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Reinvigorating K-12 Science Education

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The COVID-19 pandemic has made science education more urgent and less accessible. The nation relies on science education to prepare the virologists, immunologists and doctors who may be the world's best line of defense against the next pandemic. A sound grasp of science can also inoculate Americans against misinformation that undercuts communities' response to health crises. Yet most K-12 students lost access to science classes, facilities and hands-on investigations when school buildings shuttered in the spring of 2020.

Even before the pandemic, access to K-12 science education was uneven at best, and students' average performance in science was disappointing. The 2019 National Assessment of Educational Progress in Science offers timely insights into the challenges states faced while implementing new academic standards that focus on scientific inquiry, engineering and technology. The results of the assessment and accompanying surveys of K-12 schools, teachers and students illuminate those reforms' progress through 2019, before the pandemic struck. The data also provide a baseline for measuring the damage the pandemic has done since.

This report examines that baseline, explores the damage and considers state policies that can support K-12 science education reforms as schools recover. Such policies can do more than simply restore schools to what they were before the pandemic by accelerating the important and, at times, faltering work of improving science education.

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A Note About Terms

This report departs as follows from the language the federal government uses to describe racial and ethnic categories:

Federal Term	Education Commission of the States Term
American Indian/Alaska Native	Indigenous
Asian	Asian American
Hispanic or Latino	Latin descent

To maintain fidelity to the source data, the dashboards that accompany this report use the federal language.

Findings From NAEP's Science Assessment and Surveys

In the year before the pandemic, the news about science education reform was mixed. Eighth- and 12th-grade scores remained flat between 2015 and 2019, and fourth-grade scores declined — halting or offsetting encouraging gains that students had made in the prior six years. NAEP surveys offer evidence that schools were responding to new science standards — by teaching engineering, for example — but many students still lacked opportunities to engage in inquiry-based science. Students who are Indigenous, Black or of Latin descent were least likely to have such opportunities, as were students from households with low incomes. In addition, students who needed the most support were least likely to have access to resources, opportunities for scientific inquiry and challenging coursework.

Explore the data in an online interactive dashboard.

State Science Education Reforms

Since 2013, 20 states and the District of Columbia have adopted the Next Generation Science Standards, which depart from most states' prior standards by focusing on scientific inquiry, emphasizing the engineering design process, and developing such key skills and habits as communication, collaboration, problem solving and flexibility. Another 24 states have adopted science standards based on the National Research Council's Framework for K-12 Science Education, which was the basis for NGSS.

Science Reforms Made a Mark, but Some Goals Remained Elusive

- **Schools were adapting to new science standards.** Teachers at all three grade levels that NAEP assesses were devoting more time to engineering, a major focus of states' recent science standards. Students at all grade levels were also significantly more likely to have access to extracurricular science clubs sponsored by schools or teachers. (See Dashboard 1.)
- **State science reform goals remained elusive**. At least 40% of students at each grade level had no access to inquiry-based learning opportunities or instruction that focused on the scientific method — major goals of states' science education reforms. Hands-on science activities or projects were even scarcer. (See Dashboard 2.)
- **Time for science in fourth grade was limited in 2019 — and had fallen off since 2015**. Declines in fourth-graders' average performance accompanied declines in the average amount of time their teachers spent on science. Most fourth graders received less than three hours of science instruction per week, and the share of those receiving less than two hours per week rose significantly between 2015 and 2019. (See Dashboard 3.)
- **Students' performance in science dropped in fourth grade and leveled off in eighth and 12th grades**. Gaps persisted by race, ethnicity, family income, gender, school location and eligibility for free or subsidized lunch. (See Dashboard 4.)

Inequities Persisted in Family Income, Race and Ethnicity

- **There were significant inequities in access to resources that support science education**. Students who qualified for free or subsidized lunch were consistently less likely than their peers to have access to such resources as lab spaces, lab stations, measurement instruments, safety equipment or materials. Indigenous, Black and students of Latin descent were also less likely than their peers of other races and ethnicities to have access to science facilities, equipment or materials. (See Dashboard 5.)
- **Access and participation in advanced courses increased, but inequities persisted**. Schools were significantly more likely to offer AP science courses than they had been in 2015, and students in almost every racial, ethnic and income group were significantly more likely to take them. Yet Indigenous students, Black students, students of Latin descent and students in households with low incomes were still least likely to attend schools that offered such courses. Asian American students, by contrast, were most likely to have access to, and take, AP courses in science. Students in suburban schools were more likely than students in urban, rural and town schools to have access to such courses. (See Dashboard 6.)

