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Research Report

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Getting Students to (and Through) Advanced Math

Where Course Offerings and Content Are Not Adding Up

Sponsored by the Bill & Melinda Gates Foundation

KEY FINDINGS

- Small high schools, high schools in rural areas, and high schools that mostly serve students from historically marginalized populations offer fewer opportunities for students to take advanced math.
- Uneven access to advanced math courses starts before high school with uneven access to algebra I.
- Math teachers in high-poverty schools reported skipping standards-aligned content more frequently and were more likely to replace what they skipped with content from prior grade levels compared with teachers in low-poverty schools.
- A large proportion of math teachers were not able to devote as much time as they would have liked to math instruction in the 2021–2022 school year. Nearly half said they needed more support for delivering high-quality math instruction.

Providing students with equitable opportunities to prepare for and take advanced math courses is an essential function of K–12 mathematics instructional systems. This is because there are clear benefits associated with taking advanced math in high school. For example, students who complete advanced math courses (e.g., precalculus, calculus, and AP math courses) are more likely to major in science, technology, engineering, and mathematics (STEM); persist through challenging postsecondary coursework; and earn more money after high school than those who do not take advanced math courses (Joenson and Nielsen, 2009; Tyson et al., 2007). Moreover, advanced coursework in high school is associated with higher math achievement and higher levels of college acceptance (Byun, Irvin, and Bell, 2015; Ogut, Circi, and Yee, 2022). Additionally, students who take classes like AP math courses can earn college credits and qualify for additional scholarships and financial aid (Iatarola, Conger, and Long, 2011).

Despite these benefits, a large proportion of high school students either do not have access to or

Definitions of Key Terms

Standards-aligned math content encompasses the concepts, knowledge, and skills outlined by each state's content standards in mathematics for kindergarten to grade 12 (K–12) that students are expected to master at grade or course level.

Standards-aligned instruction refers to any instructional or teaching practice intended to facilitate student mastery of the state content standards.

Advanced math courses refers to the math classes that high school students can take after completing algebra II (e.g., precalculus, calculus, courses in probability and statistics, and Advanced Placement [AP] math courses).

Opportunity to Learn (OTL) refers to measures of exposure students have had to content, including time on instruction, instructional quality, and the nature of the content. In this report, we describe three content-related aspects of OTL: (1) teachers' reported coverage of standards-aligned content in a single math course or grade (i.e., course-level OTL), (2) students' cumulative K–12 exposure to math content (i.e., cumulative OTL), and (3) the systemic or structural aspects of OTL that facilitate access to content, including course availability and academic supports.

OTL advanced math refers specifically to the availability of advanced math courses and students' exposure to advanced math content within these courses.

are opting out of advanced math courses altogether. According to data from the 2019 National Assessment of Educational Progress (NAEP) High School Transcript Study, 43 percent of high school students graduated without taking math courses beyond algebra II (The Nation's Report Card, 2019a). Moreover, previous research highlights persistent racial gaps in the proportion of students who gain access to and stay on accelerated tracks that lead to advanced math courses (Irizarry, 2021; U.S. Department of Education, Office for Civil Rights, 2018).

Although participation in advanced coursework in high schools increased in the years leading up to the coronavirus disease 2019 (COVID-19) pandemic, performance levels in math have remained substantially unchanged since 2015 (Sparks, 2020). According to student achievement data from a 2019 NAEP study, only one-quarter of 12th graders met the standards for *NAEP Proficient,* which the NAEP defines as demonstrating competency on challenging math content (The Nation's Report Card, 2019b). These trends raise important questions about access to advanced math courses and the need for additional student and teacher supports to promote advanced math learning.

Although we still know little about how COVID-19–related learning loss has affected preparedness for advanced math courses, recent test data collected by the NAEP from a nationally representative sample of students in grades 4 and 8 confirm the inevitable: historically low math scores overall and widening achievement gaps (The Nation's Report Card, 2022). These declines were especially steep among students of color. Another study using 2022 MAP Growth assessment data from 8.3 million students in grades 3 to 8 suggests that it may be years before students fully recover from COVID-19–related learning loss (Kuhfeld and Lewis, 2022). Middle schoolers have been particularly slow to rebound, some of whom are at risk of graduating before they regain the ground they lost due to pandemic-related disruptions to learning (Tadayon, 2022; Kuhfeld and Lewis, 2022).

Opportunities to prepare for and take advanced math start in kindergarten and accumulate over time. In this context, systematic differences within and across students' exposure to advanced math content could signal major inequities in how schools are supporting teachers and preparing students, especially now. Therefore, diagnosing gaps in students' opportunities to prepare for and learn advanced math and providing teachers with targeted supports to overcome these gaps is more important than ever.

