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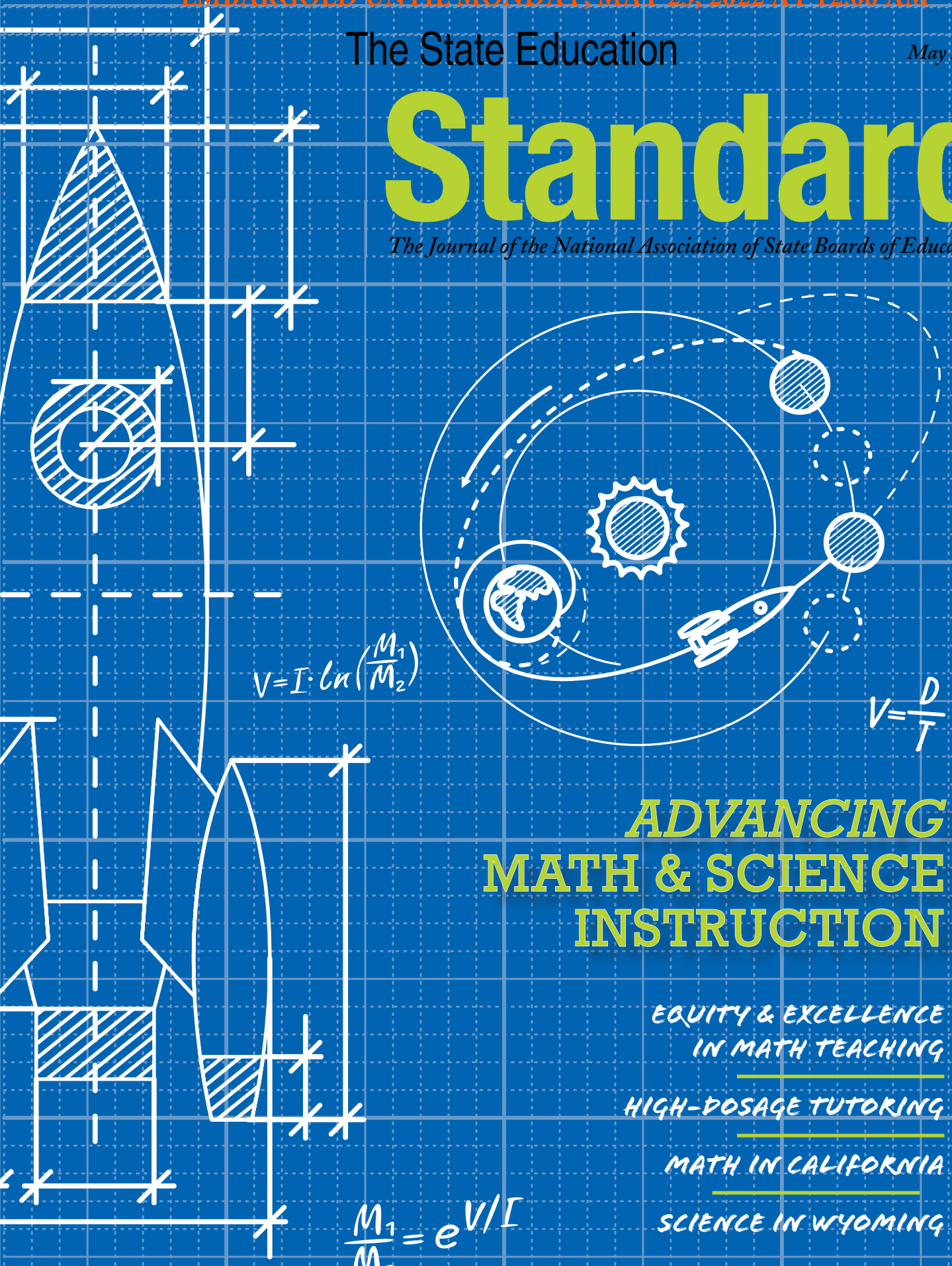
The State Education Standard

May 2022

The Journal of the National Association of State Boards of Education



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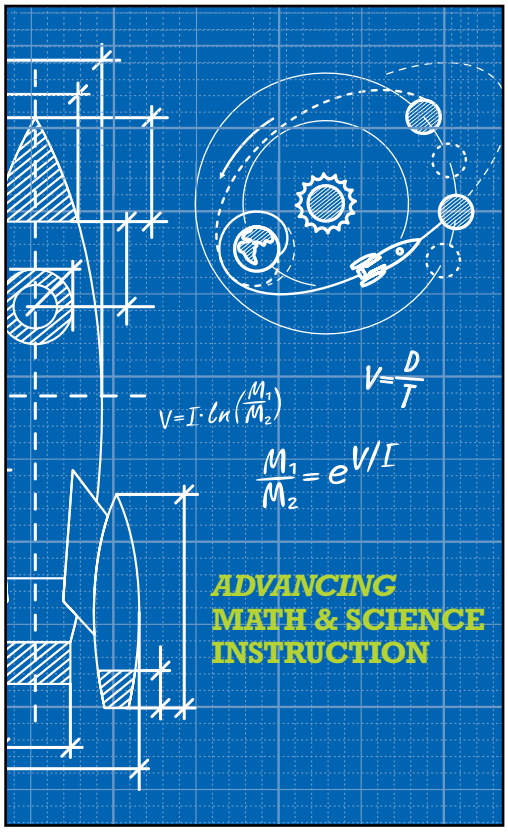

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Editor's Note

Valerie Norville
Editorial Director

As the authors in this issue make plain, many students—though not all—still learn math as a set of disconnected procedures they must master in a set sequence, and they learn science as a set of facts, possibly with a few experiments or observations along the way. And they often disengage out of boredom or the belief that they cannot excel in these subjects. The pandemic made matters worse for many. Advancing math and science instruction entails doing something different so it is possible for all students to achieve mastery.

Curriculum Associates' Jennifer Sattem and colleagues detail the challenges posed by lost opportunities to learn math during the pandemic. Supporting teachers with top-notch curriculum and professional learning is key to getting students on track, the authors write, as is a shared understanding of what content is essential for propelling students toward grade-level proficiency. New Classrooms' Joel Rose and Michael Watson also reflect on the need for math acceleration. To reach students who have fallen far behind grade level, they argue, states will need to revisit their assessment and accountability systems to lessen the incentives for teachers to focus solely on grade-level content.

As state leaders cast about for interventions that count, high-dosage tutoring is frequently prescribed. The University of Virginia's Beth Schueler lays out the evidence for targeted program designs that are most likely to boost student achievement.

AIR's Bobbi Newman makes the case for urgent attention to science instruction. Too many students lack access to high-quality science education and got less during the pandemic, and yet it has not recently played a prominent role in most state policy agendas. She suggests several ways for state boards to engage.

Jo Boaler and Jennifer Langer-Osuna of Stanford explain the impetus and goals of a math framework they helped draft in California in an attempt to turn around lackluster math achievement and combat a perception that only a few students are capable of excelling in math. The framework elevates the intersections of important math ideas, student collaboration, and data literacy.

Revitalized math instruction requires strong preparation for math teachers, adds the University of Southern California's Yasemin Copur-Gencturk. "When teachers' math understanding is fragmented and disconnected, the learning environment they create fails to be as meaningful as it could be," she says, adding that addressing teacher biases will be another key factor in engaging students of color and students from low-income families.

Wyoming state board chair Ryan Fuhrman offers some wry reflections on his intersection with state and federal education policy, first as a beginning science teacher and later as a member of the state board, which has embarked on development of a Profile of a Graduate. Washington state's Randy Spaulding and Mississippi board member Amy Zhang suggest what states can do to spur integrated STEM learning, where the benefits of cross-disciplinary learning can truly flower.

Elisha Smith Arrillaga and Dave Kung from the Charles A. Dana Center at the University of Texas–Austin, which works across the system to scale math and science teaching innovation, delve into what states can do to bust the pervasive myth that math is not for everyone. "It is not acceptable to say, 'I can't read,' " says Smith Arrillaga. "We should have that same reaction about math." ■

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News & Notes

Congress and the Biden administration made progress this spring on several policy and spending areas that are important to state education agencies and school districts. Federal leaders completed work on the long-delayed fiscal year 2022 budget, started committee hearings focused on the president's fiscal year 2023 spending request, and initiated discussions about strengthening the educator workforce, increasing data privacy protections, and addressing students' mental health needs.

In early March, President Biden signed a sweeping omnibus appropriations bill to complete the fiscal year 2022 budget process for the U.S. Department of Education (ED) and other agencies. The measure increased education spending by the largest amount in 15 years, including increases for Title I, special education state grants, teacher and school leader professional development, and more.

Only two weeks later, President Biden submitted his fiscal year 2023 budget request to Congress. The $5.8 trillion request would provide ED a 21 percent increase. Significantly, the request includes a $3 billion increase for Title I, a $2.9 billion increase for special education state grants, and a $200 million bump for the Perkins's career and technical education national activities account. Congress's education committees are reviewing the president's request and plan to hear testimony about it from Secretary of Education Miguel Cardona and other education officials.

President Biden used the State of the Union address to call on Congress to invest $1 billion to help schools meet students' mental health needs. The proposed investments would be used to hire counselors, psychologists, and other mental health professions who can meet the rising tide of mental health challenges facing youth across the country. The president's fiscal year 2023 budget request proposed to establish a new program for this purpose.

■

In late March, Secretary Cardona called on education stakeholders to make use of emergency funding provided by the American Rescue Plan to address persistent, widespread teacher shortages. He urged states, postsecondary leaders, districts, and schools to consider establishing evidence-based teacher residency programs, creating registered apprenticeship programs for the teaching profession, and increasing teacher compensation, along with a slew of other proposals. In recent weeks, some members of the education committees also discussed ideas for helping school districts address their workforce needs. Although it is not clear if Congress will take new steps in 2022 targeting this need, the topic is likely to remain a recurring theme on Capitol Hill throughout the year.

■

Enhancing data privacy protections is a top priority for the Senate and House commerce committees. Legislators are discussing plans to increase the Federal Trade Commission's budget for enforcing key federal privacy laws, such as the Children's Online Privacy Protection Act (COPPA), placing new limits on how companies may use consumer data and expanding COPPA to cover children older than age 13. This spring, the House commerce committee is expected to consider legislation that covers these and other topics. States and school districts should carefully watch this work to identify changes that may affect schools.

Thanks to Jamie Brandon and Reg Leichty at Foresight Law + Policy for this update.

Figure 1. High School Graduates Earning Carnegie Credits in STEM Courses, 1990–2019 (percent)

	1990	2000	2009	2019
All STEM Courses	76*	91*	94*	97
Advanced Math[a]	57*	73*	83*	89
Advanced Science & Engineering[b]	63*	79*	85*	88
STEM-Related Technical Courses[c]	28*	41	36*	39

** = Significantly different from 2019 (p<.05).*
Source: National Assessment of Educational Progress, High School Transcript Study, various years, 1990–2019 (2022).
a. Includes Algebra II, precalculus/analysis, calculus, and other advanced math.
b. Includes advanced biology, chemistry, advanced environmental and Earth science, physics, and engineering.
c. Includes engineering/science technologies, health science and technology, and computer science.

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NCSBEE Voice

Randy Spaulding
Executive Director
Washington State Board of Education

Advancing Elementary STEM

Washington state hosts innovative, growing companies in every industry whose demand for talent has far outstripped local supply. The jobs they create require postsecondary STEM credentials or STEM literacy, but Washington students have not been adequately or equitably prepared for these opportunities. Students of color, rural students, students living in poverty, and girls lack access or face barriers to these pathways.

As I engaged in some of the policy response undertaken since the mid-2000s, I have seen the work evolve. Conversations 20 years ago on math focused on reducing postsecondary remediation and have since moved toward the skills needed for success in K-12 and postsecondary pursuits. Similarly, science discussion once focused on college readiness, subject-matter content, and scientific method. That focus has shifted to mastery-based approaches, scientific and engineering practices, crosscutting concepts, and core ideas that bridge disciplines.

Throughout this period, policymakers have identified organizations and voices to help tackle STEM education challenges, including Governor Inslee's STEM Education Innovation Alliance, which developed a STEM Report Card and, more importantly, brought education leaders, business, and nongovernmental organizations around one table. The alliance backed K-12 science teacher training and professional learning, scholarship programs for recent high school graduates, and a host of policies to support postsecondary STEM.

Washington has also sought to improve access to math and science coursework in high school, added requirements for graduation, supported interdisciplinary coursework, and pushed for more technology and computer science education. As a result, we have seen more Washington students enrolling in and completing STEM degrees and a 46 percent reduction in math remediation over the past decade.

Now we are highlighting a long-standing, systemic problem: Washington's K-5 students have widely disparate levels of access to science learning experiences, with many spending little to no instructional time on science generally, let alone in experiences aligned to state-adopted standards and laws. This seriously impedes these students' foundational learning, STEM identity and mind-set, academic progress, and future opportunities.

Washington sees integration of science with other subject areas as a key strategy to advance equitable access to science learning. The Office of Superintendent of Public Instruction (OSPI) has launched a project that supports 140 elementary teachers and 110 leaders through professional learning and collaboration to explore and apply integration flexibly. It includes school and district pilot teams that implement common units at each grade level.

The state board added equitable access to elementary science to its legislative platform for 2022 and is collaborating with OSPI on other measures and supports. For example, the board is adapting its annual collection of district data to include instructional time on science in elementary grades.

Our state's passion for industry, diversity, and ecology have made the career and innovation opportunities vast. Bringing high-quality STEM to elementary students, with progression to their middle and high school years, is essential for our state's continued success. The greatest role for our board in this work is as advocates and conveners of public and private sector partners. ■

*** Former board member Jeff Estes and OSPI Associate Director of Elementary Science, Learning, and Teaching Kimberley Astle helped with the development of this column.**

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Student Voice

Amy Zhang
Student Representative
Mississippi State Board of Education

STEM Education for All

I have always liked math, but it took transferring to a STEM magnet school for me to truly explore the field. My previous school simply did not have the teachers, classes, clubs, or resources I needed to grow. I have these opportunities now, but they aren't available to my old classmates. We need better STEM education at all schools, not just a select few.

High-quality K-12 STEM education engages future scientists, technicians, engineers, and mathematicians early in school, inspiring them to pursue higher education. Eventually, they enter the rapidly growing STEM job market and contribute to creating innovative technology. STEM also teaches equally important soft skills: The creativity, experimentation, and problem-solving skills learned through STEM are useful for all careers.

Unfortunately, not all students reap these benefits. Disadvantaged students are less likely to receive a high-quality K-16 science education, and less than a quarter of seniors are proficient in science or math.[1] To increase STEM proficiency, state boards of education can take several actions.

Set application-based learning standards. Students are people, too! Our eyes glaze over if we learn about DNA ligase without understanding its importance. Prioritizing understanding and application through educational standards promotes meaningful mastery of STEM concepts.

Incentivize STEM teaching positions. Many schools do not have enough teachers to offer advanced STEM classes. Students may also struggle to find sponsors for STEM clubs or competitions because teachers are busy organizing other extracurriculars. By increasing the number of qualified STEM teachers—through increasing salaries for current educators or offering loan forgiveness for aspiring ones—states can fill this gap.

Offer advanced classes through nontraditional means. Adaptations to the pandemic have made distance learning and online classes more accessible. If a disadvantaged school cannot offer a STEM course, it should be encouraged to organize other arrangements: interdistrict learning, dual-credit classes with regional colleges, online courses or certifications, or STEM research/internship opportunities with local professionals. State boards should encourage schools to cooperate with outside agencies and allow more programs to count for credit.

Involve industry leaders and stakeholders. Most businesses require data analysis, information technology, or systems engineering to grow. These companies have a large stake in supporting STEM education and could help introduce students to how STEM is applied to real-world challenges. Districts should develop partnerships with interested businesses to offer STEM internships, scholarships, and career training programs to promote STEM education.

Continue seeking student opinions. The only way to know if students are engaged with their STEM instruction is to ask them. To learn what is useful—say, interesting teachers and advanced classes—and what is not (rote memorization), continue seeking student voices to shape educational policy.

STEM education may seem contrived or unnecessarily difficult to many students, but the skills it teaches are universally important. State boards should invest effort in improving STEM education for everyone. ■

[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), doi.org/10.17226/26152; The Nation's Report Card, "NAEP Report Card: Mathematics, National Achievement-Level Results, Grade 12," web page, https://www.nationsreportcard.gov/mathematics/nation/achievement/?grade=12.

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The Impact of COVID-19 on Math Achievement

Without urgent attention, the problem of unfinished learning will compound as students advance to later grades.