Students Who Needed the Most Support Had the Fewest Opportunities

- **Students with the lowest scores had the least access to instructional resources**. This finding is especially troubling, because scores among students at the 10th and 25th percentiles dropped between 2015 and 2019, while scores among higher-performing students held steady. Such inequities can widen performance gaps. (See Dashboard 7.)

- **Students with the lowest scores were least likely to be exposed to scientific inquiry.** The lower the students scored, the less likely their classes were to have engaged them in the scientific method. By contrast, students who performed lower were more likely than their higher-performing peers to have experienced hands-on science activities — although such activities were rare at all performance levels. Scientific inquiry is often hands-on, but hands-on activities do not necessarily involve inquiry. (See Dashboard 8.)

- **Students with the lowest scores had least access to advanced science courses.** These disparities were stark. For example, students who scored below basic were less than half as likely as students who scored advanced to attend schools that offered AP Computer Science A or AP Physics C. (See Dashboard 9.)

About the National Assessment of Educational Progress in Science

The National Center for Education Statistics administers the NAEP science assessment to "assess students' knowledge and abilities in the areas of Earth and space science, physical science, and life science."

- Roughly 30,400 fourth graders, 31,400 eighth graders and 26,400 12th-graders took the assessment in 2019.

- NCES administered assessments based on the same framework in 2009, 2011, 2015 and 2019.

- Unlike prior NAEP science assessments, the 2019 assessment does not offer state-level results.

- NAEP uses surveys of schools, teachers and students to collect contextual information about students' learning experiences in and out of school.

Teacher Preparation and Support

In national surveys, teachers have long reported feeling underprepared to teach science, especially in the elementary grades. Reforms that introduced new content in engineering and technology have exacerbated this challenge, as have limited and inequitable access to teacher professional development.

According to the 2018 National Survey of Science and Mathematics Education (NSSME), the share of high school teachers who felt very well prepared to teach content in science ranged from a high of 89% for the periodic table to a low of 19% for modern physics. The share of middle school teachers who felt very well prepared was generally lower, ranging from 55% for structures and functions of organisms to 7% for modern physics. Elementary teachers felt least prepared: Only 31% said they felt well prepared to teach science.

Teachers were much less confident in their preparation to teach content in engineering. Less than 15% of middle and high school teachers — and only 3% of elementary teachers — felt very well prepared to teach engineering content.

NSSME found that teachers were less likely to receive effective professional development in science than in math. Elementary teachers, who articulate the greatest need for professional support, received the least. They received less professional development in science than middle or high school teachers did, and the professional development they did receive was less likely to emphasize knowledge and understanding of science content.

NSSME also revealed inequities in teachers' access to professional development. Teachers who taught mostly underrepresented students of color were least likely to have received at least 35 hours of professional development in the prior three years — as were teachers whose classes consisted primarily of students with lower prior achievement. NSSME defined underrepresented students of color as American Indian or Alaskan Native; Black or African American; Hispanic or Latino; Native Hawaiian or other Pacific Islander; or multiracial.

The COVID-19 Pandemic's Toll

Early evidence suggests that the pandemic has further restricted access and deepened inequities in science education. In a spring of 2021 survey, **California** middle school teachers overwhelmingly agreed that the sudden shift to virtual learning limited hands-on education, inquiry and investigation in science. Eighty-eight percent said their students spent less time on science when they shifted to remote learning, and 60% said it was much more difficult to engage students in science and engineering practices. Another survey found that 72% of high schoolers from families with low incomes interrupted their AP physics courses during the pandemic.

States that have released results of science assessments for the 2020-21 school year are beginning to reveal the impact of such disruptions. **Florida**, **Michigan**, **Minnesota**, **Missouri**, **Tennessee** and **Virginia** have already posted significant drops in science scores since 2019.

Experts caution that comparisons with prior years might be unreliable because many students opted out of state assessments in 2021. Even so, few are optimistic about the pandemic's impact on students' learning.

State Policy Considerations and Examples

State policies can address the long-standing challenges to science education that the COVID-19 pandemic has exacerbated. Legislatures and state school boards have already invested substantial time in science education reform by adopting new science standards and assessments. State leaders can build on those efforts by supporting science in the elementary grades; better preparing teachers of science; improving curriculum; expanding access to equipment and materials; and broadening participation in advanced courses.

Making Elementary Science Count

To encourage greater focus on science in the elementary grades, states can recommend minimum instructional time, assess students in science more than once in grades K-5 and hold schools accountable for student performance on those assessments.