Abbreviations

AP	Advanced Placement
COVID-19	coronavirus disease 2019
FRPL	free or reduced-price lunch
FY	fiscal year
GPA	grade point average
K–12	kindergarten through grade 12
LTS	Learn Together Surveys
NAEP	National Assessment of Educational Progress
OTL	Opportunity to Learn
STEM	science, technology, engineering, and mathematics

To support these efforts, we begin this report by summarizing students' OTL advanced math in the United States and how this differs by school context. We operationalize OTL advanced math as the opportunities students have to take advanced courses in high school, their exposure to advanced content within these classes, and their cumulative OTL in math in preparation for advanced math in the years leading up to high school. Next, using data from a nationally representative sample of teachers and school leaders from the 2021–2022 school year, we examine

1. differences in high school advanced course offerings across the United States
2. the availability of algebra I and supports to help students prepare for advanced math before high school
3. differences in course-level K–12 math content coverage
4. challenges educators encountered to providing high-quality standards-aligned math instruction.

We conclude with a discussion of the implications of our findings and recommendations for education leaders and policymakers to improve students' access to and participation in advanced mathematics.

Opportunities to Prepare for and Learn Advanced Math in the United States

In this section, we describe the advanced math course sequences that students typically take in the United States. We note that these sequences are determined early and that how they are structured can constrain the number of advanced courses students take before graduation. Lastly, we make the point that the rigor and depth of content students are exposed to may differ dramatically in the years leading up to their advanced math courses.

Students' OTL Advanced Math Depends on an Array of Factors

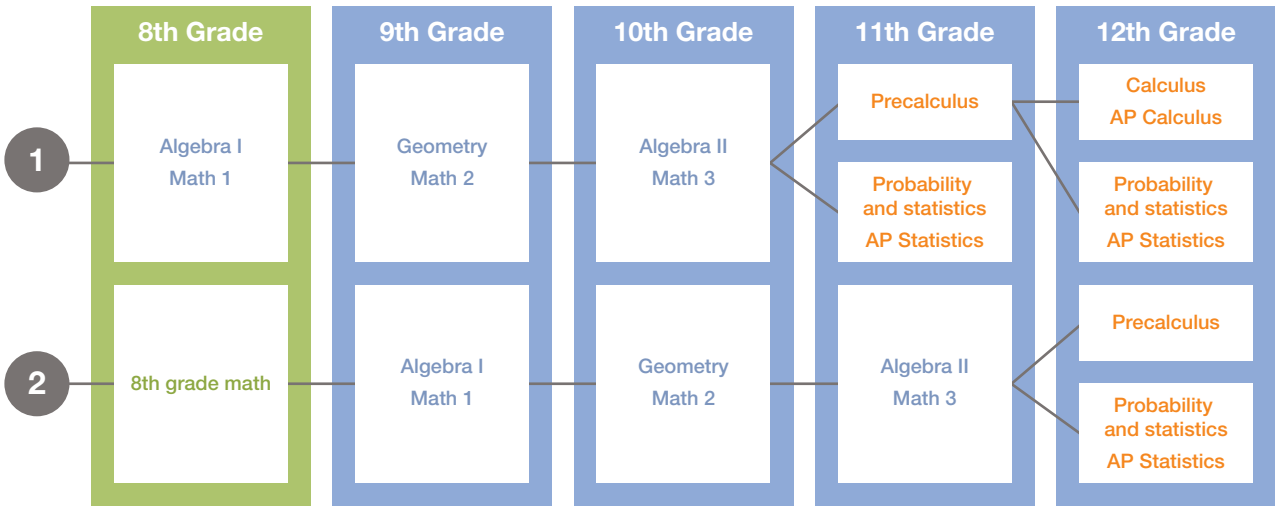
According to data collected from NAEP's 2019 High School Transcript Study, 41 percent of high school graduates' math careers culminated with a course in precalculus, trigonometry, or statistics.[1] Sixteen percent took calculus. Of those students who did not take advanced math courses, which we define as any course with an algebra II prerequisite, most students completed algebra II or an algebra II equivalent–level course. Very few students earned mathematics credits through a dual-enrollment program (The Nation's Report Card, 2019a). Our definition of advanced courses as *any course beyond algebra II* is based on previous conceptualizations in the literature, which cite especially strong links between post-secondary success and taking advanced courses beyond this threshold (Byun, Irvin, and Bell, 2015; Riegle-Crumb and Grodsky, 2010).

Below, we illustrate commonly pursued course sequences by high school students who take advanced math in the United States (Figure 1); although, math course pathways and the actual courses offered by schools may vary significantly. In fact, one study based on data from the 2009 High School Transcript Study found that high school graduates had earned math credits along more than 1,000 unique course sequences (Brown et al., 2018).

Figure 1 shows two sequences of advanced math courses: calculus pathway courses (i.e., precalculus, calculus, and AP Calculus) and statistics courses (i.e., courses in probability and statistics and AP Statistics), which are indicated in orange font. Before enrolling in advanced math courses, students must complete a sequence of foundational core classes, typically algebra I, geometry, and algebra II (Brown et al., 2018; Ogut et al., 2021). These courses are depicted in blue. As you can see in Figure 1, students who enroll in algebra I in grade 8 can take two

FIGURE 1

How Are Advanced Math Courses Typically Sequenced from Middle to High School?