Jennifer Sattem, Matt Dawson, and Elizabeth Peyser

States' annual testing data for spring 2021 showed that unfinished learning in the wake of COVID-19 is most pronounced—and most troubling—in math. In Texas, nearly 40 percent of students failed the state's math exam in 2021.[1] In Indiana, only 37 percent were proficient in math, down from 48 percent in 2019.[2] Many states saw similar results. National research by McKinsey & Company concluded that students were four months behind in math at the beginning of the 2021–22 school year.[3]

What makes the results such a cause for alarm is the sequential nature of math learning. Math skills build like a staircase. Teaching a second grader how place value relates to addition and subtraction computation allows them to understand multiple-digit multiplication in the fourth grade, which leads to concepts, such as the distributive property, in algebra. The challenges older students face relate directly to the degree to which they built a strong foundation in elementary and middle school. A student's mastery of fractions in the elementary years is a strong predictor of success in algebra and overall advanced math achievement, even when controlling for factors like socioeconomic status.[4]

Consider the difficulty confronting Jaden, a sixth grader who started this school year with fourth-grade math proficiency, as he attempts to solve a sixth-grade word problem: *Maria goes to the coffee shop. The store offers a pound of coffee for $9 or 8 ounces for $5. Which is the better bargain?*

The problem requires that Jaden compare two ratios, a progression that requires a new skill built off numbers and operations, algebra and algebraic thinking, measurement and data, and geometry. Jaden is expected to know that one pound equals 16 ounces and that he can use division to convert ounces into pounds. But he doesn't. His teachers in previous grades covered those concepts in classes he missed due to the challenges of remote learning, family illness, or a variety of other obstacles.

Should his math teacher deliver grade-level content to Jaden and his classmates, knowing that Jaden lacks the prerequisite skills and concepts to thrive? Or should she remediate by teaching the entire class fourth-grade material, which potentially robs Jaden of the chance to outperform expectations?[5] These questions plagued educators long before COVID-19. But given what test results say about unfinished learning, particularly in math, the need for answers is even more urgent.

Research on Unfinished Learning

Research from district-level interim assessments in many ways mirror what state assessments reveal about the impact of school closures and disruptions due to COVID-19.[6] For many years, districts have used these assessments, typically administered three times annually, to gather data teachers can use to guide instruction and support for students. With the cancellation of the 2020 state summative assessments during the pandemic, interim assessments also became critical tools for policymakers and researchers, providing a window into student achievement during an unprecedented series of disruptions to teaching and learning.

Our research draws on results from Curriculum Associates' i-Ready Diagnostic Assessment, taken by more than 10 million students across the country. Local diagnostic assessments,

like i-Ready, provide some of the best data available on student achievement over the previous two years. In our most recent research on unfinished learning—the fourth in a series—we examined student learning in the fall of 2021 compared with a pre-pandemic historical average.[7]

We found that fewer students in elementary and middle school started the 2021–22 school year ready for grade-level work. Every elementary and middle school grade exhibited unfinished learning in reading and math in fall 2021. However, students in early elementary grades, who are typically still learning to read, have not yet caught up to pre-pandemic on-grade-level performance. In math, the percentage of students who are on grade level is not yet reaching pre-pandemic levels in most grades, and the gaps are largest in upper-elementary and middle school grades (figure 1).

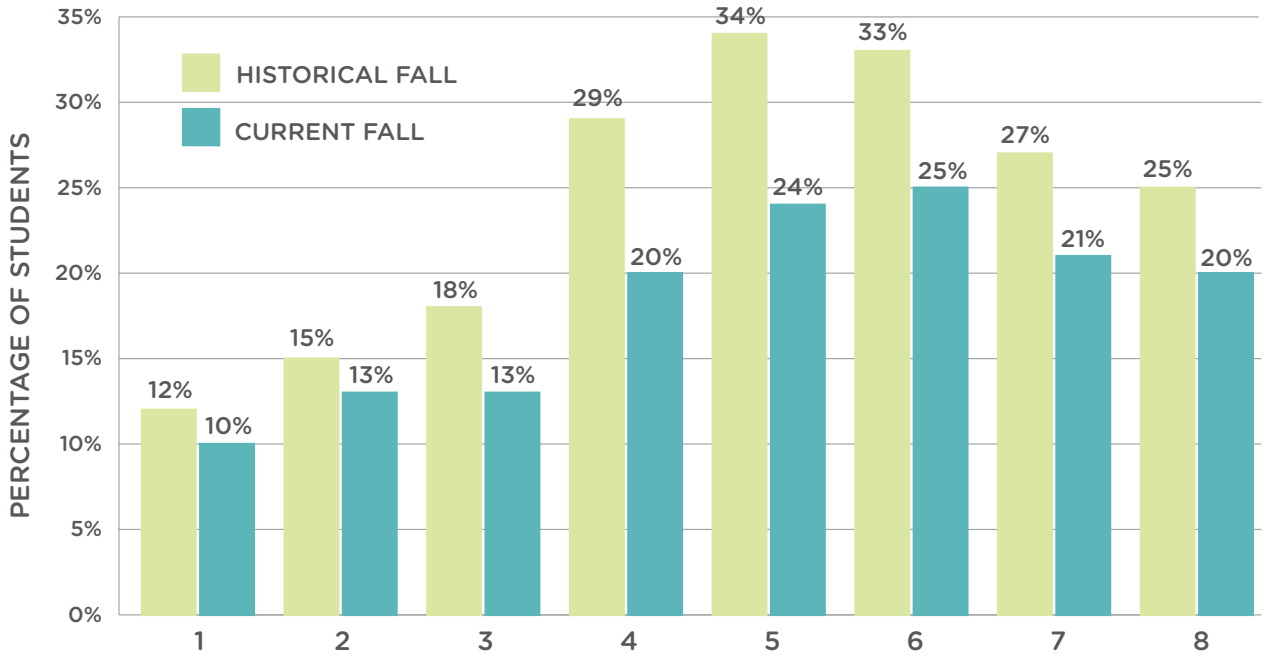
While the majority of students experienced academic setbacks, the pandemic has not affected all students in the same way or to the same degree. The conditions of education during the pandemic exacerbated longstanding inequities in learning for students of color and students in lower-income communities. Demographic data show fewer students in schools serving mostly Black and Latino students than White students and fewer students in lower-income zip codes started the 2021–22 school year on grade level.

Unfinished Learning in Math

Across our research and the most recent results from annual state assessments, one finding remains consistent: Students lost more ground in math than in reading. Why math? Students mostly learn math in school, especially as they get older. Parents are not as comfortable teaching math as they are reading to their children, and some math instruction does not translate as well to a virtual learning environment.

The findings from fall 2021 show that fewer

Figure 1. Grade 1–8 Students on Grade Level in Math, Fall 2021 and Historical Averages (percent)



Source: Curriculum Associates, "Understanding Student Learning: Insights from Fall 2021," Research Report No. 2021-17 (North Billerica, MA: Author, November 2021). The sample includes 3,331,943 students who took an i-Ready Diagnostic in math in school during the fall of the 2021–22 school year. The historical sample includes over eight million students who took the fall i-Ready Diagnostic in the previous three years in the same schools included in the current fall sample. Methodology, sample details, and study limitations are in the full report.

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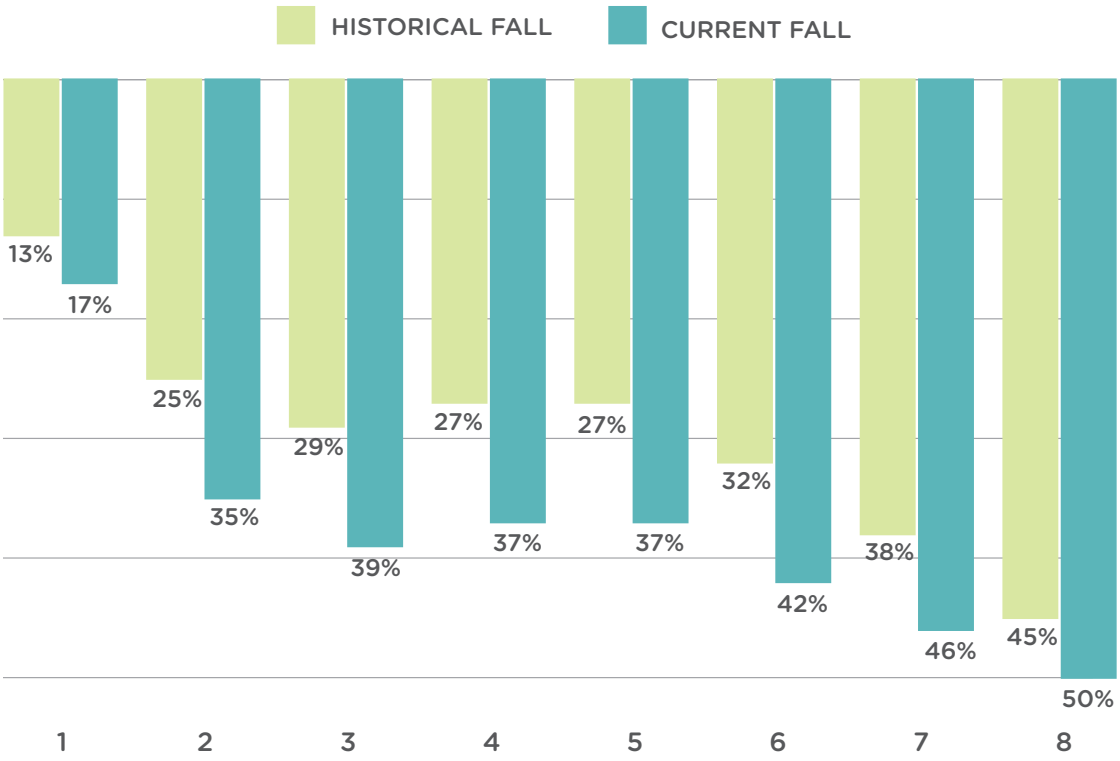
Figure 2. Grade 1–8 Students Two or More Grades below Their Chronological Grade in Math, Fall 2021 and Historical Average (percent)



Source: Curriculum Associates, "Understanding Student Learning: Insights from Fall 2021," Research Report No. 2021-17 ((North Billerica, MA: Author, November 2021). The sample includes 3,331,943 students who took an i-Ready Diagnostic in math in school during the fall of the 2021–22 school year. The historical sample includes over eight million students who took the fall i-Ready Diagnostic in the previous three years in the same schools included in the current fall sample. Methodology, sample details, and study limitations are in the full report.

students started the 2021–22 school year prepared to learn foundational math skills.[8] Fewer students in fourth grade were performing at grade level, and more students were performing two or more grades below, a 10 percentage point difference in fall 2021 compared with historical averages (figure 2).

We chose to highlight fourth grade here because students' ability to meet fourth grade benchmarks is a strong predictor of later academic success.[9] It is an essential grade to develop and master skills that prepare students for moving on to more advanced math, like algebra, that will be required throughout their secondary education.

Simply looking at the overall numbers does not tell the whole story. As shown in figure 3, more students were struggling across the underlying domains at the start of fourth grade, which illustrates the depth of the issue: It is not just a subset of knowledge and skills that were affected but all math knowledge and skills. While only fourth grade data are shown, the same pattern exists across all grades.

Accelerating Math Learning

If a student misses a science class on cumulus clouds, for example, she will not necessarily struggle with the life cycle of a frog three months later. Likewise, teachers forced to skip a chapter on the War of 1812 do not have to scramble to catch up students before they begin the unit on the American Civil War. But what does "accelerated learning" look like for math,

It is not just a subset of knowledge and skills that were affected but all math knowledge and skills.

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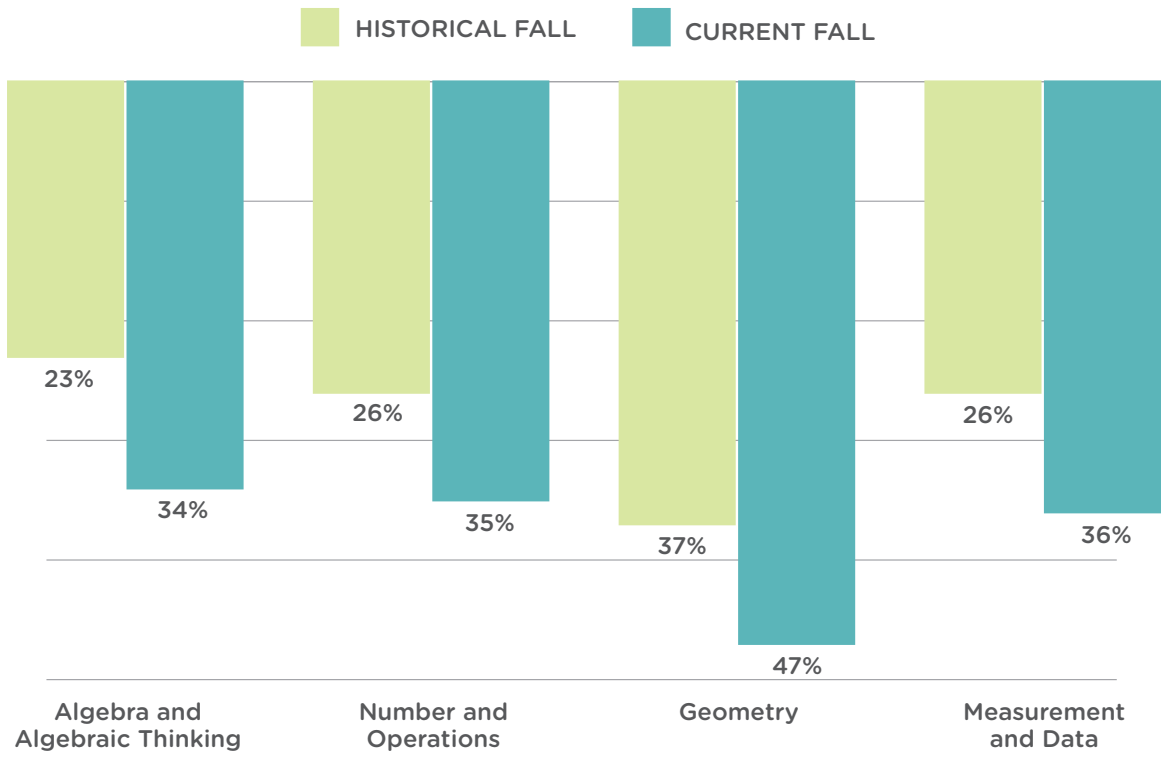
Figure 3. Grade 4 Students Two or More Grades below Their Chronological Grade by Math Domains, Fall 2021 (percent)



Source: Curriculum Associates, "Understanding Student Learning: Insights from Fall 2021," Research Report No. 2021-17 (North Billerica, MA: Author, November 2021). The sample includes 535,677 students who took an i-Ready Diagnostic in math in school during fall of the 2021–2022 school year. The historical sample includes 1,509,412 students who took the fall i-Ready Diagnostic in the previous three years in the same schools included in the current fall sample.

Great educators ask kids questions, over and over, until the missing step on the staircase reveals itself.

which at first glance might not appear to lend itself to acceleration?

Is it possible for educators to help students like Jaden catch up without stunting academic achievement by teaching content below his grade level? If so, what is a realistic, pedagogically sound way to confront unfinished learning?

There's one answer, and great educators already do it. They ask kids questions, over and over, until the missing step on the staircase reveals itself—until they have identified the specific foundational concepts that students are missing. Then they help students master those concepts while they are also learning the current year's material.

In the example of Jaden's sixth grade word problem, the goal of the lesson was to learn to create equivalent ratios, which can be done with multiplication and ratio tables. By pinpointing Jaden's missing foundational skills, his math teacher can tailor his instruction so he can answer the problem. That might mean reviewing how many ounces there are in a pound, reminding him how to create ratio tables, giving Jaden access to a calculator so he can convert ounces into pounds, or embedding a mini-lesson on conversions into the lesson, which serves the dual purpose of building Jaden's foundational skills while teaching him grade-appropriate material. The teacher and student can maintain the on-grade-level thinking of proportional relationships while not letting it turn into a lesson on division.

That's all. It does not require a new program or a radical approach to instruction. It requires teachers to identify skill gaps with precision

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while also maintaining high grade-level ambitions for students with those gaps. Doing so allows teachers to close the gaps but also ensure that students can solve not only this year's math problems but also the ones to come.

Tutoring, afterschool programs, and new curricula can be effective tools for remediation, but the work to complete unfinished learning must begin in the classroom, with teachers discovering where their students need support and then building that support into the lesson. It requires that teachers have time, resources, and support from their school and district leaders to meet students where they are without compromising grade-level mastery.

Implications for Policy

The data on unfinished learning are alarming. It would be understandable if educators' first reaction is despair and their second is to ramp up remediation. But America's schools cannot remediate their way to equity, especially because COVID-19 exacerbated inequities that were already there. In addition, students who are furthest behind have not seen learning growth sufficient to make up for the initial disruptions and unfinished learning from spring 2020.[10]

In response to the widened learning gaps, states have vowed to accelerate student learning, and state education agencies have emphasized investments in programs and initiatives that will help students recover. For example, Arizona created the Acceleration Academies Grant Program to offer teachers added professional development in best practices in math and literacy instruction.[11] Virginia has committed its education department and school divisions to emphasizing "acceleration, not remediation."[12]

State policymakers have unique opportunities to help more districts, schools, and educators gain access to high-quality, on-grade-level, equitable math instruction through intentional, strategic support. Just as teachers must identify areas in which their students need the most targeted help, we recommend that state policymakers identify strategic actions that will lead to the most impactful changes for students.