In a 2018 survey of states' science education policies, 19 states reported a policy addressing instructional time for science in grades K-5. For example, the **Alabama** State Department of Education recommends at least 30 minutes per day in grades one through three and 45 minutes daily in grades four through six. The **Missouri** Department of Elementary and Secondary Education posts similar recommendations.

Yet recommendations alone are not binding. Transparency and accountability for student performance in science can give schools and teachers incentives to devote more time to the subject. The Every Student Succeeds Act requires states to assess students in science at least once in grades K-5. Five states — **Arkansas**, **Louisiana**, **South Carolina**, **Tennessee** and **Utah** — administer state science tests in more than one elementary grade.

All five states are among the 21 that include science among the achievement indicators in their accountability systems. Elementary teachers in such states generally devote more time to science than teachers in states that do not hold elementary schools accountable for performance in science. A study of **Kentucky**'s early accountability efforts in the 1990s found that elementary teachers in grades the state tested were much more likely than those in untested grades to increase instructional time for science.

The National Academy of Science's Board on Science Education recently cautioned state leaders against assessments that measure only rote learning, calling instead for "multiple and varied assessments" that can gauge conceptual understanding and proficiency with science practices. Such assessments can inform classroom instruction while helping leaders chart progress at the school, district and state levels.

Time for science does not have to crowd out time for other subjects. For example, **Florida**'s statewide reading initiative provides reading curriculum that integrates content from science and other core subject areas. The initiative also trains elementary teachers, reading coaches and administrators to integrate content from those subject areas into reading instruction.

Strengthening Teacher Preparation in Science

Florida's professional development in reading offers one avenue for preparing elementary teachers to teach science. Teachers at any grade level need professional development to master states' new science standards. Veteran teachers may lack training in strategies for promoting scientific inquiry, for example, and teacher preparation programs offer limited and dwindling opportunities to build knowledge in engineering.

The **New Mexico** Public Education Department uses the professional development program Making Sense of SCIENCE to train teacher leaders and staff developers in inquiry-based science and pedagogy. A rigorous study of the program supported by the U.S. Department of Education found that it increased the amount of time that teachers devoted to science, strengthened their knowledge of the subject and promoted instructional practices aligned with Next Generation Science Standards.

States can also use existing professional development programs in engineering to bolster teachers' preparation. For example, states such as **Georgia** and **Massachusetts** have used state funds to expand Project Lead the Way, a nationally recognized K-12 engineering program that includes substantial teacher professional development.

The **Georgia** Governor's Office of Student Achievement's Innovation Fund relied on annual appropriations to introduce the program to 146 elementary, middle, and high schools from 2015 through 2018. The **Massachusetts** grant combined public and private funds to support Project Lead the Way in 58 schools. States can target such funding to schools that serve students from low-income households. The One8 Foundation, a partner in the Massachusetts grant program, takes this approach.

Expanding Access to Effective Science Curriculum

It often falls on districts and schools to provide curriculum and teaching materials that support academic standards. Districts and schools with smaller budgets or greater need can struggle to provide effective curriculum and materials, contributing to inequities evident in the NAEP data.

This challenge can weigh heavily on science teachers, who are less likely than math or English language arts teachers to have access to vetted curriculum and materials. State policymakers can address the challenge by endorsing and supporting science curricula and materials that have demonstrated effectiveness.

States can help districts and schools select curricula and materials in science that meet a high standard, although states have admittedly struggled to do so in the past. A 2019 study by Chiefs for Change and the Johns Hopkins Institute for Education Policy found that states regularly promoted instructional materials that received poor ratings from respected independent reviewers such as EdReports.org and the **Louisiana** Department of Education's tiered curriculum reviews.

Rhode Island, by contrast, will require local education agencies to adopt K-12 instructional materials that align with academic standards, curriculum frameworks, state tests and rigorous standards of quality. The state works with EdReports.org to identify approved materials, and its requirements for science materials will go into effect in June 2025.

A handful of states have set aside funds to help schools that serve students from households with low incomes adopt vetted STEM education programs that include curriculum and teaching materials. The **Iowa** Governor's STEM Advisory Council's STEM Scale-Up initiative awards schools and after-school providers more than $3 million in state funding each year to implement rigorously reviewed STEM education programs, many of which provide curriculum and materials on such topics as engineering, medicine, bioinformatics, elementary physics and aquaponics. The initiative reaches 75,000 to 100,000 students in pre-K through grade 12 each year, a substantial portion of the state's roughly 500,000 P-12 students.

