior of natural and computational systems.

study, rural science educators, who serve approximately 20 percent of the nation's K-12 students, reported a lack of opportunities to engage in professional development or limited access to instructional materials, which inhibits their ability to teach science well.[4]

States' data on statewide science assessments appear equally grim. A month before the pandemic shuttered many U.S. schools, California released results on its new science test. Taken by students in grades 5, 8, and 10 through 12, the new tests were aligned with the Next Generation Science Standards (NGSS) and showed wide achievement gaps for Black, Latino, and English learners. Overall, less than a third of California students met or exceeded the new standards. Other states such as Michigan, Minnesota, Missouri, Tennessee, and Virginia recently posted significant drops in science scores. In Tennessee, proficiency on its new science assessment dropped 19 percentage points.

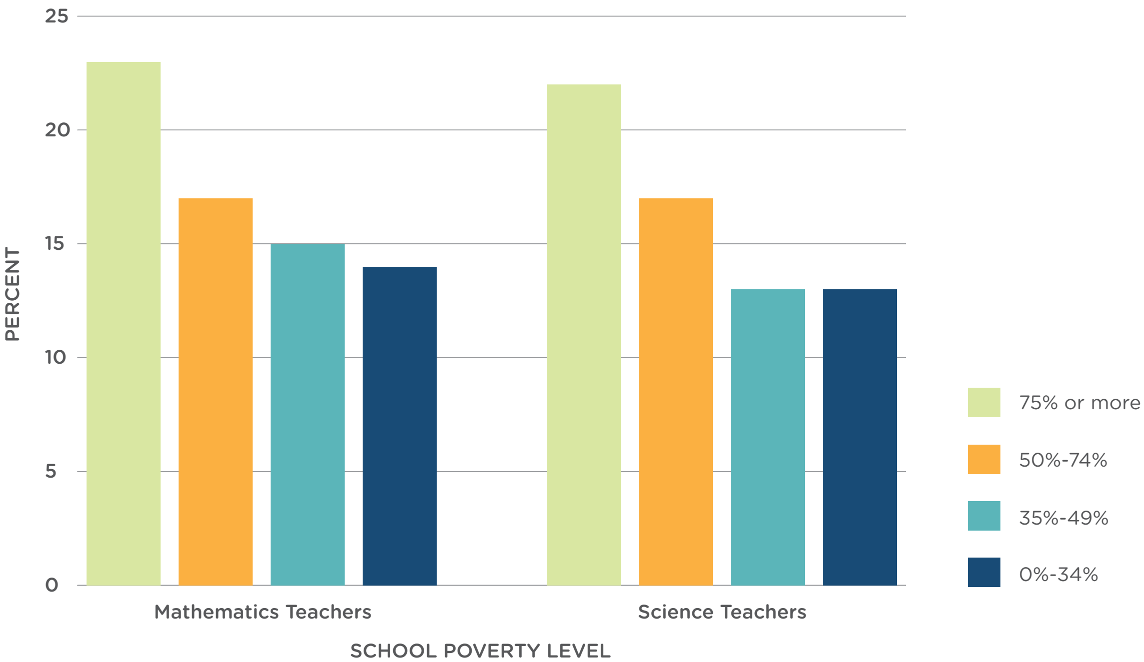
The nation's inability to effectively educate all students in STEM risks limiting future employment opportunities, weakening U.S. competitiveness, and restraining innovation. Students of color account for more than one-third of the nation's student population. As Mark Schneider, director of the Institute of Education Sciences at the U.S. Department of Education, put it, "It is going to be difficult to build a diverse STEM workforce with so many students from these groups underprepared in core STEM disciplines. If we continue to neglect the education of these students and the raw talent represented by so many Americans, the U.S. will be trying to compete with at least one hand tied behind our back."[5]

Before the pandemic, many states reported science teacher shortages as well. Maryland identified an acute teacher shortage in several content areas, including science and special education, in its 2016–18 staffing report. Connecticut school districts continue to report persistent teacher shortages in specializations or endorsements, including science and special education.

Pandemic Compounds Challenges

From preK-16 classrooms to career and technical programs to medical schools, hands-on education and experiential learning ceased during lockdown. Overwhelmed hospitals

Figure 1. Public middle and high school mathematics and science teachers with 3 years or fewer of teaching experience, by school poverty level: 2017–18.



Note:
School poverty level is the percentage of students eligible for free or reduced-price lunch.