- Accelerating instruction is not simply moving students through academic content or standards faster. It requires intentional decision making about what students must learn to be proficient in current and future courses. State boards can **make sure that states have processes in place to develop a shared understanding of essential math content and standards that engage teachers, content experts, and instructional leaders in decision making.**[13]
- States can **ensure that teachers have access to high-quality math curricula and resources that support just-in-time prerequisite support and acceleration to on-grade-level instruction.** States such as Louisiana, Texas, and Massachusetts are using state processes for review of curriculum materials to ensure that educators have access to high-quality materials. Their reviews outline clear expectations for curriculum materials and the materials' alignment to state academic standards. High-quality curriculum maintains coherence across grade levels and concepts and includes multiple access points for students.
- In order to best support students, states must **provide resources for and prioritize professional development that emphasizes deep math understanding, progressions of learning, and conceptual understanding.** Just as states have dedicated funding to additional professional development in the science of reading, states should consider additional funding to focus on deepening teacher understanding of math. States can leverage research on effective teaching practices that outlines strategies to support instruction no matter where that instruction takes place.[14]

In COVID-19's wake, many state boards are making critical decisions regarding many competing priorities. Research has brought into focus the true extent of the need. The data point to the glaring need for more focus on math instruction. In order to address students' needs for accelerated learning, decision makers must take into account the content areas, grade levels, and communities most in need of additional support. ■

[1]Emily Donaldson and Corbett Smith, "Nearly 4 out of 10 Texas Students Failed State Math Exams in 2021," *Dallas News*, June 29, 2021.

[2]Arika Herron, "ILEARN 2021 Results Show Pandemic's Impact on Learning Could Take Years to Recover From," *Indianapolis Star*, July 14, 2021.

[3]Emma Dorn et al., "Covid-19 and Education: An Emerging

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America's schools cannot remediate their way to equity, especially because COVID-19 exacerbated inequities that were already there.

Jennifer Sattem is senior director of research strategy, Matt Dawson is director of efficacy and implementation research, and Elizabeth Peyser is national director, content and implementation at Curriculum Associates.

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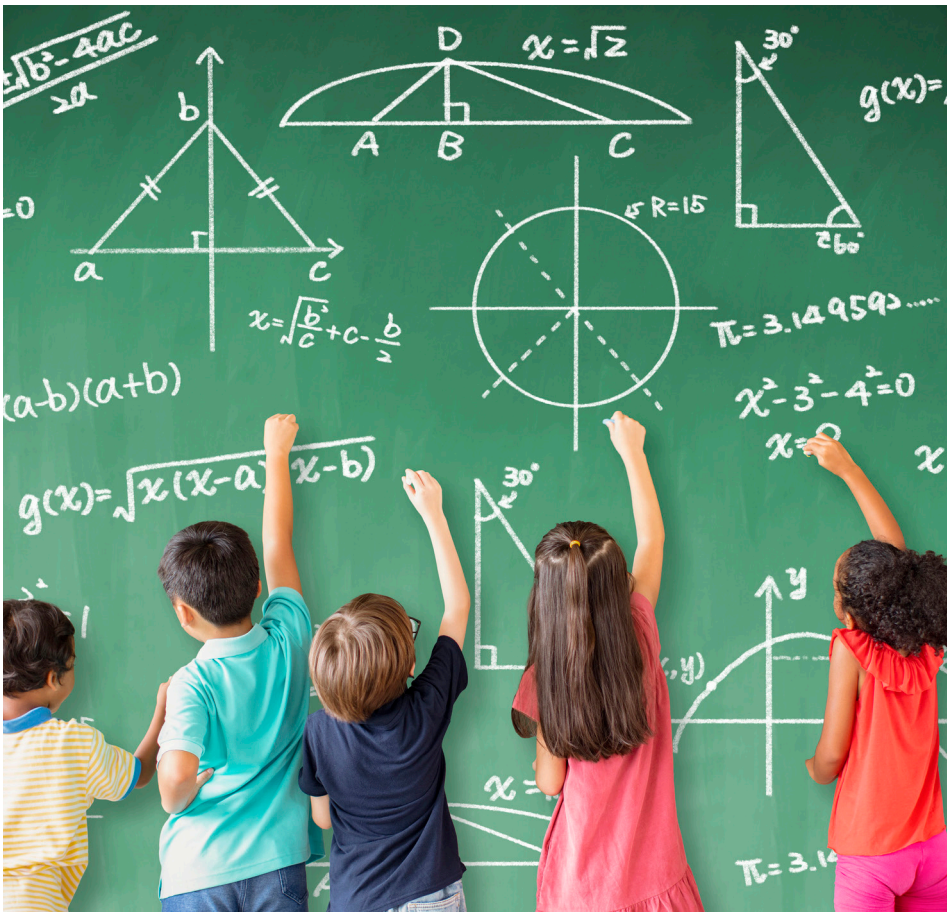


States can shift away from grade-level myopia to help students catch up.

The Urgent Need for Tailored Math Instruction

Joel Rose and Michael Watson

Teachers have long struggled with the tension between ensuring a rigorous education for all their students and the reality that students arrive at the start of a school year with vastly different skills and conceptual understandings. The tension can be even more acute in math, which relies heavily on students mastering foundational concepts in prior years. The last two years made matters far worse—especially for students from historically disadvantaged groups.[1]

Given this trajectory, state policymakers, administrators, and teachers have choices to make. Should they double down on the teaching of grade-level material, as federal policies signal they ought? Or should they instead refocus instruction and systemic incentives on meeting each student where they are?

Research suggests the latter. Lev Vygotsky's research on the "zone of proximal development" suggests that the fastest way to accelerate student learning is to provide opportunities where students are challenged at the appropriate level for their existing skills and knowledge—not too easy, not too difficult.[2] Students might not be able to conquer a brand-new topic on their own, but with the right supports, they can learn and retain something new that was previously out of reach.

In cumulative subjects like math, the need to focus instruction within students' zone of proximal development may even

be more essential. Eighth grade students, for example, are expected to learn about multistep equations, regardless of whether they already mastered critical skills such as solving simple equations, operations on rational numbers, or adding and subtracting algebraic expressions. Each of those concepts take time to master—something not always possible with a breezy review in advance of a grade-level lesson.

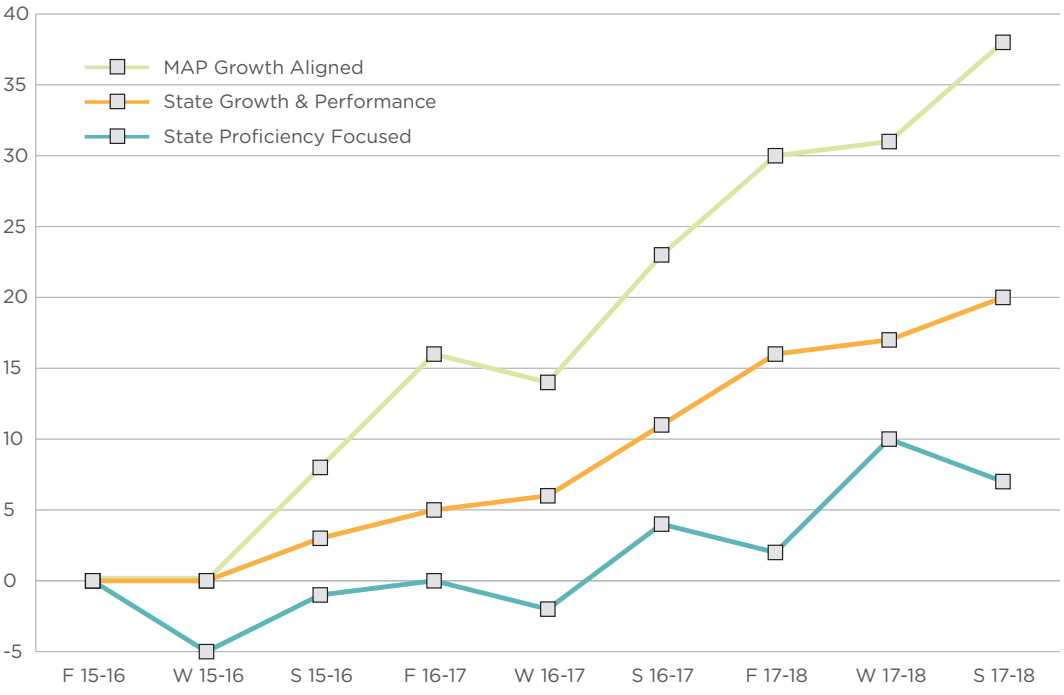
Following a policy push in the early 2000s to place many eighth-grade students in algebra who would otherwise have taken a pre-algebra course, researchers explored the impact of giving students content beyond their zone of proximal development. Tom Loveless found in a 2008 study that very low-achieving math students enrolled in algebra courses performed about seven grade levels below their peers on the National Assessment of Educational Progress and struggled with questions that tested elementary-level understanding.[3] Another study found that low-achieving students pushed into algebra did less well in subsequent math courses throughout high school, especially in geometry.[4]

The fact that it is so unlikely for students to catch up to grade level once they're behind is a reflection not of their capability but of a systemic approach that treats all students the same based on their age instead of what they know and do not know. Students would be far more likely to catch up and even get ahead if they could access an instructional program tailored to what they need to learn. Providing students with that opportunity requires a set of pedagogical strategies more in line with the research and a set of federal and state policies that permit schools to adopt them.[5]

Our own organization's research supports addressing key foundational gaps in the service of tailored acceleration. The program we designed, Teach to One, operated in multiple schools from 2015 to 2018. During that time, schools requested a variety of program adjustments that either emphasized or deemphasized grade-level content. A 2019 study looking at student progress found that students in schools that emphasized pregrade and grade-level exposure that met students' zone of proximal development made stronger gains than those focused solely on grade-level material (figure 1).[6]

Students would be far more likely to catch up if they could access an instructional program tailored to what they need to learn.

Figure 1. Change in School-Level Percentile by School Category



Source: Jessie Margolis, "Three-Year Map Growth at Schools Using Teach to One: Math" (MarGrady Research, February 2019).

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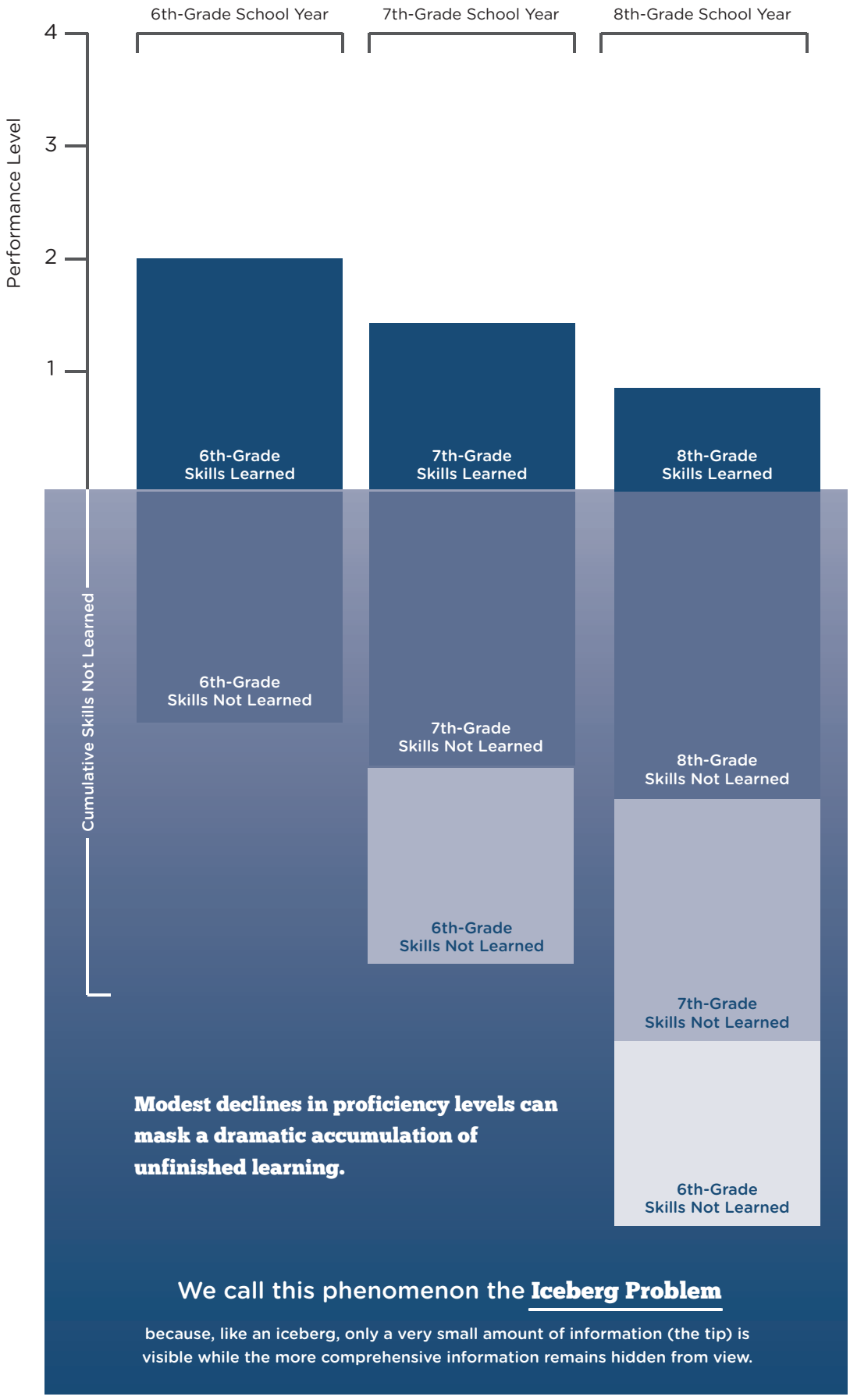
Figure 2. How Learning Gaps Accumulate Over Time



What Drives Grade-Level Focus

Education policy nonetheless signals a clear preference: teach to grade level and accelerate grade-level exposure. The historical inadequacies of remedial education, the need for a clear and coherent system of accountability, and the importance of trying to mitigate the systemic and subconscious biases within the K-12 system have collectively outweighed what might be pedagogically more impactful for individual students.

The shift to more rigorous college- and career-ready standards was one of the biggest policy developments in recent decades. Federal law, adopted in 2001 under No Child Left Behind and amended in 2015 under the Every Student Succeeds Act (ESSA), requires each state to administer annual math and reading tests aligned with grade-level standards for grades 3 through 8 and at least once in high school. The cumulative impact has been a set of more consistent expectations for students based on benchmarks pegged to a college- and career-readiness trajectory. This effort yielded progress in several areas, including greater transparency into achievement gaps between student subgroups, increased clarity for teachers on what they should be expecting from students, coordinated and aligned grade-level summative state assessments, and more objective information for families on whether students are reaching key milestones.

While these are important, worthy achievements, it is hard to argue that these policies have lived up to their promise. Roughly one-third of students graduated ready for college or a career back then, and the same is true today. Performance on international assessments have not moved in 20 years, while recent trends on the National Assessment of Educational Progress indicate that performance is going in the wrong direction.[7]

Policymakers can fairly debate the myriad factors that feed student performance trends and the overall impact of the law itself, but few could credibly argue that the teach-grade-level-only approach in math was systematically succeeding before the pandemic. As millions of students have since fallen even further behind, these policies seem even more problematic.

Teachers and students bear the brunt of all of this. School report cards (and in some cases teacher evaluations) continue to rely on grade-level assessments, which almost exclusively include grade-level material. Since covering those standards takes the full 180-day school year, there isn't much time to address students' foundational gaps. Nor do teachers have the tools to do so in the grade-aligned textbooks that guide daily instruction. Thus many teachers will opt to focus on grade-level content. This core academic strategy will result in students falling further behind as learning gaps accumulate year after year (figure 2), a phenomenon we detailed in a 2019 report, "The Iceberg Problem."[8]

A Misunderstood Definition of Growth

Some state policymakers may believe their basic approach to accountability addresses this problem because it includes both proficiency and growth. Indeed, ESSA permits states to include growth metrics in their accountability system and to weight growth's relative importance in different ways.

But because each grade-level assessment is based almost exclusively on grade-level material, true learning growth is not being measured. Even for states that have created better assessments that measure pregrade and on-grade standards, the federal accountability system points states toward measuring only grade-level questions. A student in a sixth-grade class who scored a Level 1 on the fifth-grade test and then a Level 1 again on the sixth-grade test looks like she did not grow. Growth does not in this example reflect the difference from where the student started and where she is now. It is a reflection of her performance relative to each grade's standards.

While the distinction may seem academic, it is actually quite significant because of the underlying instructional incentives. Policies signal to a sixth-grade teacher, for example, that she should teach all students the sixth-grade curriculum regardless of where they start from. If a student began the year on a third-grade level and her teacher was able to accelerate her to a fifth-grade level, those learning gains (two years of learning in a single year!) would not be captured under the accountability system; it would only consider her mastery of sixth-grade material.

Few could credibly argue that the teach-grade-level-only approach in math was systematically succeeding before the pandemic.