NOTE: This figure shows how students' opportunities to take advanced courses during their last two years of high school depend on when they take algebra I, either in (1) grade 8 or (2) grade 9. The foundational sequence of courses (algebra I, geometry, and algebra II) is depicted in blue font. Calculus pathway classes and statistics courses are depicted in orange font. The boxes indicating high school grades are shaded blue to distinguish them from grade 8, which is shaded green.

years of advanced math. Over the past decade, some school districts have experimented with different foundational sequences, including integrated sequences that combine concepts from algebra, geometry, and statistics (i.e., math 1, math 2, and math 3); however, the traditional series (i.e., algebra I, geometry, and algebra II) is still the most common.

Some of the literature that ascribes postsecondary benefits to taking advanced courses is based on students who have earned credits in calculus pathway courses or AP math courses. Other advanced math course classification schemes include courses in probability and statistics as these have traditionally been taken after algebra II (Chen, 2019; Burkam and Lee, 2003). We include probability and statistics here also as a type of advanced course but acknowledge that the prerequisites required for taking these courses, the content-based aspects of OTL associated with them, and their postsecondary benefits could differ depending on context (see Box 1 for additional context about why this matters).

Advanced Course Offerings Are Determined by School-Level Factors, such as School Size, Location, and Levels of Students Living in Poverty

Previous studies reveal significant disparities in the number of advanced courses high schools offer based on student poverty levels, geographic location, school size, and school type (i.e., charter compared with traditional public schools). By the most-recent accounts, including a 2018 U.S. Government Accountability Office report and a 2021 study based on data from the U.S. Department of Education, the gap between the proportion of schools that offer calculus stands at 35 to 40 percentage points between high- and low-poverty schools (Nowicki, 2018; Leung et al., 2021). Across all poverty levels, large high schools (more than 1,000 students) and non-charter schools are more likely to offer calculus and more AP math courses than small schools (fewer than 200 students) and charter schools; magnet schools offer more AP courses then either non-charter or charter public schools in high-poverty areas (Nowicki, 2018).[2]

Students in rural communities may be particularly disadvantaged by limited opportunities to take advanced courses. Previous studies based on nationally representative samples of students from the 2005 High School Transcript Study, the High School Longitudinal Study of 2009, and the 2011–2012 Civil Rights Data Collection show that, in comparison with suburban high schools, rural high schools tend to offer fewer advanced math courses (Saw and Agger, 2021), and they are significantly less likely to offer any AP math courses, especially when the school is small and located in geographically remote and/or economically disadvantaged communities (Gagnon and Mattingly, 2016).

Even in schools that offer advanced courses, students from historically marginalized communities may be less likely to be enrolled in equivalently challenging versions of the same courses. As suggested by one study based on data from the 2012 Programme for International Student Assessment, within-school variations may be the largest source of OTL inequality in the United States between economically advantaged students and students living in poverty (Schmidt et al., 2015). In a follow-up study, Schmidt, Guo, and Houang (2021) note that this effect is appreciably compounded by race- and ethnicity-based sources of OTL inequity within and across schools. This is because systemic inequities coupled with the practice of identifying students for advanced courses based on past achievement or more-subjective measures, such as teacher nominations, have historically led to the disproportionate assignment of students of color and students living in poverty into lower tracks where they have fewer opportunities to learn challenging math content (Hallinan, 1994; Wronowski et al., 2022; Schmidt, et al., 2015).

Students' High School Course Sequences in Math Are Often Determined in Middle School

For students to take advanced math courses by grade 11, which allows for calculus before high school graduation, school districts must provide accelerated options for completing core foundational courses before junior year (see Figure 1). One common solution is to offer algebra I before high school. Other solutions involve concurrent course-taking in high school, condensed summer courses, or accelerated models that combine content from grade 7, grade, 8, and algebra I into a two-course series taken before high school (Common Core State Standards Initiative, 2017).

Currently, one-quarter to one-third of students take algebra I before high school (Walston and McCarroll, 2010; U.S. Department of Education, 2018).[3] Disproportionately fewer students of color and students living in poverty are enrolled in algebra I (Patrick, Socol, and Morgan, 2020; Stein et al., 2011). Rural students, too, are more likely to begin high school with less mathematical knowledge than their peers (Anderson and Chang, 2011). Because of the central position algebra occupies as "a gatekeeper to higher mathematics" (Stein et al., 2011), differential access to algebra I between student groups has led some states and districts to experiment with more extreme approaches to "leveling the playing field," including promoting algebra I for all students in grade 8 (e.g., California and Minnesota) or universally delaying algebra I until grade 9 (e.g., San Francisco Unified) (Sawchuck, 2018; Jacobson, 2008).

Students who successfully complete algebra I before high school possess unique advantages over those who do not. Although most studies have been unable to fully tease apart the inherent selection bias associated with early algebra, one recent study, based on data from hundreds of middle schools in California, found that taking algebra I in grade 8 resulted in higher math achievement overall and participation in more advanced courses during high school (McEachin, Domina, and Penner, 2020). The authors of this study noted that female students, English learners, and students of color differentially benefited from early access to algebra I compared with their

BOX 1

Which Math Courses Should High School Students Be Taking?