Source(s):
National Center for Science and Engineering Statistics, special tabulations (2020) of the 2017–18 National Teacher and Principal Survey, National Center for Education Statistics, Science and Engineering Indicators.

closed operating rooms, so nursing, medical, and surgery students did not receive the typical training and exposure to clinical experiences. Bench scientists working predominately in laboratories reported a sharp decline in time spent on research and pursuing new projects. This decline in hands-on learning and research will affect scientific discovery and innovation for years, researchers predict.[6]

Preparation programs for aspiring science teachers faced similar challenges. In a 2021 book, researchers and practitioners document the challenges facing Indiana's science educators and preparation programs during COVID-19.[7] Eighty-eight percent of teachers in a recent survey indicated that students spent less time learning science remotely than they had in a face-to-face classroom.[8] Only 38 percent had been involved in experiments and investigations while learning remotely. Educators also reported that lack of internet access severely limited remote science learning.

Despite these well-documented challenges, science education appears to be nearly absent from state-level policy agendas. In states' plans for use of the Elementary and Secondary School Emergency Relief Fund (ESSER), states typically emphasized the science of reading and math instruction. One state's ESSER plan, California, planned to use the federal funds for educator recruitment and retention strategies, including support and training in early science instruction and environmental literacy.

The National Math and Science Initiative produces the STEM Opportunity Index, which displays how states, districts, and schools perform on 10 indicators critical to successful delivery of STEM education. State boards can use it to see how science education stands in their state and others.[9]

What State Boards Can Do

All state boards have three significant means for advancing science education for all students. They can raise questions, convene experts and stakeholders, and adopt and revise policies. State board members can begin by discerning the vision and landscape for science education in their state.

Questioning and convening. States can gather feedback to understand the needs of students, educators and leaders, teacher preparation programs, industry, employers, and postsecondary institutions in relation to science education. The Pennsylvania Department of Education, for example, held 14 in-person and virtual sessions in early 2020 with stakeholders across the commonwealth on what to include in its updated academic standards for science, environment and ecology, technology, and engineering.

State boards should also ask how students are performing in science across the continuum. For example, does the state provide early science learning opportunities for all students? Early science exposure promotes students' later success in science. Are there patterns in course taking that reveal that some students lack access to advanced coursework?

State boards can also ask how educators can better understand students' misconceptions, errors, and misunderstandings of foundational knowledge taught in earlier grades. Many state education agencies provide educators released assessment items from the TIMSS and NAEP so teachers can develop focused instruction to address common misunderstandings. Virginia, for example, sends educators guidance on items that their students are struggling with.

State leaders can spearhead a task force to develop a statewide strategic plan for science education. The group should include business leaders, postsecondary institutions, researchers, industry leaders, teachers, educators, families, students, interagency leaders, informal science educators, postsecondary institutions, STEM advisory councils, nonprofits, school leaders, and the out-of-schooltime providers, science centers, museums, and others who combine to make up community ecosystems for STEM learning. Out of the task force's recommendations, a science education roadmap should emerge to focus on implementing the recommendations, gathering feedback, and encouraging statewide coordination.

State policies should seek to align standards, instruction, and high-quality science instructional materials.

Adopting and revising policies. A statewide self-assessment can capture current state policies and practices as they relate to science education. Where do policies and initiatives to bolster science education already exist, and where are there new opportunities to support continuous improvement of science education?

State policies should seek to align standards, instruction, and high-quality science instructional materials. Nearly all states and the District of Columbia report they have based their standards on the National Research Council's 2012 framework for K-12 science education and the subsequent Next-Generation Science Standards. States are now working toward aligning the new rigorous standards with high-quality instructional materials to help teachers plan, teach, and assess student learning throughout the year. States can also prioritize the use of such materials in their multitiered systems of support.

Policies also ought to incentivize science teacher recruitment, retention, and learning. No single action will solve the science teacher shortage, so states must work with local partners to devise a multipronged approach that may, for example, leverage career changers, and salary and bonus incentives. Teacher residencies are a promising practice to prepare future educators. Modeled after the medical residency, school districts partner with teacher preparation programs to recruit and prepare teachers.[10]

A growing number of states have created STEM networks, STEM learning ecosystems, and informal STEM education networks as support networks for STEM teachers and thereby to improve retention. States must also continue to support policies and funding for sustained professional learning. Through its governor's PAsmart initiative, for example, Pennsylvania forms STEM learning ecosystems by funding grants to expand opportunities in education, training, apprenticeships, and STEM careers.