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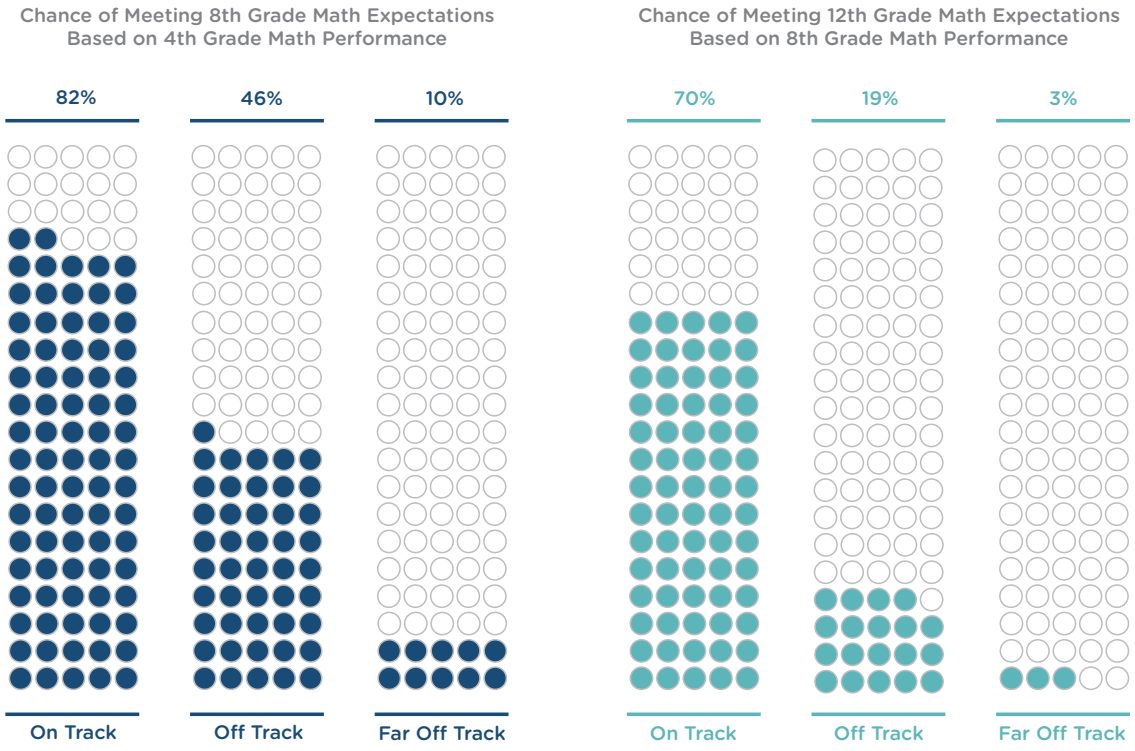
Figure 3. Likelihood of Catching Up



Source: Chrys Dougherty and Steve Fleming, "Getting Students on Track to College and Career Readiness: How Many Catch Up from Far Behind?" ACT, November 2012.

The grade-level-or-bust playbook turns a temporary state of academic deficit into a permanent one.

Given this approach, schools and districts will insist that their teachers focus instruction on sixth-grade material with the hope that students will demonstrate a greater level of mastery on the sixth-grade test than on the test in the preceding year. While a student will not master most of what she is taught, it is at least possible that she will pick up on enough sixth-grade skills to get to a Level 2.

Does this approach actually result in students catching up? One study conducted by the Institute for Education Sciences at Johns Hopkins University examined more than 1,600 middle schools and found that only 1 percent of the schools were able to consistently reduce the achievement gap in math and improve scores for the lowest-performing students.[9]

For the vast majority of students, the grade-level-or-bust playbook turns a temporary state of academic deficit into a permanent one. A study released by the ACT in 2012 showed just how unlikely it is for students to catch up once they have fallen behind (figure 3). Among its findings, a student who was "far off track" in eighth-grade math had only a 3 percent chance of reaching college readiness by the end of high school.[10]

The Role for State Policy

State policymakers have an essential role in a pivoting away from one-size-fits-all instruction to an approach more centered on the unique needs of each student. Many teachers will continue to focus on grade-level instruction until states step in and begin to articulate a new vision, set of policies, and regulatory landscape.

Some state policymakers will rightly argue that the current orientation around annual grade-level standards are a product of federal legislation that will be the law of the land until the next renewal of the Elementary and Secondary Education Act. While the law itself does hinder states looking to embrace a student-centered paradigm, there are still several shifts they can consider in order

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to create the space for more personalized approaches to instruction.

First, states can more accurately capture comprehensive learning growth by creating or using assessments that cover standards from across multiple grade levels. Nebraska and Georgia, for example, began piloting new state assessment systems that incorporate items from multiple grade levels and that are designed to capture both proficiency and true learning growth.[11]

Second, states can modify their accountability systems in ways that would create more space for personalization. For example, they can more heavily weight student proficiency at key grade levels (e.g., fifth or eighth grade) or change ESSA-aligned growth metrics to consider shifts over multiple school years (e.g., changes from fifth to eighth grade) in order to allow schools to take a multiyear approach to acceleration. They may also create a separate accountability system that would run alongside the federal system in order to provide more clarity on true student learning growth.

Third, states may use funds set aside in federal recovery dollars to launch math innovation zones, as North Dakota and Montana have done.[12] Modeled after what Texas set up before the pandemic, these innovation zones are statewide efforts to incubate high-quality blended learning programs. These programs effectively operate under a different system for accountability that runs alongside the federal system and that give volunteer schools permission to implement solutions that are more oriented around meeting each student's unique needs and building their strengths. Fourth, states should examine their procurement and state curriculum adoption policies and strategies to ensure their definition of high-quality instructional materials allows for innovative solutions that integrate precise diagnostics, multigrade content, and personalized instructional pathways to proficiency.

An Overdue Shift

Policymakers cannot ignore the fact that math learning is cumulative. When students do not fully master foundational skills, unfinished learning accumulates, making it increasingly challenging for the student to catch up.

The instructional incentives and pressure to deliver exclusively grade-level content created by the predominant assessment and accountability structures is fundamentally at odds with the needs of students who enter school multiple grade levels behind. These same policies may be causing some of the most disadvantaged students to fall even further behind in the pandemic's wake. The resulting blind spot in accountability threatens the equity and transparency these systems were designed to protect.

Expectations matter, but expectations are not all that matter. Students need a viable path that connects where they are starting from to where they need to be. The need for state leaders to explore innovative strategies centered on learning acceleration and recovery existed long before the pandemic. It is now more visible and more urgent.

But until states comprehensively revisit their existing policy infrastructure and create the conditions for new approaches to teaching and learning that challenge the grade-level orthodoxy, it is difficult to see how comprehensive efforts aimed at learning recovery in math can succeed. ■

[1]Emma Dorn et al., "Covid-19 and Education: An Emerging K-Shaped Recovery" (McKinsey & Company, December 17, 2021), https://www.mckinsey.com/industries/education/our-insights/covid-19-and-education-an-emerging-k-shaped-recovery.

[2]Seth Chaiklin, "The Zone of Proximal Development in Vygotsky's Analysis of Learning and Instruction," in Alex Kozulin et al., eds., *Vygotsky's Educational Theory and Practice in Cultural Context* (Cambridge, UK: Cambridge University Press, 2003).

[3]Tom Loveless, "The Misplaced Math Student: Lost in Eighth-Grade Algebra" (Washington, DC: Brown Center on Education Policy at Brookings, 2008).

[4]Charles T. Clotfelter, Helen F. Ladd, and Jacob L. Vigdor, "Algebra for 8th Graders: Evidence on Its Effects from 10 North Carolina Districts" (Washington, DC: The CALDER Center, American Institutes for Research, 2013).

[5]New Classrooms, "The Iceberg Problem: How Assessment and Accountability Policies Cause Learning Gaps in Math to Persist below the Surface…and What to Do about It" (New York: Author, 2019), https://newclassrooms.org/icebergproblem/.

[6]Note that a broader group of students, including those not continuously enrolled, showed average three-year gains of 13 percentile points. Jessie Margolis, "Three-Year Map Growth at Schools Using Teach to One: Math" (MarGrady Research, February 2019), http://margrady.com/tto/. The statistical power of these studies is not sufficient to prove that meeting individual student needs is more impactful than focusing on grade-level expectations. But it still carries more weight than research focusing on grade-level instruction regardless of students' starting points.

[7]National Center for Education Statistics, U.S. Department of Education and the Institute of Education Sciences, "NAEP Report Card: Mathematics," The Nation's Report Card, https://www.nationsreportcard.gov/mathematics.

[8]New Classrooms, "Iceberg Problem."

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States can more accurately capture comprehensive learning growth by creating or using assessments that cover standards from across multiple grade levels.

Joel Rose is the co-founder and chief executive officer at New Classrooms, which published "The Iceberg Problem," from which this essay is adapted. Michael Watson is the vice president of policy and advocacy for New Classrooms and the former chief academic officer and associate secretary of education for Delaware (2013–18).

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High-Dosage Tutoring

Strong evidence points to equity and well-being benefits from well-designed programs.

Beth Schueler

Two years of disruptions to schooling, coupled with recession and other pandemic-induced effects, appear to have widened preK-12 educational inequality. In particular, low-income students of color fell further behind their higher income White peers than they were pre-pandemic, on average, with the largest declines in math achievement.[1] High-dosage tutoring is a strategy uniquely suited to the moment, and state education leaders would be hard pressed to find another intervention backed by as large and rigorous a research base.

An early sign of the challenge came from March 2020 Google search data, which revealed a dramatic widening in the gap between high- and low-socioeconomic communities in the intensity of searches for online learning resources.[2] More recent evidence across a number of studies on academic achievement outcomes confirms that the pandemic's negative effects on learning were greatest for economically disadvantaged students as well as Black and Hispanic children.[3]

What can be done to narrow these inequities going forward? Researchers have shown consistently large, positive effects of high-dosage tutoring in myriad studies based on randomized field trials—the method best suited to fully isolating the causal effect of a program from other factors that influence student achievement. The studies cover a range of academic subjects, including math, across grade levels, contexts, and time periods.[4] They underscore that tutoring is not a new and promising fad but rather a method that has been tested and validated over decades. Researchers are notoriously hesitant to say something "works," and so it is particularly notable that tutoring finds such high levels of support among those trained to spot weaknesses in evidence-based claims.

An added potential benefit of tutoring that is especially relevant in pandemic times is the opportunity to cultivate strong tutor-student relationships. Given the disruption, trauma, and social isolation brought on by the pandemic for many children—disproportionately low-income students of color—the opportunity for students to develop a connection with a caring adult either one on one or in a small group over time could provide much-needed support for students' well-being, regardless of the impact on their academic success.[5]

Vacation Academies

"Vacation academies" represent another notable evidence-based approach to individualizing instruction. These are programs for which leaders recruit talented teachers to work with small groups of roughly 10 struggling students in a single subject over week-long vacation breaks. These programs produced notable gains in math and English language achievement in two Massachusetts districts serving high concentrations of low-performing, low-income children of color: Lawrence[6] and Springfield.[7] My colleagues and I have found that participation in these academies explained more than half of the impact of districtwide turnaround efforts on math achievement in the historically low-performing Lawrence Public Schools. In Springfield, these programs also appeared to improve students' social and emotional well-being, reducing their exposure to exclusionary discipline after the program. Importantly, the reduction in suspensions was concentrated among students in the program who were assigned to the same teacher for the whole week (rather than rotating through different teachers), consistent with the idea that individualized instruction can benefit student well-being by building positive teacher-student relationships.

Given the 1:10 ratios, these programs come with lower upfront costs than

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high-dosage tutoring. These programs could also be thoughtfully paired with a tutoring program to maximize results. For example, vacation academies could serve students below proficiency benchmarks but not at the very bottom of the performance distribution (the students for which these programs have demonstrated impacts in the past) while one-on-one tutoring could be reserved for those in need of the most intensive, tailored forms of support.

Effective One-on-One Tutoring

Getting back to tutoring, it is important to note that not all programs are created equal. A subset generates the most impressive results, often referred to as "high-dosage" programs. As the term implies, these programs are implemented with high levels of frequency—typically at least three 30- to 60-minute sessions per week; over relatively long periods—at least 10 weeks if not a full school year; and with low tutor-to-tutee ratios—between one-to-one and one-to-four.[8] Although the highest-impact programs are typically staffed with certified classroom teachers, studies have also documented successful models that rely on paraprofessionals or AmeriCorps members. Therefore, it appears that, with low student-tutor ratios along with the right training and support, tutors from a wide variety of backgrounds can improve student outcomes.

Getting program design right is critical to avoid waste and unintended consequences.

Getting program design right is critical to avoid waste (at best) and unintended consequences (at worst), as illustrated by a recent study of a light-touch remote math tutoring program in Kenya that actually resulted in negative effects on student learning.[9] The program did not conform to all that is known about tutoring best practices. It was also implemented universally, although evaluation revealed that the program appeared most productive for subsets of students who had been lower achieving before the pandemic.

Virtual Tutoring

Program design is particularly important when it comes to virtual tutoring programs, which several states are implementing.[10] The research base is much more limited for these programs than it is for in-person models. Just a few recent studies have shown gains from remote tutoring in the United States, Italy, and Botswana.[11] These are relatively small-scale studies, and questions remain about the populations to which these results generalize and whether the gains are consistently comparable to those generated by in-person programs. Additionally, it may be more challenging to generate deep tutor-student relationships virtually than in person. The broader literature on the disappointing results of virtual versus in-person schooling should give state leaders pause before implementing remote tutoring at scale.[12]

If states are experimenting with virtual tutoring, particularly in communities for which there remains high demand for online learning options, state leaders can insist on pairing these programs with rigorous evaluation, both to inform state policy and the field more broadly. It would truly be tragic if unprecedented federal education recovery dollars were spent on untested, ineffective programs without generating information from which policymakers could learn.

Bringing Programs to Scale

Despite tutoring's impressively high benefit-cost ratios,[13] upfront costs have historically been a barrier to wide-scale implementation. Pandemic-related staffing shortages also create challenges. State leaders should resist the temptation to implement subpar universal programs and instead opt for high-quality tutoring programs targeted to those student populations the pandemic hit hardest and who are most likely to benefit. To avoid creating stigma, leaders could implement programs at higher levels of aggregation—for example, in schools serving high concentrations of low-performing students (rather than targeting particular students). Additionally, leaders can consider other approaches to individualized instruction—such as vacation academies—that are likely more affordable to bring to scale given their 1:10 rather than 1:1 ratios.

Role for State Leadership

States can play an important role in getting individualized instructional programs up and running. State boards can advocate for high-quality programs that are designed in alignment with research-based best practices or are paired with evaluation when they diverge from proven models. States can centralize efforts to

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recruit talented tutors from across the state to work with students who do not necessarily live in their own geographic district. Massachusetts has done so with its vacation academy program, which the Massachusetts Department of Elementary and Secondary Education dubs "Acceleration Academies." State education agencies could assume responsibility for program overhead rather than asking already-overwhelmed districts or schools to build their own programs from scratch.

Some states, like Utah, are using federal recovery funds to support partnerships connecting community centers that provide tutoring programs with schools so that these centers can better align their efforts with the schools' learning objectives. Finally, state leaders can support efforts to build a learning agenda and support rigorous evaluation of new tutoring and academy programs so that the field can gain a better understanding of how adaptations affect program success.

Educational inequality was already unacceptably high before the pandemic but appears to have grown quite dramatically since its onset. This is true despite educators' and parents' herculean efforts to support students while navigating their own pandemic-related challenges and despite the fact that low-income children of color are no less capable than their higher-income White peers. The growth in inequality simply reflects the pandemic's uneven effects on learning opportunity and other divergent life experiences of children and families based on race and class.

High-dosage tutoring and vacation academy programs can reduce this educational inequality by providing individualized instructional support to those students hardest hit by COVID-19 and by contributing to students' overall social and emotional well-being. However, program design and targeting matters for maximizing positive impact and avoiding unintended consequences. State leaders, including state boards, have a special role to play in the success of efforts to provide individualized support for the students who need it most. ■

[1]Megan Kuhfeld, James Soland, and Karyn Lewis, "Test Score Patterns across Three COVID-19-Impacted School Years," *EdWorkingPaper* No. 22-521 (Providence, RI: Annenberg Institute at Brown University, 2022).

[2]Andrew Bacher-Hicks, Joshua Goodman, and Christine Mulhern, "Inequality in Household Adaptation to Schooling Shocks: Covid-Induced Online Learning Engagement in Real Time," *Journal of Public Economics* 193 (2021): 104345.

[3]Martin West and Robin Lake et al., "How Much Have Students Missed Academically Because of the Pandemic? A Review of the Evidence to Date" (Center for Reinventing Public Education, 2021).

[4]These studies are synthesized in Andre Nickow, Philip Oreopoulos, Vincent Quan, "The Impressive Effects of Tutoring on PreK-12 Learning: A Systematic Review and Meta-Analysis of the Experimental Evidence," National Bureau of Economic Research Working Paper No. 27476 (Cambridge, MA: NBER, 2021); and Roland G. Fryer, Jr., "The Production of Human Capital in Developed Countries: Evidence from 196 Randomized Field Experiments," *Handbook of Field Experiments* 2 (2017): 95–322, https://scholar.harvard.edu/files/fryer/files/handbook_fryer_03.25.2016.pdf.

[5]Debora L. Roorda et al., "The Influence of Affective Teacher-Student Relationships on Student Achievement: A Meta-Analytic Approach," *Review of Educational Research* 81, no. 4 (2011): 493–529.