Although calculus has traditionally been viewed as the zenith of high school math, some STEM advocates are calling on school districts to reorganize their math curriculum with opportunities for students to study data science, statistics, and other math topics that may be more relevant for participating in civic life and the modern workforce (Cavanagh, 2007; Sparks, 2018). Proponents argue that expanding access to challenging courses in probability and statistics, computer science, and discrete math will equip more students with the technical skills required to compete in today's workforce and make mathematics compelling and approachable for broader audiences (Levitt, 2022).

Not everyone agrees. Those who question the development of alternative pathways in place of traditional calculus preparatory classes argue that one unintended consequence could be the creation of systems that disproportionately redirect students from communities that are underrepresented in STEM fields away from such courses as precalculus—courses that they argue are critical for a future in STEM (Ford, 2022).

Others suggest that arguments over which types of math courses are best for students are "missing the forest for the trees" (Burdman, 2022; Noguera and Polikoff, 2022). These scholars point to the large proportion of students performing below grade level as evidence of a need to create multiple types of rigorous course options, especially for students of color and students living in poverty. Indeed, more than one-quarter of high school seniors skip out on a fourth year of math completely (Brown et al., 2018). Against this backdrop, some states are experimenting with models that allow students to replace core math requirements with "course-level equivalent" foundational courses in applied or data-oriented topics.

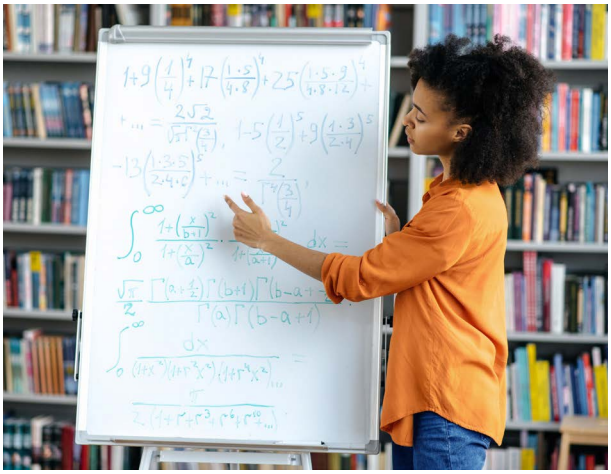
For example, the Ohio Department of Education is developing multiple math pathways in partnership with the Ohio Department of Higher Education to allow students to take algebra II equivalent courses in probability and statistics, mathematical modeling and reasoning, data science, and discrete math/computer science in place of algebra II. Depending on the pathway students choose, after they have completed an algebra II equivalency course, students can move on to such courses as AP Statistics, AP Computer Science, or College Credit Plus math courses to earn college credits (see Ohio Department of Education, undated). Students are also required to take four math credits before they graduate. The goal of programs like these is to provide and incentivize opportunities for students who are not planning on majoring in STEM to continue developing mathematical competencies throughout high school.

counterparts and that more-stringent enrollment thresholds were associated with higher benefits.

This does not mean all students are academically prepared for algebra I by grade 8. The findings in McEachin, Domina, and Penner (2020) echo those from an earlier study which characterized universal algebra I policies as risking the trade of "one type of error for another" (Stein et al., 2011). That is, although universal algebra leads to increased enrollment in algebra I among prepared students, it also increases enrollment among students who are underprepared. Stein et al. (2011) posits that for universal algebra policies to have their intended impact, at the very least, schools must also provide additional instructional hours and supports for struggling students. Alternatively, McEachin et al. (2020) hypothesize that another solution could involve enhancing access for learners from historically marginalized groups without universalizing access. Regardless, the goal, as suggested by Stein et al., 2011, should be better preparation for "students who are in the pipeline moving toward algebra" and increased support for those who are already enrolled in algebra.

In the Years Leading Up to Advanced Math, Students' Exposure to Challenging Math Content May Vary Substantially

Math courses are meant to build on one another from year to year with the goal of preparing students to take advanced math classes and to succeed in college-level math courses, should they choose to take them. Like a map, state content standards provide the benchmark for what students should know and be able to do in math at each grade level. Although states have significant latitude to define their own content standards, most states' thresholds for proficiency align with NAEP's standards for proficiency, which provide a high and substantiated measure for student performance (Hamlin and Peterson, 2018). Together, state content standards and their associated frameworks form the intended curriculum by outlining what teachers are expected to teach and what students are expected to learn in anticipation of the next math course.



By this logic, by the time they reach high school, students should have been provided with equivalent opportunities to learn rigorous math content over the duration of their academic careers. However, for many students, this is not always the case. This gap exists, at least in part, because the choices teachers make about *what* content to teach and *how* to teach it (i.e., the *enacted* curriculum)—and how these choices interact with students' readiness to learn—can vary widely within and across school contexts in the years leading up to advanced math. Even when students are enrolled in courses that have the same name and that are based on the same content standards, including their K–8 math courses and courses such as algebra I, geometry, and algebra II, their course-level OTL may be substantially different (Schmidt et al., 2015).