Michigan's MiSTEM Advisory Council oversees a similar initiative that annually awards $3.05 million in state funds to support carefully vetted K-12 STEM programs in schools across the state. Like the Iowa and Michigan councils, the **Alabama** STEM Council plans a strategy to "identify evidence-based and effective STEM initiatives and scale their utilization across Alabama schools … with an emphasis on reaching traditionally underserved populations."

Expanding Access to Equipment and Materials for Science Education

States can provide grants or resource libraries that provide schools and teachers free science equipment and supplies. The **Massachusetts** Life Sciences Center, a quasi-public agency, oversees a state-funded STEM Equipment and Professional Development Grant Program to help schools serving communities with low incomes purchase the equipment, materials, supplies and technology they need to teach the life sciences. The fund provides up to $100,000 per high school and $50,000 per middle school to support capital expenses.

The **Utah** STEM Action Center maintains a STEM Equipment Library with locations across the state where teachers can check out equipment to support their lessons. **Idaho**'s STEM Action Center maintains a similar library.

The pandemic also prompted schools to explore online resources — such as virtual laboratories and simulations — that replaced physical equipment and materials when school buildings closed. Even after the pandemic, online resources like this could help schools that lack facilities and materials provide their students rich lab experiences.

Broadening Access to Advanced Science Courses

In 2016, Education Commission of the States released model components of a comprehensive state policy to expand access to, and participation in, Advanced Placement Courses. These components include guaranteed access to AP courses; pre-AP courses and training; financial support; and teacher professional development.

States have enshrined some of those components in statute. For example, **Arkansas** requires every school district to offer at least one AP course in each of four areas: English, math, science and social studies. **Texas** Administrative Code specifies that the state must subsidize AP exam fees, reimburse the costs of teacher training, and offer students and teachers financial incentives for strong performance. The National Math + Science Initiative's College Readiness Program incorporates many strategies embedded in the model components. It has been a vehicle for expanding access to AP courses in states like **Pennsylvania.**

Arkansas, the **District of Columbia** and **Georgia** are incorporating AP and International Baccalaureate indicators in school accountability plans to create new incentives to boost participation and success in those programs.

States can also implement dual enrollment programs, which allow high schoolers to take college-level coursework for college credit. Research on dual enrollees in **Florida** and **Texas** suggests that students of color and students from households with low incomes can experience the largest benefits from such programs. Education Commission of the States has released model policy components to help state leaders devise dual enrollment policies that do not exclude those students.

Avoiding Piecemeal Efforts

Each state policy strategy above can address barriers to science reform, but none in isolation can solve the constellation of challenges that the 2019 NAEP science test reveals. States can embrace a multi-faceted approach to improving science education and focusing on the students who need the most help.

State STEM advisory councils such as those in **Alabama**, **Idaho**, **Iowa**, **Michigan** and **Utah** can identify state needs and coordinate diverse strategies to meet those needs. In addition to scaling effective curriculum and professional development programs, for example, the Iowa Governor's STEM Council has fostered dozens of partnerships between schools and businesses, hundreds of teacher externships in STEM workplaces, STEM teaching endorsements at seven universities, and a media campaign to promote the profile of STEM education and jobs. All five STEM Advisory Councils enjoy gubernatorial and legislative support, which helps secure reliable funding and widespread attention to the councils' agendas.

The Board on Science Education calls for local and regional alliances of key STEM stakeholders that, like STEM councils, can coordinate diverse evidence-based strategies for fostering opportunity and equity. Such strategies include providing excellent instructional resources, building the teacher workforce, creating pathways through K-12 and postsecondary education, and tackling disparities in access.

State leaders can support such local alliances. For example, **Pennsylvania** funds STEM learning ecosystems through grants from the Governor's **PAsmart** initiative, an effort to expand opportunity in education, training, apprenticeships and STEM careers. STEM ecosystems advance local collaborations among community partners to improve access to STEM learning opportunities. Partners such as business leaders, teachers, school districts, higher education institutions, parents and after-school programs work together in ecosystems that focus on local needs, offer a continuum of opportunities for all students and support students who have the fewest advantages.

Final Thoughts

Results from the 2019 NAEP science assessment suggest that the work of science education reform is unfinished. Student progress has stalled or reversed, gaps between the highest and lowest performances have widened, and students who need the most support receive the least. The pandemic has worsened those trends and inequities, but state leaders can adopt policies to repair the pandemic's damage and address the challenges that predate it.

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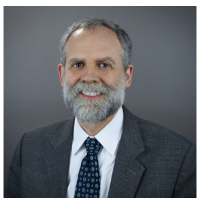

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