[6]Beth E. Schueler, Joshua S. Goodman, and David J. Deming, "Can States Take Over and Turn Around School Districts? Evidence from Lawrence, Massachusetts," *Educational Evaluation and Policy Analysis* 39, no. 2 (2017): 311–32, https://scholar.harvard.edu/files/schueler/files/schuelergoodmandeming_lps_eepa_2017.pdf.

[7]Beth E. Schueler, "Making the Most of School Vacation: A Field Experiment of Small Group Math Instruction," *Education Finance and Policy* 15, no. 2 (2020): 310–31.

[8]Carly D. Robinson et al., "Accelerating Student Learning with High-Dosage Tutoring," EdResearch for Recovery: Design Principles Series (Providence, RI: Annenberg Institute at Brown University, 2021).

[9]Beth Schueler and Daniel Rodriguez-Segura, "A Cautionary Tale of Tutoring Hard-to-Reach Students in Kenya," EdWorkingPaper No. 21-432 (Providence, RI: Annenberg Institute, 2021).

[10]Dana Goldstein, "Back to School but Still Learning Online," *New York Times*, January 21, 2022.

[11]Jeremy Roschelle et al., "Evaluation of an Online Tutoring Program in Elementary Mathematics," project report (San Mateo, CA: Digital Promise, 2020), https://files.eric.ed.gov/fulltext/ED604743.pdf; Michela Carlana and Eliana La Ferrara, "Apart but Connected: Online Tutoring and Student Outcomes during the COVID-19 Pandemic," EdWorkingPaper No. 21-350 (Providence, RI: Annenberg Institute, 2021); Noam Angrist, Peter Bergman, and Moitshepi Matsheng, "School's Out: Experimental Evidence on Limiting Learning Loss Using "Low-Tech" in a Pandemic," NBER Working Paper No. 28305 (Cambridge, MA: National Bureau of Economic Research, January 2021).

[12]H. Alix Gallagher and Benjamin Cottingham, "Improving the Quality of Distance and Blended Learning," EdResearch for Recovery Brief No. 8 (Providence, RI: Annenberg Institute at Brown University, 2020); Carycruz Bueno, "Bricks and Mortar vs. Computers and Modems: The Impacts of Enrollment in K-12 Virtual Schools," Annenberg EdWorking Paper No. 20-250 (Providence, RI: Annenberg Institute at Brown University, 2020); Maya Escueta et al., "Upgrading Education with Technology: Insights from Experimental Research," *Journal of Economic Literature* 58, no. 4 (2020): 897–996; Michael S. Kofoed et al., "Zooming to Class? Experimental Evidence on College Students' Online Learning during COVID-19," IZA Discussion Paper No. 14356 (Bonn: Institute of Labor Economics, May 2021).

[13]Douglas N. Harris, "Toward Policy-Relevant Benchmarks for Interpreting Effect Sizes: Combining Effects with Costs," *Educational Evaluation and Policy Analysis* 31, no. 1 (2009): 3–29.

[14]Utah State Board of Education, American Rescue Plan (ARP) Act Afterschool and Summer Funding, web page (2022), https://schools.utah.gov/coronavirus?mid=5499&aid=8.

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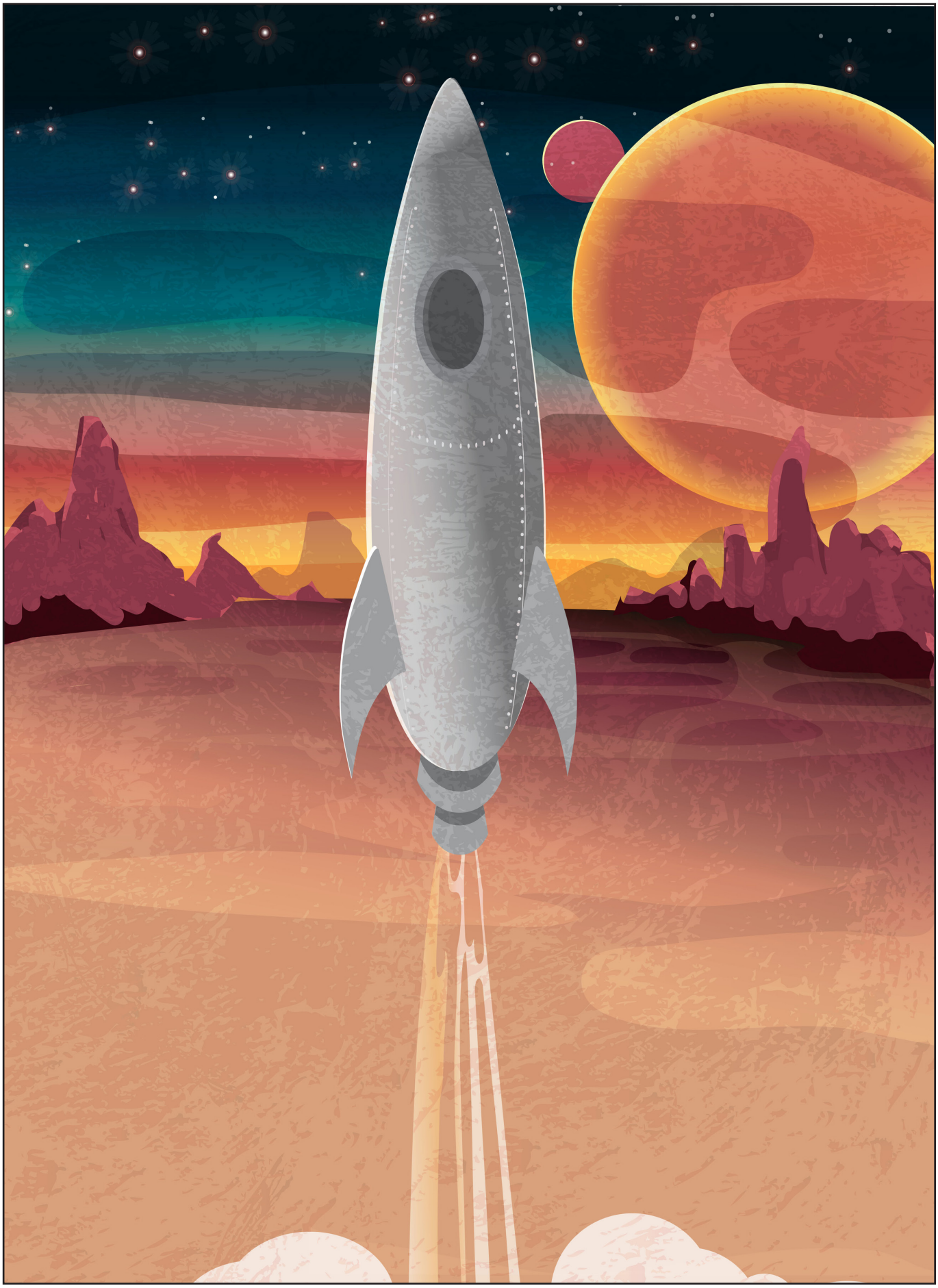

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Advancing Science Instruction

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

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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

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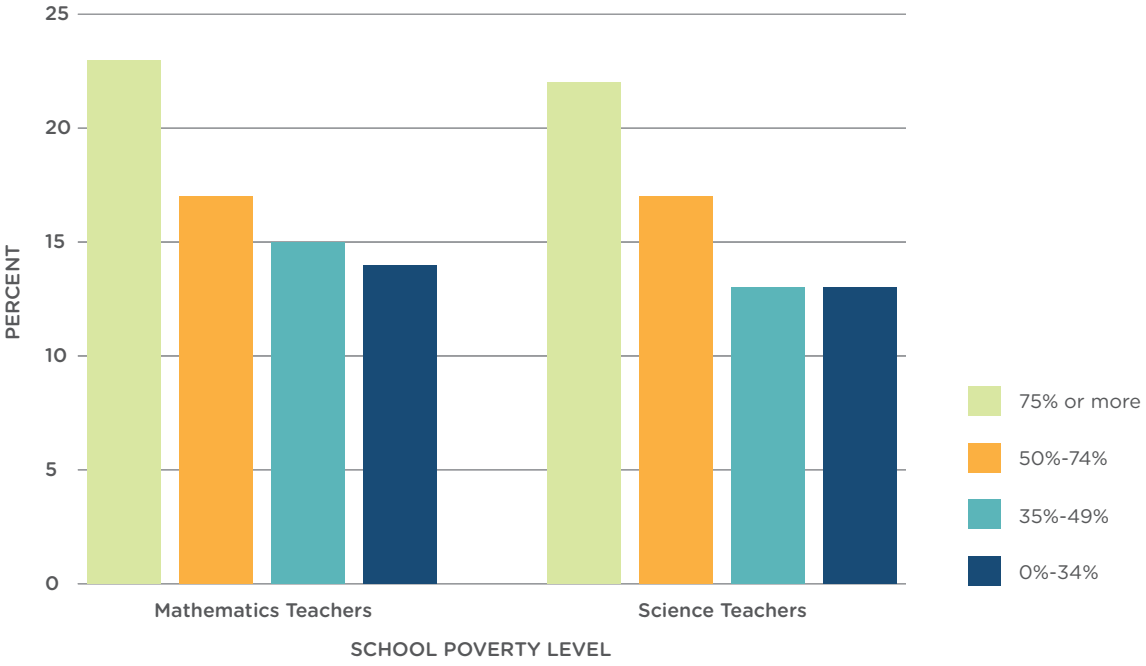
Figure 1. Public middle and high school mathematics and science teachers with 3 years or fewer of teaching experience, by school poverty level: 2017–18.



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

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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.

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.

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

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- **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. ■

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

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[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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10 Lessons Learned from the Science Classroom

Experience with high-stakes accountability informs teacher's standards setting on the state board.

Ryan Fuhrman

I am no expert in science standards. But as a former junior high science teacher who started his career the same year that No Child Left Behind (NCLB) became law in 2002 and who now serves as chair of the Wyoming State Board of Education, I have a perspective to share. Wyoming, like many other states, is wrestling with the legacy of high-stakes testing ushered in by NCLB, the resulting rigorous standards of Common Core, and now the opportunities offered by the Every Student Succeeds Act (ESSA). The Wyoming state board is grappling with the best approach to revising standards, including for math and science, in a system that still has components from earlier reforms.

I often liken the current education system to Johnny Cash's famous song, "One Piece at a Time," about cobbling together a Cadillac that had been snuck out of the factory one piece at a time over many years.

Now, up to now my plan went all right
'Til we tried to put it all together one night
And that's when we noticed that something was definitely wrong
The transmission was a '53 and the motor turned out to be a '73
And when we tried to put in the bolts all the holes were gone
So we drilled it out so that it would fit
And with a little bit of help with an adapter kit

Every year a different legislature, board, or standards committee adds a piece to the system, and educators work to make sure everything is as aligned as possible.

The Wyoming state board is tackling this issue head on. Recent guidance from the state attorney general tasked the state board with developing specific standards for graduation. Realizing the systemic impact of such changes, the state board is working to set standards by 2023 that not only will produce students worthy of walking across the stage at graduation but also students ready to walk out of school as healthy, contributing members of our communities. Before we can do that, we have to first distill our thinking into a Profile of a Graduate. And before we can do that, we have to take a step back to listen to stakeholders. Is the system aligned to their goals for it?

As I help lead this work, I can't help but reflect on my own career journey. Having now spent almost two decades in education, I would like to share lessons gained along the way that inform my work on the state board.

I remember walking into my "new" eighth grade classroom a week before the students showed up that fall of 2002. It was in an old high school and had one outlet and no sink. When I asked the principal, "What do I teach?" he pointed to a cupboard of old textbooks and unhelpfully replied, "Here are the books," and added, "The standards are so general you can teach whatever you want to cover."

During those first years, I was never encouraged to work with other teachers. Instead, I had complete freedom to either follow the textbook I had or take a wild swing for the fence. Like any fresh-out-of-college, former camp counselor, I swung for the fence. When the Jet Propulsion Laboratory rovers *Spirit* and *Opportunity* landed on Mars in 2003, my science classroom followed every update in the early mission days (we did not realize that the original 90-day mission would last until 2010 for *Spirit* and *Opportunity*, amazingly, until 2018). My students were hanging out our

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window as they tested their designs for landing a rover (an egg) onto the surface of Mars (the sidewalk below the window) when the other science teacher brought out his class to watch. His lesson for the day was to watch mine.

Lesson 1: Without rigorous standards and accountability, some teachers will take opportunities to innovate and follow student interests.

Lesson 2: Without rigorous standards and accountability, some teachers will phone it in.

Science, history, and all the other subjects were the chorus line for the main characters, English and Math.

As for many teachers, NCLB and the resulting high-stakes testing altered my teaching. I went from the freedom to design my own scope and sequence to sweating over what random assortment of science facts would be quizzed on the Colorado Student Assessment Program (CSAP) in the spring. Even though science was not under the microscope of NCLB, I nonetheless felt the pressure for our school to raise its reading and math scores. We became "targeted" in our approach. Everybody, including PE teachers, was responsible for additional writing practice. I worked to master and assign formulaic Step up to Writing paragraphs to assist.

One moment from that era has stayed with me: In a fall conference with a student, I admonished him for a low CSAP score that seemed below the ability that I knew he had displayed in class. His reply—that testing day fell a day after he received news that his brother had died in the Iraq War—was a punch to the gut. How can we let one day define our students?

Lesson 3: Accountability pressures affect all aspects of school. Schools will narrow their focus to try to boost scores.

Lesson 4: Placing all the weight of accountability on one day of testing is wrong.

After six years in Colorado, where I got my initial introduction to content standards, I moved my family back to my home state of Wyoming and started teaching at a rural K-8 school on the edge of a large (for Wyoming) urban district. For four years, I wasn't just the science teacher, I was the science department. The focus on testing—this time the Proficiency Assessment of Wyoming Students, or PAWS—did not change. I taught science but professional development and energy went toward assisting reading, writing, and math. Given that state standards were pretty basic, I had to predict what science content would show up on the PAWS at the end of four years of science instruction (science tests were administered only in grades 4, 8, and 10).

I found myself teaching a reading group. I also became a member of a new professional learning community (PLC), something that was also happening in Sheridan, where they were getting great test results. Our PLC was focused on tested skills, so science, history, and all the other subjects were the chorus line for the main characters, English and Math. The district even went so far as to require kits to help K-8 teachers follow their science curriculum. That was too much for me. I applied to work in Sheridan, the state's top-performing district and home to its best PLCs.

Lesson 5: Ham-handed efforts to support teachers can leave them uninspired and ready to exit.

Lesson 6: PLCs can be a real waste of time without strong leadership and focus.

When I joined my current school, Sheridan Junior High, as their new science teacher in 2012, I quickly realized that what my former district called a PLC was a mere shadow of what a true, focused PLC could be. Additionally, and more important, the games that my previous districts were playing to boost test scores were shots in the dark compared with the systematic focus on supporting teachers in a collaborative environment to discover and use best practice.

I was a good teacher, but I had never before sat in a meeting with other teachers to answer the question, "What do we want our students to know?"[1] Before, I had used state learning standards as a checklist to see whether what I wanted to teach fell under its broad umbrella. But now standards became a key component of my planning.

The other world-changing aspect of teaching in Sheridan was our leaders' belief that professional development for educators should be more than a "sit and get" during a professional development day. Instead, teachers were supported to organize their own book studies. The book that changed my life was *Creating Cultures of Thinking* by Harvard researcher

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Ron Ritchhart.[2] It revealed to me that what I had been calling teaching was not the same as learning. In teaching, I was most interested in transferring what I knew to students as efficiently as possible. After the book study, I wanted to learn what was happening in the minds of my students. One of the most basic examples is simply asking what has been called the golden question, "What makes you think that?"

To teach the standard on phase changes, for example, I had students collect a beaker of snow, place it on a burner, and chart changes in temperature as it went from melting to boiling. They could all chart the temperature change and dutifully identify when phase changes happened. But then I asked them what they thought was in the bubbles forming at the bottom of the heating water. Most students thought the bubbles contained oxygen or air. Their answers exposed the blind spot in my teaching: The correct answer is that the bubbles contained water vapor. This aha moment led me to pivot my instruction. I credit the support of this PLC, coupled with a shift in focus on learning, for my being named teacher of the year in 2017 and then landing on the Wyoming state board, which has seats reserved for a current teacher, a local board member, a district-level administrator, a business member, and for each of the state judicial districts.

Lesson 7: Teachers can be empowered to work collectively to use the standards as the basis of their teaching. It requires district leadership and support that honors the teacher's expertise.

Lesson 8: How students learn matters greatly. Standards alone will not address this.

The Wyoming board adopted new science standards in 2016. They were closely modeled on the Next Generation Science Standards (NGSS). Like many teachers, I assumed that "the department" was responsible for them. But I soon found myself on the state board of education, and thus I was learning how to drive the standards-setting process while I was also in the classroom working to implement the new standards. I had to be able to see both the trees and the forest, to make a new metaphor.

As members of a strong department at a district actively working to empower teachers, my colleagues and I were trained to "unpack" the new standards, identifying key standards that we could leverage for deeper learning or that were essential for enduring understanding.[3] As my PLC worked to align our teaching to the new standards, I was impressed with the exacting detail that the NGSS inspired. Gone was the broad umbrella of topics. Instead, there were specific skills that teachers would help students master. Modeling became more than a solar system made of Styrofoam balls. It was introduced as the tool scientists use to explain and test phenomena. Writing focused on making scientific claims supported by evidence rather than creating generic paragraphs to prepare for a state test.