For example, studies about California's previous efforts to increase grade 8 enrollment in algebra I demonstrated that merely enrolling more students in algebra I—without providing adequate supports—will not automatically translate into higher math achievement for all students or all students enrolling in advanced courses in high school (Liang, Hechman, and Abedi, 2012; Domina et al., 2015). As posited by some researchers, the practice of promoting students who do not meet certain criteria into higher-level courses, such as algebra I, before they are ready may inadvertently result in students failing to grasp critical content or some teachers simplifying their content to make it more accessible for students who they perceive as underprepared (Loveless, 2013). This means that, even if students take algebra I in grade 8, they may not be equally prepared for advanced math in high school.

Regardless of the causes, as demonstrated by the research on academic tracking, the impact of teachers' instructional choices in combination with structural and systemic inequities on student achievement, students' math identity, and their future OTL in math could be cumulative (Francis et al., 2020; Gamoran, 2009). Previous studies show that year after year, lower achieving students tend to be assigned to classes where they spend less time on content—and that students from historically marginalized communities are more likely to have teachers with less content knowledge and experience who spend less time on instruction (Desimone and Long, 2010). One study that analyzed the course learning objectives of grade 9 algebra I teachers, for example, found that students who were enrolled in remedial classes, which focused on less cognitively demanding content (e.g., basic concepts, algorithms, and computation), were less likely to complete algebra II and had lowered perceptions of their own math identity compared with their peers in algebra I classes that incorporated more problem-solving and practical applications (Wronowski et al., 2022). The students enrolled in remedial algebra I courses were significantly more likely to be Black or Hispanic/Latino or economically disadvantaged.

Analysis of Our Data

Our survey population: Our survey data were collected from nationally representative samples of K–12 teachers (n = 3,606) and principals (n = 1,694). We assigned a cross-sectional survey weight to each LTS participant to ensure that estimates based on the LTS sample reflect the national population of educators during the 2021–2022 school year. Our analysis of the teacher data includes only those who said they were teaching at least one mathematics course during the 2021–2022 school year in a general education classroom (n = 1,603). For additional information about the LTS, including technical documentation and survey results, see Doan et al., 2022.

How we analyzed course offerings: In our analysis of advanced course offerings, we defined *high schools* as schools with grades 9 through 12 (n = 464). To understand which students have access to pre-algebra and algebra I before high school, we defined and analyzed schools with *middle grades* as schools with grades 7 and 8 because these are the grades during which these courses would typically be offered (n = 630). Our definition accommodates alternative school configurations with grades 7 and 8 (e.g., kindergarten to 8, grades 5 to 8). We controlled for schools with higher grade levels to ensure meaningful comparisons.

To determine whether there were differences in course offerings based on school-level characteristics, we analyzed principals' responses about the courses they offered at their school by locale, school size, student poverty levels, and student body racial/ethnic composition. For details on how we defined these variables, see Box 2.

How we analyzed data from teachers: We explored how math teachers' responses differed by school-level characteristics (e.g., locale, student poverty levels, and student body racial/ethnic composition) and teacher-level characteristics (e.g., grade level, experience, and math content expertise). To understand how math teachers' responses differed by grade levels instructed, we grouped teachers into grade bands based on the grades they reported teaching: elementary (kindergarten to grade 5), middle (grades 6 to 8), high (grades 9 to 12), and teachers whose assignments spanned two or more of these categories. We do not present the results of the fourth band.

How We Analyzed Our Data

In this report, we present selected findings from the 2022 American Teacher Panel (ATP) and American School Leader Panel (ASLP) Learn Together Surveys (LTS) related to math instruction. The LTS ask educators about multiple topics, including social and emotional learning, student supports, mathematics instruction, teaching students with disabilities, and professional learning. We surveyed teachers and principals in March and early April 2022. In this report, we draw on school leaders' reports about the math courses offered in their schools and math teachers' perceptions of their instruction of standards-aligned math content. The results are intended to inform policy.

This analysis is based primarily on comparisons between sample means. Subgroup comparisons are reported as simple differences in means without statistical adjustment for covariates. Unless otherwise noted, the subgroup differences we highlight in this report are statistically significant ($p < 0.05$) based on pairwise comparisons (see "Limitations" subsection on p. 11). We advise the reader that the drivers underlying our findings are complex and, in some cases, interrelated (see Box 3). Moreover, some of the differences we observed across subgroups could be driven by factors that we did not ask about in this survey. Consequently, our findings should be strictly interpreted as descriptive characterizations of educators' responses. They are not intended to suggest causality.