Another area ripe for state policy enactment and revision concerns instruction, assessment, and accountability.

- **Instruction.** Science instruction in elementary school is related to later science achievement, and impactful science teaching requires five hours of weekly instruction.[11] Thus a review of policies on instructional time is in order. Does the state set specific time recommendations for science instruction, particularly at the elementary and middle grades? To what extent are American Recovery Plan funds applied to afterschool and summer programs that augment science learning?
- **Assessment.** States that adopt a continuous improvement mind-set for assessment will incentivize the use of formative and performance-based assessment to improve student learning. Because students will need to demonstrate their learning in performance-based measures throughout their lifetime, continuously improving states will see statewide assessments as an opportunity for students to apply their learning in authentic ways that will better prepare them for the workforce and future STEM careers.
- **Accountability.** The Every Student Succeeds Act (ESSA) requires states to assess students in science at least once in grades K-5. Only five states—Arkansas, Louisiana, South Carolina, Tennessee, and Utah—administer state science tests in more than one elementary grade.[12] Less than half of states include science as one of the academic indicators or school quality indicators in their ESSA accountability plans.

While states have historically invested far more resources in math and reading, they must give more attention to improving science education and performance. State boards are well positioned to elevate science education across the P-16 continuum. They can gauge the extent to which their states offer access to high-quality science instructional materials, educator professional development, and dedicated instructional time devoted to science and hands-on-science inquiry. Working together and with partner organizations, members of state boards can advance science education and thereby improve the future of students and the nation. ■

[1]National Academies of Sciences, Engineering, and Medicine, *Call to Action for Science Education: Building Opportunity for the Future* (Washington, DC: The National Academies Press, 2021).

[2]Mark Schneider, "IES Learning Acceleration Challenges," blogpost (U.S. Department of Education, Institute of Education Sciences, December 14, 2021); Mark Schneider, "If It Wasn't for Bad News, Would There Be Any News at All?" blogpost (U.S. Department of Education, Institute of Education Sciences, May 26, 2021).

[3]National Science Board, *Science and Engineering Indicators* 2022, NSB-2021-1, figure K12-15 (Alexandria, VA: National Science Foundation, 2021).

[4]Doron Zinger, Judith Haymore Sandholtz, and Cathy Ringstaff, "Teaching Science in Rural Elementary Schools: Affordances and Constraints in the Age of NGSS," *The Rural Educator* 41, no. 2 (2020): 14–30.

[5]Mark Schneider, "To Build a STEM Workforce, We Must Invest in Education Science. But a Bill Congress Is Considering Doesn't Go Far Enough," *The 74* (June 29, 2021).

[6]Jian Gao et al., "Potentially Long-Lasting Effects of the Pandemic on Scientists," *Nature Communications* 12, no. 6188 (2021).

[7]Valarie L. Akerson and Ingrid S. Carter, eds., *Science Education during the COVID-19 Pandemic: Tales from the Front Lines* (Monument, CO: International Society for Technology, Education and Science, 2021).

[8]National Academies of Sciences, Engineering, and Medicine, *Teaching K–12 Science and Engineering during a Crisis* (Washington, DC: The National Academies Press, 2020).

[9]National Math and Science Initiative, https://www.stemopportunityindex.com/.

[10]Roneeta Guha, Maria E. Hyler, and Linda Darling-Hammond, "Teacher Residencies: A Promise for Transformative Teacher Preparation" (Palo Alto, CA: Learning Policy Institute, 2016).

[11]F. Chris Curran and James Kitchin, "Early Elementary Science Instruction: Does More Time on Science or Science Topics/Skills Predict Science Achievement in the Early Grades?" *AERA Open* (July 3, 2019), https://doi.org/10.1177/2332858419861081; Tammy Kolbe, Caitlin Steele, and Beth White, "Time to Teach: Instructional Time and Science Teachers' Use of Inquiry-Oriented Instructional Practices," *Teachers College Record* 122, no. 12 (2020), https://www.tcrecord.org/Content.asp?ContentId=23517.

[12]U.S. Department of Education, National Center for Education Statistics, table 2.4, Science Statewide Assessments in Grades 3-8, by state: 2017–18, https://nces.ed.gov/programs/statereform/tab2_4.asp

Science instruction in elementary school is related to later science achievement.

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