As I worked to master the new standards in the classroom, I was also working to master the standards creation and adoption process at the state level. In Wyoming, there is a robust system that involves committees of educators and collection of public and educator feedback (a product of earlier efforts to calm the Common Core uproar). The problem I found was the dearth of real feedback. Teachers were operating as I had before joining the board. They were galloping through the many standards during their workday, then complaining about their number, focus, or lack of focus. They did not realize that failure to seize opportunities to provide input or get involved meant that they were in part responsible for the resulting standards.

Lesson 9: Quality standards matter.

Lesson 10: There are too many standards for deep learning and for teachers to explore the opportunities.

I am in my sixth and final year on the Wyoming state board. Using the lessons learned along the way, I try to make the various parts work a little better with an "adaptor kit." My experiences and journey have informed me, but they also remind me that I am but one teacher with a particular set of experiences with state learning standards. It is essential that we as a state board actively seek classroom perspectives, from both educators and students. Since embarking on developing a Profile of a Graduate, we have done just that. Innovative educators and students have shared how they are navigating the current system

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I was learning how to drive the standards-setting process while I was also in the classroom. I had to be able to see both the trees and the forest.

Ryan Fuhrman, chair of the Wyoming State Board of Education, is currently assistant principal at Sheridan Junior High School.

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Mulling Changes to Math Instruction

A framework proposed in California seeks to boost achievement by increasing the engagement of all students.

Jo Boaler and Jennifer Langer-Osuna

Despite California's status as the world's fifth largest economy and a hub of technology innovation, its students' math achievement ranks among the lowest in the United States, which itself ranks 37th in the world on the Program for International Student Assessment (PISA). Even before the pandemic slowed learning for many, only 39 percent of California students demonstrated proficiency on the state math assessment. During the pandemic, the proportion of math-proficient students fell to one-third.[1] At the same time, the STEM workforce faces shortages and a lack of diversity,[2] which call into question the longstanding practice of filtering the majority of students out of advanced pathways in math, often from a young age.

To address these problems, a committee of California math educators proposed changing the approach to teaching math based on what research has revealed about what will improve math achievement and engagement. In 2021, California started the process of revising the framework that guides math instruction.

The committee recognized the increasing need to prepare students to navigate 21st century workforce demands with skills in problem solving, reasoning, and data analysis. Yet the form of instruction that dominates math classrooms nationwide has students working through narrow questions and repeating methods shown to them. This instruction has led to widespread math anxiety and low achievement. The teaching of math as a disconnected set of procedures turns off even high-achieving students, as it so frequently offers students no access to meaning or deep understanding.

The committee met throughout 2021, drawing on research on effective teaching as well as practical wisdom from classroom educators. We were part of a writing team who distilled the committee's recommendations into a proposed framework for California math instruction. It was released for a 60-day period of public review and comment in March and will be considered by the state board for adoption later this year. For the benefit of other state boards who might be exploring revitalizing math education in their states, we share the evidence that underlies four of the recommendations in the proposed framework: open high-level pathways to more students, teach to big ideas and connections, teach through collaboration and discussion, and encourage data literacy.

Open High-Level Pathways to More Students

The proposed framework offers options for providing high-level opportunities to many more students so that they might be better prepared to qualify for STEM jobs in California. The framework proposes keeping high-level pathways open to more students for a longer time while also enabling exceptional students to move through courses at a faster pace.

One of the problems that districts face in keeping math pathways open for as many students as possible is that high schools typically have more prerequisite classes in front of the highest level courses—calculus or statistics—than there are years in high school. Thus students must complete algebra in middle school to enable them to reach the highest levels. The proposed framework acknowledges that middle schools need to offer algebra as an option in eighth grade, at least until high schools change, but recommends that tracking decisions are not made before then. Some California districts put students on different pathways in fourth grade, and many put students on different pathways in sixth grade, the beginning of middle school, using data from elementary school.

Such approaches fail to reflect the fact that all students can grow and learn. Instead, setting students on tracked math pathways in elementary school reflects a widespread belief in a pervasive myth

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that relatively few students have a "math brain" capable of understanding advanced math concepts.

Design problems have plagued the research on tracking. For example, when students are put into different classes and taught different content, high achievers are able to score at higher levels by design. Some studies have overcome this problem by monitoring student achievement and course taking over years, examining the achievement of students in tracked and detracked cohorts.

In one such study in New York City, middle school students were placed into regular or advanced classes for the first three years of the study. In the last three years of the study, all students took the advanced content and worked in the same groups. The researchers followed six cohorts of students through to the end of high school. They found that the students who worked in heterogeneous groups took more advanced math in high school, enjoyed math more, and passed the state test a year earlier than students who had been taught in tracks.[3] Further, the advantages accrued across the achievement spectrum. Other studies of initiatives to detrack middle school classrooms that compare student achievement with and without tracks have shown similarly promising results.[4]

Students benefit from viewing math as a vibrant, interconnected, relevant, and creative set of ideas.

Despite these promising results from detracking, districts remain caught in a system where the only way students can reach high-level courses in high school is to compress important middle school content to fit prerequisite courses into the math sequence. One of the recommendations of the new framework is that this progression be reviewed and that high schools reduce the number of courses needed so that all students can have access to high levels and learn the intended content of middle school.

Teach to Big Ideas and Connections

Math comprises important ideas and connections. Curriculum standards and textbooks tend to divide up math into smaller topics, which has led students to believe that it is disconnected and procedural. In a review of the research, the National Research Council, concluded that

> [s]uperficial coverage of all topics in a subject area must be replaced with in-depth coverage of fewer topics that allows key concepts in the discipline to be understood. The goal of coverage need not be abandoned entirely, of course. But there must be a sufficient number of cases of in-depth study to allow students to grasp the defining concepts in specific domains within a discipline.[5]

The proposed framework in California shares a set of big ideas in math, organized by grade level and content standards. These ideas were first set out in the California Digital Learning Integration and Standards Guidance initiative, which was released in May 2021.[6] The selection of a few big ideas allows for the teaching the most important topics more deeply and coherently and also allows teachers and students to work on collaborative problem solving. This approach builds on research that has shown that teachers who organize content around big ideas are more successful (see box).[7]

The proposed framework includes many examples of big-idea tasks from across preK-12 to illustrate how they can foster understanding of multiple math standards. Students benefit from viewing math as a vibrant, interconnected, relevant, and creative set of ideas. As educators create opportunities for students to engage with and thrive in math through teaching to big ideas, they value the different ways questions and problems can be approached and learned, and many more students view themselves as belonging to the mathematics community.[8] Such an approach prepares more students to think mathematically in their everyday lives and helps society develop more students interested in and excited by science, technology, engineering, arts, and mathematics pathways.

Teach through Collaboration and Discussion

When students enter these careers, they will almost certainly need to collaborate with others, connecting ideas and perspectives as they solve complex problems. In fact, PISA now assesses collaborative problem solving internationally, and the upcoming National Assessment of Educational Progress in math will include collaboration as a practice. The proposed framework we helped write highlights an approach in which students work together, learning to reason and critique each other's reasoning. Math problems can also be used to build students' awareness and understanding of important problems

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Box 1. Developing Teachers' Capacity: A District Example

To realize the ambitious vision for math instruction set forth in the framework, teachers will need support to develop what for many will be new teaching practices. Drawing from a research-practice partnership between a research university and a K-8 school district on the West Coast, we offer an example of a professional development approach that was focused on collaborative learning in the elementary grades. The district serves primarily Latinx and Pacific Islander students, with a majority designated as English learners.

Historically, the district has emphasized literacy but chose to emphasize math for the first time with the hiring of a new district math coach for elementary teachers. The coach worked with a small cohort of classroom teachers meant to serve as site-based instructional leads. Their work focused on developing teacher curiosity about student mathematical thinking; using open tasks that invite student mathematics thinking; eliciting, interpreting, and responding to student thinking in whole-class and small-group discussions; and making sense of student work from an asset frame. Instructional leads were supported to develop their own practice but also to share their work with interested colleagues at their school sites.

With the district superindendent's support, the district coach has autonomy sufficient to engage cohorts of teachers in slow, deep, responsive work. The hope is that the development of instructional-lead cohorts helps scale the work into each elementary school, such that instructional leads work in collaboration with the district coach. By beginning with teachers who opt in to professional learning communities, curiosity and excitement builds, and real change in instructional practice grows over time.

facing California, such as water shortages, fires, and climate change.

When students work together, their solutions tend to be more sophisticated and they tend to learn more.[9] Math communication and collaboration can simultaneously raise student achievement and work against inequities.[10] In a meta-analysis of research on cooperative math learning from prekindergarten through the university level, researchers Gulfer Capar and Kamuran Tarim found a mean effect size on student grades of 0.59,[11] indicating that this teaching method influences student achievement more strongly than traditional methods.

Discussions also offer students opportunities to explain their mathematical thinking, make sense of others' reasoning, and jointly develop flexibility with numbers, which serves as the basis for number sense. A key component of successful collaborative learning is student agency within the classroom to use their own ideas and resources to make sense of and solve problems.[12] It marks a significant departure from the typical passive engagement of students in traditional lecture-style classrooms.

Despite the evidence that collaboration benefits students, instructors often struggle to implement an active learning environment that centers on collaboration.[13] This struggle highlights that simply placing students in groups does not necessarily result in effective collaboration.[14] In some cases, social status and other factors can hinder it.[15] Complex instruction (CI), for example, is one pedagogical approach to collaborative learning suggested by the framework. CI centers on students working on "groupworthy" tasks in small groups, valuing multiple perspectives, and broadening opportunities for contribution and success.[16] Studies of CI teaching in high school math classrooms have shown an increase in student achievement,[17] an increase in students' appreciation for each others' ideas,[18] and more effective collaborative work.[19]

Encourage Data Literacy

The content currently taught in high school math courses was set out in the 1800s and has not changed since. Yet mathematics has changed considerably, particularly as regards

Instructors often struggle to implement an active learning environment that centers on collaboration.

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All students need to be able to interpret data and consider its source, purpose, and meaning.

data science. All students need to be able to interpret data and consider its source, purpose, and meaning.[20] If schools do not help students develop data literacy, they will be left vulnerable to misinformation, often shared through social media, and lack the foundations of important understanding. Teachers of all grades can help students though data investigations, engaging in "data talks," and generally infusing data inquiry into different lessons.

The University of California and California State University systems communicated to high schools that they value students who have followed a data science–statistics pathway as highly as those who have followed a calculus pathway. Stanford has also updated its admissions statement to include a data science possibility. Thus the framework sets out a high school course option in data science that students can take after they have taken integrated 1 and 2 or algebra and geometry. The course would be an excellent prelude to an AP statistics course. Students could also choose to take data science and calculus courses.

The availability of data science as a possible high school course reflects the broad nature of mathematics and the need to offer high school students more choice. Students who are intending to major in STEM in college will still need to take courses that enable them to start college with a calculus course, but many students will be better served by a data science–statistics pathway in their high school years.

Conclusion

Change is needed in California. Given the state of math achievement, it is hard to defend the status quo. The framework sets out an approach that allows students to problem solve, reason, collaborate, investigate, and connect ideas while also delaying tracking decisions so that more students can pursue math pathways. It takes an approach that the most successful teachers have been using for many years and would scale it to teachers and schools across the state. Its success will depend on teacher learning opportunities provided over the next few years, as well as the opportunities to educate counselors, school leaders, and parents. If time for learning is provided, a different mathematical future is a real possibility for the students of California. ■

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Achieving Equity and Excellence in Mathematics Teaching

States should revamp how teachers are equipped to deliver effective instruction.

Yasemin Copur-Gencturk

International and national assessments suggest that U.S. students' mathematics performance declines drastically as they progress to higher grades.[1] Improvement in K-12 performance remains elusive despite efforts to set more rigorous academic standards, align curriculum materials more closely with those standards, and test more frequently. Such reforms have not changed how math is

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Math instruction in the United States still focuses more on rules than on making sense of concepts.

taught. Math instruction in the United States still focuses more on rules than on making sense of concepts.[2] Until that changes, student performance is unlikely to change.

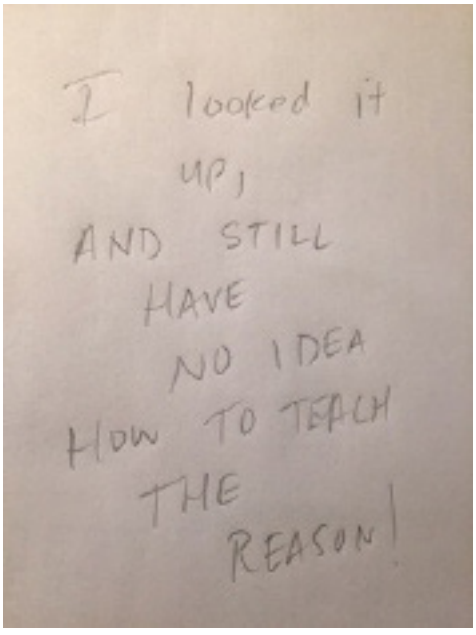
Boosting Content Expertise

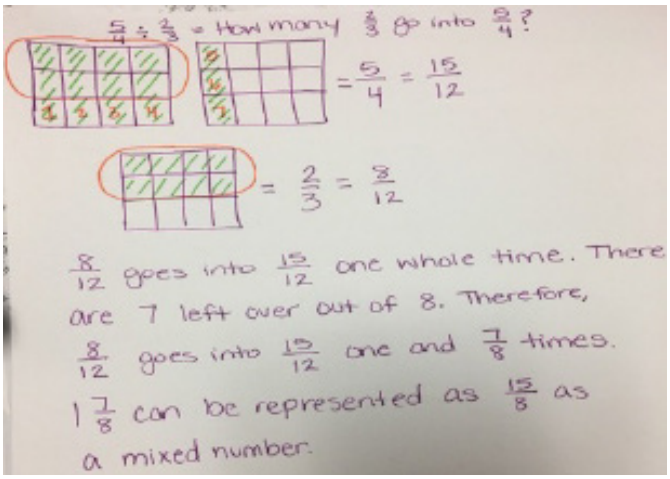
One way to improve instruction is through a more systematic approach to teacher training. Researchers have learned much over the last two decades about the nature of math teaching expertise and how to develop it.[3] A robust understanding requires teachers to have mastered the conceptual underpinnings of the math rules they are teaching (e.g., why do you need to create a common denominator when adding two fractions with unlike denominators?), and they should know how different concepts taught within and across grade levels are connected (e.g., fractions can be connected to division).

When teachers' math understanding is fragmented and disconnected, the learning environment they create fails to be as meaningful as it could be. Studies dating to the early 1990s have shown that teachers' robust understanding is closely related to the way they help their students make sense of math.[4] Yet teachers in general, and elementary school teachers in particular, still do not routinely master conceptual underpinnings of the topics they teach. In a recent study with more than 300 grade 4 and 5 teachers, I found that 58 percent reported either not knowing how to explain fraction division conceptually or they explained it incorrectly.[5] Only 26 percent provided a correct conceptual explanation (figure 1).

It is important to examine what these results mean for students, particularly students of color and students from low-income families, who typically have less access to teachers with strong mathematical knowledge.[6] These students will learn rote procedures and probably struggle to remember them because they have no understanding of why a procedure works. Alternatively, students whose teachers help them make sense of the algorithm by making connections to key ideas will have a better learning experience (e.g., the number of groups of 2/3 that can be made from 5/4). These students can divide fractions even if they do not remember the invert-and-multiply algorithm and are more likely to see a connection between the division of fractions and making groups, a concept learned in earlier grades.

Figure 1. Sample Responses Teachers Provided as Conceptual Explanations for the Division of 5/4 by 2/3





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Another important element of teachers' expertise is knowing how students learn concepts and building a repertoire of effective tools and strategies to aid conceptual understanding. Despite research that says students' math struggles are rooted in a lack of such understanding,[7] teachers tend to assume these struggles with particular concepts are mainly related to an inability to remember rules and formulas.[8]

In turn, instructional responses often focus on helping students master procedural skills that teachers assume they lack. For instance, when students err in comparing fractions (say 3/8 and ¾), teachers tend to assume students have forgotten how to compare fractions by using a benchmark fraction (3/8 is less than ½, but ¾ is more than ½) or by creating a common denominator. However, the root cause of the error may be a student's conceptual misunderstanding: viewing numerators and denominators as separate whole numbers rather than as a single number with a value. Appropriate, effective instructional responses will thus depend on the teacher's interpretation of why a student struggles.

When professional development for math teachers focuses on how concepts are developed and connected across the learning standards and across grades, teachers are more likely to develop the robust understanding they need to improve math instruction.[9] Such programs should also include opportunities for teachers to learn more about students' mathematical thinking and their common struggles, as well as which tools and representations best support their learning. Evidence suggests that one way that teachers can build mathematical knowledge for teaching is by analyzing students' responses.[10]

One-shot workshops or fragmented learning opportunities will not significantly change teachers' practices. They need a series of opportunities organized around key mathematics domains, and they need to learn evidence-based practices to help students with common struggles.[11]

State education leadership will be instrumental for ensuring that teachers receive this support. I also encourage state boards of education to partner with universities to offer funded programs and to fund cohorts of in-service educators to receive the support they need to develop content-specific expertise.