To test the robustness of our findings, we conducted further significance testing using linear regression models that adjusted for certain school- and teacher-level characteristics. We used these models to better understand whether the descriptive associations we observed in our primary analysis were potentially confounded by these other factors. In our model for course offerings, we included student poverty levels, student body racial/ethnic composition, locale, school size, and other grade levels offered. School size is a well-known driver of course offerings, and we speculated that accommodating other grade levels in the same building may contribute to capacity issues that affect a schools' ability to provide advanced courses. In our models for teachers, we included student body poverty levels and racial/ethnic composition, locale, teaching experience, teacher content expertise, and grades instructed. We use the results of these regressions throughout the report to reflect on the robustness of our unadjusted findings, and we note which findings remained robust to specifications that controlled for other school and educator characteristics. Where our findings between subgroups were many, including those related to course offerings, we organized the presentation of our key results based on those that remained significant after we accounted for other school and educator characteristics. Because the intent of this report is to provide descriptive information rather than to test causal hypotheses, we did not conduct multiple hypothesis tests.

BOX 2

School- and Teacher-Level Indicators

Student poverty levels:

- High-poverty schools: 50 percent or more of students are eligible for free or reduced-price lunch (FRPL)
- Low-poverty schools: Fewer than 50 of students are eligible for FRPL

Student body racial/ethnic composition:

- Mostly students of color: 50 percent or more of students are students or color
- Mostly white students:[4] Fewer than 50 percent of students are students of color

School size:

- Small: Fewer than 450 students
- Large: 450 students or more

Teaching experience:

- Novices: Teachers with five years of experience or less
- Veterans: Teachers with more than five years of experience

Teacher content expertise:

- Math content expert: Includes teachers with a bachelor's or master's degree in mathematics and math teachers that passed a subject-specific licensure exam in math
- Non-math content expert: Includes teachers with non-math degrees and teachers that did not pass a subject-specific licensure exam

Teacher grade bands:

- High school teacher: Reported teaching grades 9, 10, 11, or 12 only
- Middle school teacher: Reported teaching grades 6, 7, or 8 only
- Elementary school teacher: Reported teaching kindergarten, grades 1, 2, 3, 4, or 5 only

Limitations: Our findings are subject to several limitations. First, the LTS rely on self-reported information from educators—a limitation present in all survey research. Although some research suggests that educators can accurately estimate the frequency of their own instructional practices, others demonstrate that their responses can vary depending on several factors (Kaufman, Stein, and Junker, 2016). Additionally, educators' responses to some questions may have been influenced by their context (e.g., when responding to questions about student supports, teachers in low-poverty communities may have been thinking about the resources that their students access outside school, such as private tutoring, whereas teachers in high-poverty schools may have been thinking about supports offered by the school). Second, when we compare the responses of teachers to those from previous school years, we did not include the results of significance testing. This is because although the cross-sectional comparisons we make are useful for describing descriptive trends, the weights we employed are not intended for longitudinal analysis. Finally, because of the nature of sampling, educators' responses represent individual perspectives rather than the perspectives of all educators in a school or district.

OTL Advanced Math in High School Is Associated with School Size, Locale, and Student-Level Characteristics

We begin this section with an overview of the advanced math courses available to high school students across the United States based on reports from the principals we surveyed and a discussion of how these course offerings differed depending on school size, student characteristics, and locale. To add context to our findings, especially in rural areas, we include information about the proportion of principals who said they offered non-advanced math courses (e.g., business, consumer, or other applied math; online math courses for high school or college credit) as proxies of alternatives to advanced math courses available to students in some contexts.

In the second half of this section, we explore how differential access to advanced courses begins with differential access to algebra I before high school by looking at course offerings in schools with middle grades across different school contexts and the availability of additional supports to prepare middle school students for advanced math.

BOX 3

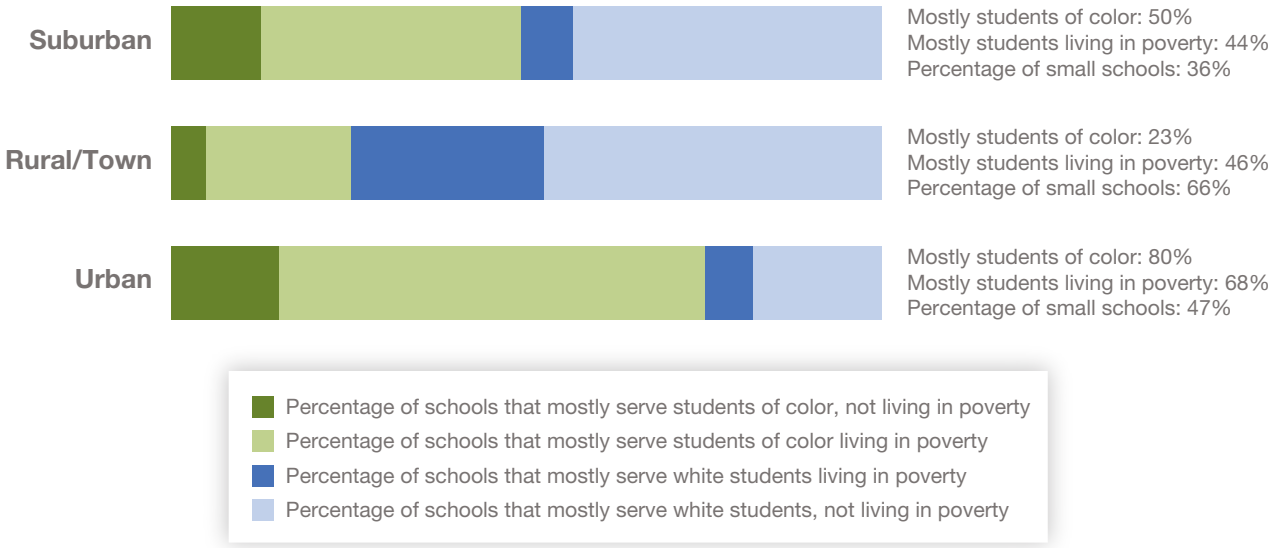
Trends Related to Student Poverty Levels, Student Race/Ethnicity, and Locale