Bias as a Barrier to Equity

Improving teachers' expertise in teaching math can improve all students' math performance while also addressing the historic inequity in students' access to expert teachers. However, latent cultural stereotypes also undermine the math performance of students from particular groups and thus must also be confronted. Such stereotypes link performance to natural rather than acquired ability and assign this ability based on gender or race. Students are particularly vulnerable to such cultural messages, which can harm their academic self-concept and performance.

Like everybody else, teachers are shaped by these stereotypical beliefs, which might inadvertently affect their expectations of students and their interactions with them. Teachers' unconscious biases about their students' cognitive abilities stymie students' academic growth, as such biases shape instructional decisions and recommendations of students for gifted education programs.[12]

Distinguishing between teachers' unconscious biases and their accurate assessments of student ability is not easy, given that there are differences in subgroup performance. My colleagues and I conducted experiments in which teachers show implicit biases regarding the mathematical ability of students based on race and gender.[13] In one study, teachers were given the same set of student solutions and asked to (1) grade the student's work based on its correctness and (2) estimate the student's math ability based on the student's response. The only difference was that teachers saw gender- and race-specific names linked to each solution, such as "Todd" (a White male-sounding name) or "Shanice" (a Black female-sounding name), as shown in figure 2. Our rationale for this study design was that if teachers lacked biases, they would not rate the same solution differently based on the different names.

Yet in data collected from 390 teachers, we found that teachers assumed students had higher math ability when they saw White-sounding names than when they saw Black-sounding names. Implicit bias was also observed for girls, who were perceived as having lower abilities than boys. Our findings showed that although teachers' evaluations of students' work did not change based on the students' race or gender, race and gender affected their perceptions of students' capacity to learn math. Both White and non-White teachers showed some type of implicit bias, which underscored the fact that no one should be assumed to be free of it.

Teachers tend to assume these struggles with particular concepts are mainly related to an inability to remember rules and formulas.

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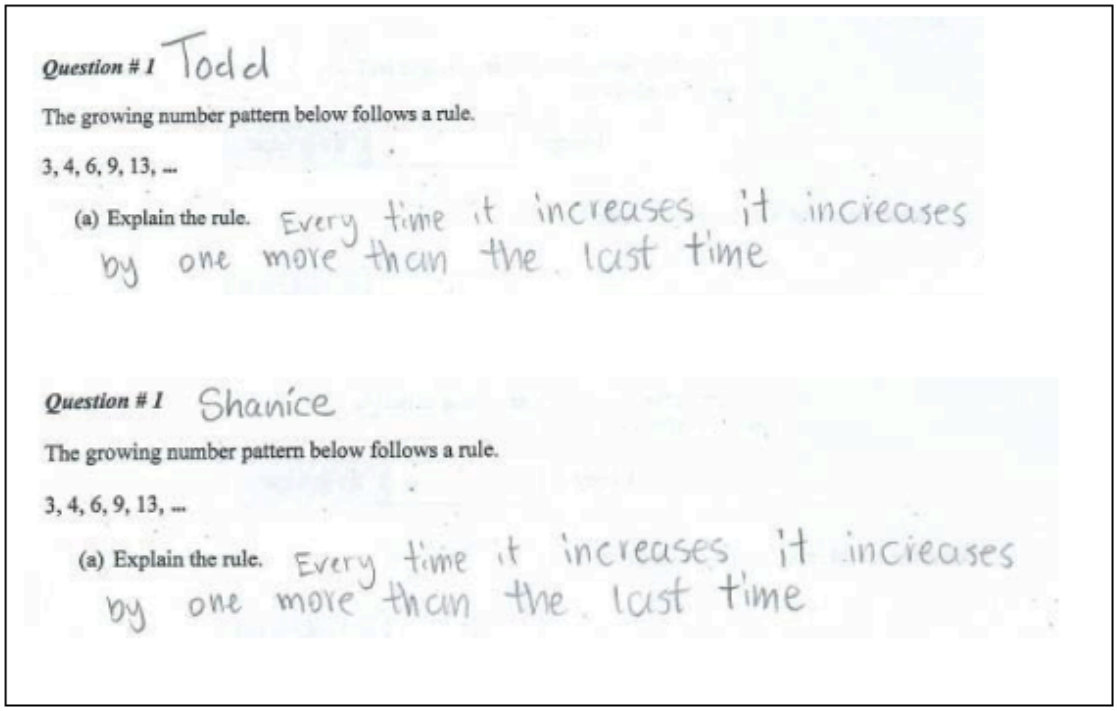
Figure 2. Sample Student Solutions



Implicit bias affects students' success, the careers they pursue, and academic self-concept.

There are several implications from these findings. When female students and students of color struggle with math, it might signal to their teachers that they inherently lack the ability to do math. A recent study showed that male students who were not academically successful still majored in mathematics-heavy STEM fields such as engineering and computer science at a dramatically higher rate than female students with similar achievement levels.[14] It could be that when girls are not doing well in math, they are receiving implicit messages to suggest it is because of low mathematical ability. Inherent biases may also explain why students of color are likewise underrepresented in math-heavy STEM fields.

Evidence-Based Implicit Bias Training

Implicit bias affects students' success, the careers they pursue, and academic self-concept. Thus efforts to boost teachers' content-specific expertise alone will be insufficient to increase math performance.[15] They should also be offered specific training to enable them to identify the conditions under which they might be relying on their implicit biases and how to overcome them.

State education officials can ensure that the training teachers receive is evidence based and specific to their work as teachers. More generic training may fail to address the impact of implicit biases on teaching. For example, knowing that teachers tend to draw on their biases in more ambiguous situations,[16] teacher implicit bias training should include strategies the teachers can use to gather more information from their students before they make instructional decisions or recommendations. Training programs should also help teachers learn more about pedagogical practices that facilitate learning about their students, such as asking students to explain their thinking. Such practices might help teachers attend to students as individual learners rather than as members of an underrepresented group.

Teacher Pipeline and Licensure

Implicit bias training is an important lever by which state policymakers can improve students' math performance. But state boards can also

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take strategic actions to improve the teacher pipeline. I propose modifying the teaching licensure requirements in the following ways: content licensure tests that capture teachers' robust math understanding, performance assessments for teacher candidates, and math content licensure and performance assessments for elementary school teachers. Given the efforts states are making to address teacher shortages, state board members might assume their hands are tied on licensure requirements. However, these shortages are closely related to the low salaries the teaching profession offers as well as working conditions.[17] Thus I argue that changes in licensure will have little impact on teacher shortages. Rather, such changes will lead teacher education programs to refine their curricula to equip preservice teachers with the skills they need, skills that are also measured on the licensure tests. More important, these changes will improve the quality of student learning.

Content Licensure. Licensure exams leverage states' efforts to improve the quality of their teacher preparation programs. Yet evidence suggests that what is measured on existing content tests provides little information regarding future teacher effectiveness.[18] State boards should investigate the extent to which the content licensure test they use measures the mathematical knowledge that matters for teaching. Indeed, Massachusetts' investigation of its licensure tests through an independent study is an exemplary approach to investigating whether what is measured on these tests matters for student outcomes. Similarly, other states can partner with experts to evaluate their current licensure tests or revise them accordingly.

Performance Assessments. Given that students of color and students from low-income families are more likely to be taught by novice teachers, it is an essential component of equity to ensure that all teacher candidates have grasped the rudimentary aspects of math teaching before they enter the classroom. Such pedagogical knowledge, along with a robust understanding of the content math teachers are teaching, leads to an increase in students' math achievement.[19] State policies should not overlook the critical need for teachers to know how their students learn particular concepts and to acquire a repertoire of tools and practices that promote student learning. Currently, 16 states require a performance assessment that measures teachers' knowledge of how to teach, which is a necessary step forward.[20]

Elementary Teachers. Another way to improve students' math performance is to create strong mathematical foundations for all students in the early grades. Currently, elementary teachers have limited academic preparation in math and a less robust understanding of math concepts. Yet only a little more than half of U.S. states require elementary teachers to pass a content licensure test in mathematics.[21]

Even in states that require performance assessments, teacher candidates who hold multiple subject credentials are not required to have a separate passing score on how to teach mathematics. Nevertheless, elementary education plays a tremendous role in shaping students' math learning experience as well as their attitudes toward the subject. Thus requiring elementary teacher candidates to demonstrate mastery of mathematics teaching can help break the cycle of students struggling in mathematics.

Conclusion

Reforms to improve student math achievement and math curriculum have not yielded the hoped-for outcomes because improving math performance demands more systematic changes in how math teachers are equipped at the preservice and in-service levels. Research advances on the expertise needed in mathematics teaching have identified distinct knowledge and skills math teachers need. Policies to ensure that teachers and teacher candidates are equipped with this knowledge and these skills is the most viable solution to the nation's ongoing problem with math learning. Furthermore, it is essential to understand that no one, not even a teacher, is immune to societal stereotyping. Providing a system of supports to overcome teachers' reliance on implicit biases could help erase inequity in math instruction and close the performance gap of students from different groups. ■

What is measured on existing content tests provides little information regarding future teacher effectiveness.

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while offering innovative opportunities to get students ready for life beyond the standards.

Bonus: The state-level working of the system is so far removed from the general classroom that it is incumbent on state leaders to make extra effort to communicate and network with practitioners. ■

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The NASBE Interview

The Charles A. Dana Center at the University of Texas–Austin works with educators, administrators, policymakers, and other partners to dismantle barriers in education systems while creating and scaling the types of math and science education innovations that support student success. ***Elisha Smith Arrillaga*** *is managing director and* ***Dave Kung*** *is director of policy at the center. Paolo DeMaria, NASBE's president and CEO, interviewed them in March 2022 about their center's efforts to help states improve math instruction.*

Elisha Smith Arrillaga
Managing Director
The Charles A. Dana Center

Dave Kung
Director of Policy
The Charles A. Dana Center

Do you think there is a shared understanding of how to help students achieve at higher levels in math? How can we create a stronger imperative for improvement?

Smith Arrillaga: What we have seen not only within states but also within the math community more broadly is there is not consensus around a vision for modern math—what students need for humanities or social science, for example. We all agree that we need to do better in math, but there is not general agreement on the how.

In K-8, there is general agreement around the core concepts for students to understand. But once we start getting close to eighth grade, we start to see more disparity in terms of what math folks think students need for various careers or pathways. It doesn't mean that K-8 math is perfect. Although we have the content piece right, there is still work to do on implementation.

Kung: Higher education plays an increasingly large role as you get through high school. There is not the same consensus within higher education about what these pathways should look like.

If there's greater clarity in the K-8 space why don't we see more change? There is an idea in our culture that some people just aren't good at math. Is there enough awareness that children should have a "yes, I can do this" mind-set?

Smith Arrillaga: We were working with some folks who did some polling in the fall. Ninety percent of the parents and teachers surveyed believe that either you can do math when you are born or you can't. That's a big statement, right? It is not acceptable to say, "I can't read." Immediately, folks are like, "Let's figure out how to solve that." We should have that same reaction about math. There is work to be done in changing mind-sets, and a lot of that work could happen in K-8.

Even though the content is there on the K-8 side, we don't necessarily have the math teachers we need due to the teacher shortage. Even though we have the tools, we haven't really taught people how to use them. Even though the way that the content is lined up shows students how to be critical thinkers, we don't necessarily teach it that way. So they don't see math in the world around them, which is actually where math is and what makes math come alive and helps folks to see themselves as math people.

How do you help students see relevancy and the reasoning behind math?

Kung: Everybody does have potential to do great math. The question becomes, "What's going to hook this particular student?" Then the challenge is to come up with a system that is better at getting students to do that and making sure we are not leaving particular communities behind.

Smith Arrillaga: The folks at Family Math are doing good work in the early grades, not only with students but to bring in the whole family around building a math identity. There is also great work in states to rethink eighth grade through higher education and make sure those pathways have options, for instance, so students are getting data science and statistics earlier. In Algebra II, it helps students see all the ways that math is being used in the world.

Kung: We are seeing interesting work at the intersection of education and social science. In behavioral sciences, the growth mind-set work of Carol Dweck and others has been powerful. That has morphed into questions about how to structure things in the classroom to make sure students see themselves as mathematicians. There are some easy tools to make sure everybody feels a little bit more like they belong in those spaces.

How do we create the conditions for student success, even if it means a bit of productive struggle?

Kung: Everybody hits a place where it's hard. The question is, how do you respond? People who don't see themselves as part of the math community, as that being a safe space, are more likely to hit that barrier. People who feel more confident and feel like they belong are like, "This is getting hard. I should double down and work a little bit harder." It also goes back to students seeing math as this thing that requires brilliance or genius. If that's your belief, then when you hit something hard, your reaction is, "I'm just not one of those people."

This is an example of a *wicked* problem—something incredibly complex with a lot of facets. You have to get above the system to see it. A dozen years ago, math standards revisions in a lot of places brought fantastic new strategies. But we didn't give teachers all the tools they need to implement it well and all the ideas that went along with it. Part of it being a wicked problem is that those teachers came through a system that inculcated in them so many things about the idea of brilliance, about speed being important. Those of us who are mathematicians don't think of speed as particularly important. We think of deep thinking as important.

One of the programs I've run is Mathematical Association of America Project NExT, professional development for new postsecondary math faculty. We can make a huge difference, especially when we get professors early in their careers. We also see real strides in teacher preparation once those students understand the point of modern math education. We see also that it's difficult to send people out into a system that's not built to support that kind of teaching and learning. That's the struggle. I don't know about you, but I'm way too impatient to make change one retirement at a time.

Does that mean better professional development for practicing teachers? Or making sure principals and teacher leaders understand what the approach should be?

Kung: There is no silver bullet, and there never will be. We have to attack this problem on multiple fronts, including attacking the idea that math requires brilliance. No first-year teacher is going to attack it by themselves. That's something we have to work on collectively. Is it something where the math community and the business community come together and say, "We have to have very persistent, consistent messaging to continue the drumbeat of, 'Everybody can do math'?"

Smith Arrillaga: There's no silver bullet, but there are definitely things we've been thinking about: Bringing the math community together around this shared agreement on modern mathematics is key. The way we think has to change from static mathematics to mathematics that can evolve as technology shifts. The other piece is working with communities around math

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identity and mind-set: empowering communities and students to see the math that is at work all around them in the world. On the policy side, K-12 work often is dictated by what's happening in higher education, particularly around admissions. More and more we're seeing coalitions in states work across K-12 and higher education—in Ohio and Georgia, for example, where we're seeing changes in terms of alignment and getting general agreement on what we need.

Kung: Somewhere right now, there's a high school junior who wants to study French literature or Russian history, and they are going to take AP calculus next year because they think it's going to get them into a better school. But they would be much better off in quantitative literacy or statistics. The thing that kills me is that they're right: Calculus will get them into a better school. That's a system that needs to change.

Do you think parents understand that you shortchange your own child if you don't hold the system accountable for nurturing their math competency? It's an essential tool in the life toolbox.

Smith Arrillaga: I had a meeting with an organization called Oakland REACH, which works directly with parents and has done amazing work in literacy. They did this program with parents where the students and those schools' literacy scores increased in the midst of COVID. More than eighty percent of parents they surveyed say the next thing they want to work on is math. As they talked about math—and the fact that at some of those schools, fewer than one in 10 Black and brown kids are doing math at or above grade level—the number one thing they said was, "No one is coming to help us." That was a super powerful statement. They were talking about the mismatch between how we currently teach mathematics and the math students actually need for today's society. How do we do that work with parents so that we can save ourselves? For me, it was an exciting moment, because we always want people to have autonomy, but also a sad moment. It just compounded for me that we are urgently called on, now more than ever, to fix these issues.

Kung: There are organizations like Just Equations that focus on equity and mathematics, following Bob Moses's important claim that algebra is a civil right. We need to broaden that. It's not just algebra; access to high-quality math is a civil right. They are focused in the transition space in high school and transitions into college, and they have done great work on understanding why calculus is held up as this golden ticket [and] on the power of admissions and what we need to do to change that.

People are increasingly understanding that effective reading instruction is connected to content knowledge: A teacher might do a unit on soccer, but if students don't know what soccer is or how it works, it's hard to make the text make sense. How do you help people see the math in other areas?

Kung: If you ask people, "Do you use algebra in your work or your everyday life?", the vast majority say no. If you say, "Do you use spreadsheets in your work?", a huge percentage say yes. There is a complete disconnect, as if a huge portion of what we're doing in spreadsheets is not algebraic thinking. That disconnect is entirely on us: We in the math community have managed to teach the subject as if it has no relevance.

We in the math community have managed to teach the subject as if it has no relevance.

Are there other barriers that stand in the way of improvement in K-8 math?

Smith Arrillaga: One huge issue is teacher workforce shortages, especially in subjects like math. There's a lot of work to be done in teacher prep programs, making sure that teachers have the tools they need. Teachers are not immune to that identity concept. If they are having those same math identity issues and are then trying to teach students not to have those issues around math, it becomes very complex.

Kung: There's interesting data about teachers' mind-sets: whether teachers have a growth mind-set or a fixed mind-set about student learning. Teachers with a fixed mind-set can inhibit students so that even if you try to push

growth mind-set implementations, teachers can counteract it. It is about making sure we have the right content and the right framing, but then teachers need to reinforce that every day.

Let's imagine a dean of a college of education was part of this interview. Would they recognize that their support for math instruction might not be aligned with what practitioners believe teachers should be doing?

Smith Arrillaga: I was on a panel of some deans of schools of education at the Just Equations conference, and there is a lot of diversity. Some are trying innovative things; other folks are more hemmed in. There are bright spots out there; you just have to find them. What those deans seemed even more concerned about was modern math itself and the proliferation of math-related tools like informatics and data science. A top major at University of Texas–Austin right now is informatics, which requires math. How are we training math teachers for these new math-related subjects? How are math departments partnering with those areas? How are math and informatics departments partnering with schools of education?

Kung: I see great work in college departments of education, but they don't have the power to define what mathematics is. Students going through those educator preparation programs may get great messages from the education department, but they are still taking math courses in the math department. High school teachers especially are getting a math major, which is constructed around a 1950s or 1960s vision of getting a few people through calculus—a wicked problem. It's a structural issue that no department of education by itself is going to solve.

It sounds like there has to be collaboration between colleges of education and their respective math departments around what teachers should know and be able to do.

Kung: You hit on a key point, which is about alignment. There are a lot of problems within our system, and one of them is that when future teachers talk about math in education classes, it doesn't always align with their experiences in the math department. But there are so many other issues, including the transition from K-8 math into high school math, the transition from high school math into college math, which is happening earlier and earlier.

The dual enrollment space is exploding. We have places in this country where a third of community college students are high school students taking dual enrollment courses. We need to make sure there is alignment there and then alignment between those programs and four-year schools to make sure students are not caught in a system that is not fighting for them.

Most of the policymakers I talk to went to a single four-year institution and then graduated. That is not the experience most students have, but it is especially not the experience for students experiencing poverty, especially Black and brown students. Those students are much more likely to be caught up in these gaps and the misalignments in our system.

Can you share a description of the work you are currently doing at the Dana Center?

Kung: A lot of our work, including the Launch Years initiative, could be framed in a very simple way: Each student deserves the *right* math at the *right* time with the *right* support. That's about it. Systems are not set up to do that. The right math for many students is not a path toward calculus, it's a path toward statistics or quantitative literacy. They are not getting it at the right time. Some students eventually get to quantitative literacy, but only after they have gone through what some call the death march toward calculus. And they are not getting the right support. A lot of students are either placed into courses and struggling, or they are placed into developmental sequences that lead nowhere. Few students get through those.

To reach this goal, we have to attack this problem at different levels. One is the policy level. We need to make sure there are state policies that support the idea that we need the right math for these students. We worked with

The right math for many students is not a path toward calculus, it's a path toward statistics or quantitative literacy.

Georgia in the first phase of the Launch Years project. We were able to get a policy change, which changed the definition of Algebra II to include more data science and a lot more statistics. It's a huge win for the students of Georgia. It is not just about policy; it's about how that policy gets implemented. We also work with state leaders, district leaders, and teachers to make sure they understand what it means to teach a different version of Algebra II than the one they took and the one they may have been teaching for 10, 20, or 30 years. We are trying to attack these problems at multiple levels simultaneously.

The first Launch Years project has completed, and we are moving to the next phase. Different states are in different places. This wicked problem is, from a game theory perspective, a problem of who is going to make the first move. The most effective way is for higher education to make the first move. We're going to be working with states where higher education has yet to make that move.

When I say, "make that move," I mean create greater alignment between different systems, common course numbering, and structured pathways that include paths toward statistics, quantitative literacy, data science, programming. Can we get higher education on board? And then can we start to work downward into K-12? Eventually, we need to go further than just high schools. What can we be doing in grade schools to set up students so that they have early experiences with data so that when they get to high school, it's not such a heavy lift. The ability to work with data is power.

The systems we have are not set up to support problem-based learning.

Some elementary teachers get that. And it's great to see young students graphing data in elementary classrooms—they love it. It's about laying foundations for data analysis, identifying patterns and trends, and making predictions.

Kung: Let's start with really small data sets. Then when we get to more advanced kids, let's give them electronic devices to collect data. Then let's have them deal with big data sets. There's a lot to be learned from the U.S. Census and from all these data that students find fascinating. We need to make sure that students have the mathematical tools to address the questions they have.

Smith Arrillaga: We have seen innovative examples recently in terms of climate data in places where there are fires. Students are using local data to predict all kinds of things. Helping students see that the whole world around them is mathematical is powerful.

Kung: The systems we have are not set up to support problem-based learning. Some policies have detailed learning outcomes that force teachers into a mode of teaching this little fact and that little fact instead of giving bigger, open-ended modeling problems that we know are more in line with what students are going to need later.

Are you finding fertile ground within the higher education community?

Kung: Having conversation is fertile ground. Progressing toward consensus is a little bit harder. These conversations have never been more important but also never been more fraught. We've never been in a more difficult messaging environment, a more difficult political environment. When you dig into that phrase "every student," that brings up all sorts of issues that some people are going to grab onto to drive a wedge between groups.

Smith Arrillaga: I attended a conference where the CEO of the National Science Foundation started talking about accelerating the pace of research around innovation and accelerating research-practice partnerships. She also talked about the key to that work being to diversify the foundation and the base of folks doing research to ensure that we have all the most innovative ideas possible. Dave and I were in another meeting with the Mathematics Association of America, where they are trying to work with math departments. [But] while we wait for math departments to come to agreement, there is still an accelerated pace of growth in informatics, data science, and other math-related topics. Bifurcation can mean that some students get to take those branches and others do not, so [how fast] we can come to agreement

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around what modern math is and how math departments want to sit in that space is going to be really important for students.

Where is the business community on this?

Smith Arrillaga: We have started to see the proliferation of workarounds because departments and systems are not moving fast enough on the education side. That is why we're seeing, for instance, a proliferation of certificate programs that employers are offering themselves that may be math related because they are finding there are not enough folks who have the training they need for the roles they have open.

Since the education system is slow to change, in some ways businesses are trying to create their own solutions. In some places they are trying to work closely with schools and colleges to help them transform the work they are doing, but I would say those examples are few and far apart.

Kung: Higher education, especially four-year schools, has not always been great at working closely with the business community. The places that are excellent at this are community colleges. Community colleges are fantastic at responding to the needs of the community and, in particular, to needs of local employers. We are seeing some of that innovation in work we've done on math for nursing and for manufacturing at the local level in community colleges. If there were greater coherence on the message about what math is needed, then we could have some of that innovation scaled across the country. Right now, that innovation is very localized.

Are there other states that are pushing the envelope?

Kung: We are seeing a couple of models, including in Ohio. Getting all the math chairs together, along with K-12 leaders, has led to this vision where they have five versions of Algebra II. State policy said, "You need to take Algebra II or its equivalent," so they took that and ran. Now it is a path toward STEM, statistics, quantitative literacy, a data science path that they're developing now, and programming. The other model is in Georgia, where they keep Algebra II together but then modernize it. We are seeing some of that in the Pacific Northwest. There is a lot of innovation out there.

The challenge is finding coherence because if you want change at scale, you need things like excellent classroom materials. We are not going to get excellent classroom materials if all 50 states are doing things differently. So bringing some coherence to the system will help as long as we are attentive to things like implementing changes with equity in mind and leveraging the increased use of technology that everybody is more comfortable with than they were before the pandemic.

What is the role for state boards of education?

Kung: One of the things that is coming out clearly is that in states that require four math classes for high school students, students take four math classes. In states that don't, you see a huge drop-off. In that last year, if students are not taking math, they are much less likely to go on and pass math classes when they get to higher education. That is a place where policymakers have a really important role.

Smith Arrillaga: There are only two things I would add. The state boards' convening power around setting a table and then making sure that table includes students and communities is a powerful role as well. Then, in thinking about assessments, if there are ways that state boards can help ensure formative assessments are aligned to more national measures and are used along the way so that teachers are getting that just-in-time information they need to adjust math instruction to what students need. That's a powerful tool. In addition to the formative assessments, having growth metrics based on summative assessments is key to see how students grow versus just that point in time.

Kung: We are eager to work with states, and we are getting funding to work with states and to have the boards in that position where they are convening. We would love to be working with more states. ■

Employers are finding there are not enough folks who have the training they need for the roles they have open.

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Jenna Zerylnick
Colorado Assistant Attorney General
K-12 Education Unit

NCOSEA Voice

The Struggle to Control Academic Content

Because they reflect local values about what students should learn during their K-12 years, academic standards are inherently political. Through a variety of ways, federal, state, and local actors have long sought to control decisions about what constitutes "official knowledge."[1] From book bans to state laws restricting curricular choices, the politics of academic content is once again making news.

A review of the legal framework for these content decisions may provide helpful context for state boards of education. States adopt academic standards, which are goals for what students should know and be able to do, and school districts and teachers then develop curriculum aligned to the standards. Consequently, academic standards vary from state to state, and the federal government cannot directly control these decisions.[2]

But federal actors still shape academic content. In 2010, when state leaders developed the Common Core State Standards, the U.S. Department of Education offered waivers and funds to states adopting these standards. Some groups saw these incentives as coercing a national curriculum.[3] However, a federal judge denied that Common Core constituted a curriculum or that ED's incentives exceeded its authority.[4]

Courts often defer to educational decision makers when outside groups dispute content choices. For example, in *California Parents for the Equalization of Educational Materials v. Torlakson*, parents challenged California's standards and curriculum as "hostile" toward the Hindu religion. The Ninth Circuit rejected the suit, explaining that without discriminatory intent, equal protection challenges to curriculum content fail.[5]

The recent challenges to books used in schools implicate two interests: parental rights to direct children's upbringing and a student's access to information and ideas. School boards likely do not have unfettered discretion to ban books. The Supreme Court decision in *Island Trees Union Free School District v. Pico* is most frequently cited on this issue. In it, a plurality of justices suggested that students have rights to information and the First Amendment limits school boards' authority to remove books. However, experts call this case so "fractured" that its meaning is debatable.[6] No doubt more litigation on this topic is forthcoming.

A recent spate of state legislation seeks to restrict what schools teach about certain topics, such as race and gender. Many of these bills would ban teaching "divisive concepts," mirroring language from an executive order issued by former President Trump.[7] These legislative efforts' legality remains to be seen. Some prohibitions are so nebulous that determining whether curricular materials run afoul of the law would be difficult. A federal district court in 2017 struck down an Arizona law banning ethnic studies, calling it unconstitutional and reasoning that the law was motivated by "racial animus" and impaired students' rights without "legitimate pedagogical concerns."[8]

Academic content decisions are playing out in new ways, and the legal landscape for these decisions is evolving. Adopting academic standards is a central responsibility for state boards. This chapter of heightened public and political interest in academic content will undoubtedly affect how boards build consensus on the standards they adopt and how schools implement the standards. ■

[1]Michael W. Apple, *The State and the Politics of Knowledge* (Abingdon: Routledge, 2003).

[2]U.S. Const. amend. X; Prohibition against Federal Control of Education, 20 U.S. Code § 1232a.

[3]Robert S. Eitel and Kent D. Talbert, "The Road to a National Curriculum: The Legal Aspects of the Common Core Standards, Race to the Top, and Conditional Waivers," *Engage* 13, No. 17 (March 2012): 21–22.

[4]Jindal v. U.S. Department of Education, 2015 WL 5474290 (M.D. La. 2015).

[5]California Parents for the Equalization of Educational Materials v. Torlakson, No. 19-15607 (9th Cir. 2020).

[6]Mark Walsh, "Yanking Books from School Libraries: What the Supreme Court Has Said, and Why It's Murky," *Education Week*, December 15, 2021.

[7]Jonathan Friedman and James Tager, "Educational Gag Orders: Legislative Restrictions on the Freedom to Read, Learn, and Teach" (New York: PEN America, 2022), https://pen.org/report/educational-gag-orders/.

[8]González v. Douglas, 269 F. Supp. 3d. 948, 974 (D. Ariz. 2017).

We the Media

Renée Rybak Lang
Communications Director

Reshaping Family Engagement

More than two years into the pandemic, family engagement has taken on a whole new meaning in education. Parents (this one included) witnessed firsthand how children were learning, what they were learning, and perhaps what they weren't learning, which has largely shaped parents' interaction with schools and teachers. In fact, 93 percent of parents said they will be as or more involved in their children's education, according to results from a 2021 Learning Heroes' survey.[1]

Yet while parent engagement does not always translate to constructive collaboration, there are ways that it can.

Despite the pandemic, parents' expectations remain high in their children's academic achievement. Nine in 10 believed their child was performing at or above grade level, even though only 44 percent of teachers thought most students would show up prepared for grade-level work this school year.

This disconnect may be partly due to the information parents receive about achievement and interpretation. "Parents believe grades are a reflection of grade-level achievement, whereas teachers equate grades with effort more than grade-level mastery," said Learning Heroes' Windy Afflito-Lopez during a session at this year's NASBE Legislative Conference. Yet parents need—and want—access to multiple measures of achievement. They desire a clear picture of their child's achievement.

Learning Heroes' findings showed that building trust and teamwork is critical to meaningful, lasting family engagement. But a strong minority of vocal parents that are working against such principles has overshadowed this, said Kentucky state board member and teacher Allison Slone during the session. "We must create the space to bring diverse voices together, ensure they are heard, and have a conversation to change mind-sets and bring to light the fact we are working towards the same goals," she added. Lori Morrow, Maryland State Board of Education's parent member, echoed that sentiment: "Let's keep students at the center of our work. We cannot get distracted by politics."

Additionally, Learning Heroes' Eyal Bergman presented three pillars for designing effective family engagement:

- **Build trust.** Nurturing trust and centering teamwork in home-to-school relationships are essential to effective family engagement strategies. Trust, like oil in a car engine, is the "lubricant that helps all the moving parts of the education system work together collaboratively," said Bergman.
- **Anchor student learning.** Families and educators care about the same thing: student success and learning. Often, though, student learning is only tangentially related to family engagement in schools. To better support strong engagement, provide parents a holistic and accurate understanding of the situation and invite them to contribute.
- **Invest in systems.** Most educators have not witnessed excellent family engagement and have little pre-service training or ongoing professional development to support it. What infrastructure can we design to support the learning journey of educators and ensure better family engagement?

Creating systems that are centered around inclusivity and building teamwork and trust will eventually quiet the divisive rhetoric that dominates today's headlines and prevents policy leaders, educators, and families from being true partners in providing excellent education for all students. ■

[1]Learning Heroes, "Parents 2021: Going beyond the Headlines" (December 2021), https://bealearninghero.org/research/.

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Paolo DeMaria
NASBE President and CEO

from the President's Pen

Picture Every Student Loving Math and Science

Three movies amplify the main point of this issue. The first is *Stand and Deliver*, the story of how teacher Jaime Escalante helped youth in East Los Angeles master calculus and achieve high scores on the AP Calculus exam—despite skeptics who made accusations of cheating. The second is *October Sky*, about how Homer Hickam in rural West Virginia, against all odds, does not become a coal miner like his schoolmates but instead pursues a love of rocketry all the way to a career at NASA. *Hidden Figures* illustrates the struggle of three Black women in the segregated, male-dominated math and science world of America's nascent space program.

Every student should be able to see themselves in the students portrayed in these movies. There is no math or science gene that only some people have. And again in all caps: EVERYONE CAN BE GOOD AT MATH AND SCIENCE. Just as when a student is struggling to master an instrument or a foreign language—which everyone is also capable of—we must believe in them and cultivate their desire to succeed (Escalante calls it *ganas*).

In each film, teachers play an essential role. The best ones find ways to help students master needed knowledge and skills, recognizing that different approaches to problem solving resonate with different students and are totally acceptable. The best teachers never let students believe they cannot succeed. They reveal these subjects as elegant, beautiful, and immensely satisfying—and thus something students can love.

Because math and science permeate daily existence, we can teach these subjects in ways that are relevant to students' lives. When students see relevance, they become engaged, and when engaged, their desire to succeed increases. Yet without a solid command of mathematical and scientific concepts, students are walled off from many of life's best opportunities and experiences.

I see great progress across the country in reading and literacy. It's time to do similar good work in math and science. Here are key ideas to reinforce:

- Believe that every student can succeed in math and science. Every thought we think and word we speak should echo this belief.
- Help students form their math and science identity. What math and science concepts intersect with their daily lives and their aspirations?
- Make math and science instruction relevant to students. Math and science are everywhere!
- Ensure that parents and communities reinforce the belief that students can excel in math and science.
- Highlight how every career—particularly emerging, high-paying ones—leverage math and science skills and thinking.
- Ensure that teachers, schools, and districts use high-quality curriculum, proven instructional approaches, personalization, relevancy, and meaningful tutoring and that they create a culture where students believe they can succeed.

I have fond memories from my youth of excellent math teachers (Miss Morasco, Dr. Lattimer) and science teachers (Mr. Corea, Ms. Potts, Mr. Porter). They made math and science come alive and nurtured my love for exploring them. Every student should have this kind of instruction and emerge with knowledge, skills, and confidence in their math and science abilities. Let's make it happen! ■

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