Because of the spatial distribution of wealth and poverty, and how this intersects with race and ethnicity, in our sample, we observed a large degree of overlap in students' demographic characteristics and school poverty levels, as shown in Figure 2. For example, high-poverty schools also tended to disproportionately serve students of color. In contrast, low-poverty schools tended to serve mostly white students. Associations between poverty, student race/ethnicity, and other student body characteristics are well-documented elsewhere (Nowicki, 2018). Likewise, readers should be aware of certain demographic trends by locale. For example, urban schools tended to serve larger concentrations of economically disadvantaged students of color than rural or suburban schools. Suburban and rural schools tended to serve larger concentrations of affluent white students.

However, there are important nuances to these generalities. For example, a large proportion of schools in rural and suburban communities *also* serve students living in poverty. Moreover, 50 percent of schools in suburban areas predominantly serve students of color. Finally, because of how our survey is structured, we were unable to examine differences in OTL among students from historically marginalized communities in schools that do not serve large proportions of students in these groups; however, we know from the literature that the experiences of such students differ profoundly. We encourage readers to keep this limitation in mind.

FIGURE 2

What Is the Relationship Between Locale, Student Poverty Levels, and Student Body Racial/Ethnic Composition?



NOTE: This figure shows school-level characteristics by school locale based on the school leaders we surveyed (n = 1,694). The term *mostly students of color* refers to schools where students of color make up 50 percent or more of the student population. *Mostly students living in poverty* refers to schools where 50 percent or more of the student population is eligible for FRPL.

Most High Schools Offered Precalculus and Calculus. Large High Schools Provided More Options Overall for Advanced Course-Taking Than Small Schools

Three-quarters of the high school principals we surveyed reported offering at least three of the five advanced courses we asked about (i.e., precalculus, any calculus, courses in probability and statistics, AP Statistics, and AP Calculus; see Figure 3). Most principals said their school offered precalculus and calculus. Three-quarters of principals reported offering courses in probability and statistics. Substantially fewer said their schools offered AP math courses. For context, nearly all of the high school principals we surveyed reported offering algebra II (92 percent), which is important because completing algebra II or an equivalent-level course is required before students are eligible for advanced math courses. The proportion of principals who reported offering calculus in our sample is higher than what has been previously reported (Nowicki, 2018; Leung et al., 2021).[5]

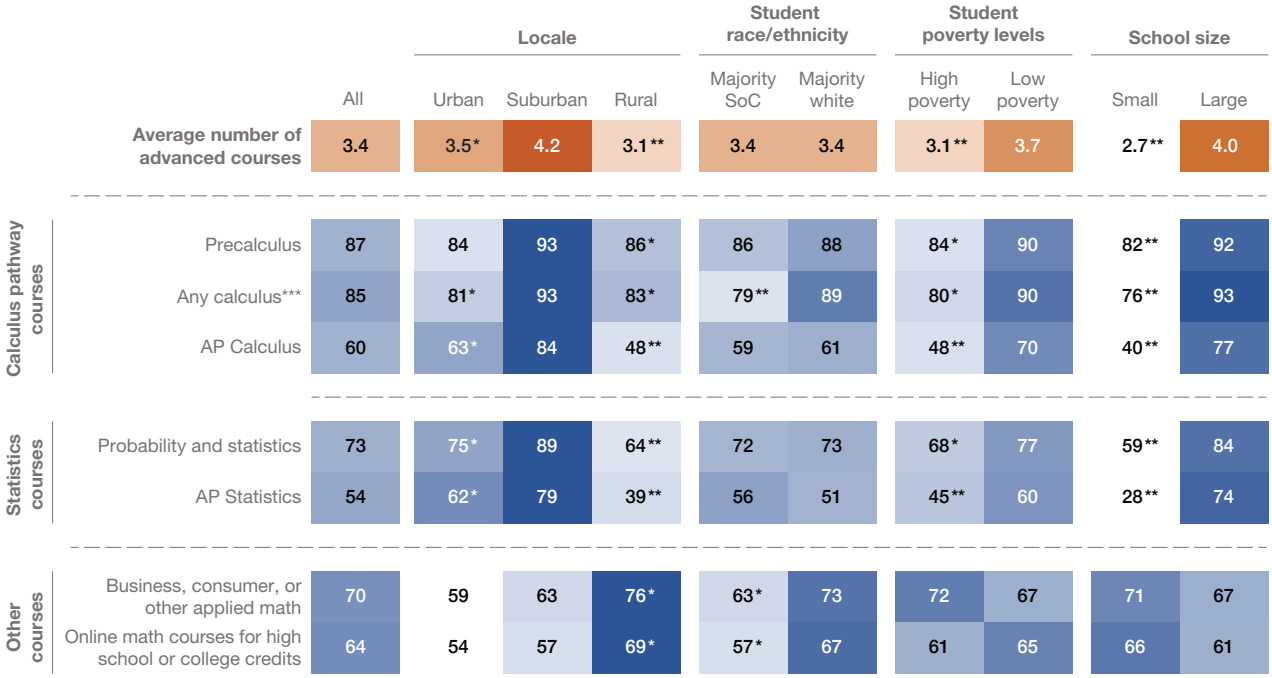
On average, principals from large high schools (greater than 450 students) reported offering more advanced courses overall and were substantially more likely to report offering the individual courses we asked about. These large differences, which ranged from 10 to 46 percentage points, remained significant when we controlled for other school-level factors, including student body demographics and locale. This finding is consistent with findings from other studies that measured the relationship between school size and course offerings (Nowicki, 2018).

Rural High Schools Were Less Likely to Offer AP Courses or Courses in Probability and Statistics, Regardless of School Size

Compared with suburban high school principals, rural high school principals reported offering fewer advanced courses on average (Figure 3). Likewise, they were substantially less likely to report offering any of the advanced courses we asked about. The difference in the proportion of rural principals who

FIGURE 3

What Advanced Courses Do High Schools Offer?



NOTE: This figure is based on high school principals' responses to the following LTS item: "Do you offer the following math courses at your school, and if so, which students are eligible to take these courses?" (Responses in this figure are the weighted percentages of school principals who said they offered each respective course (blue boxes), n = 464.) Single asterisks (*) indicate that the percentage of principals in a subgroup who said they offered the course was significantly different ($p < 0.05$) from the percentage of principals in the counterpart subgroup who said likewise, before controlling for school-level characteristics. Double asterisks (**) indicate that the percentage of principals in a subgroup who said they offered a course was significantly different ($p < 0.05$) from the percentage of principals in the counterpart subgroup who said likewise, before and after controlling for school-level characteristics. Principals in suburban schools are the baseline comparison group for both rural and urban principals. "Any calculus" indicates that a school offers any calculus course, including AP Calculus. The values depicted in the orange cells show the average number of advanced courses offered (from 0 to 5). SoC = students of color.

reported offering courses in probability and statistics was particularly notable: There was a 25-percentage point difference between the portion of rural and suburban principals who said they offered these courses. Moreover, fewer than half of principals in rural schools reported offering AP Calculus or AP Statistics compared with more than three-quarters of suburban principals. Rural principals were also less likely to report offering AP courses or courses in probability and statistics than urban principals.

Because rural high schools tend to be smaller (see Figure 2), one might hypothesize that differences in course offerings between rural and suburban schools could be predicted by differences in school size. However, even after we controlled for school size and other student body characteristics, rural principals were still less likely than suburban principals to report offering fewer advanced math courses. They were also still less likely to report offering probability and statistics and AP math courses. Our findings comport with those of other researchers who have suggested that focusing exclusively on school size when considering disparities in course offerings will not fully resolve the problem of fewer advanced courses in rural schools (Saw and Agger, 2021; Mader, 2015).

Rural principals were more likely than urban or suburban principals to report that their school offered other alternatives to advanced math courses, including business, consumer, or other applied math courses. Although these differences did not remain statistically significant when we controlled for other school-level differences, coupled with the findings above, they imply substantive differences in the routes offered to rural students for earning high school math credits compared with students in other locales. This finding is consistent with other stud-

ies that suggest students in rural areas may be more likely to turn to these types of alternative opportunities to fulfill graduation requirements instead of taking advanced math courses (Mader, 2015).

Finally, although the increased rate of online course offerings in rural areas provides a theoretical work-around for advanced course-taking whereby students could access advanced coursework or earn college credits even if their schools do not provide these opportunities, just under one-half of the rural principals we surveyed who provided these opportunities (48 percent) said that these courses were open to any student who wanted to take them.

High-Poverty High Schools Offered Fewer Advanced Math Courses. Schools That Predominantly Serve Students of Color Were Less Likely to Offer Calculus

On average, high school principals in high-poverty schools reported offering fewer advanced math courses than high school principals in low-poverty schools. When we controlled for school size and other student body characteristics, high school principals in high-poverty schools were still less likely to report offering either of the AP math courses we asked about: Less than 50 percent of principals in high-poverty schools said they offered AP Calculus or AP Statistics compared with 70 percent and 60 percent of principals in low-poverty schools, respectively. These results are consistent with those found in other studies; although, the differences in advanced course offerings documented by other researchers are more extreme (see Leung et al., 2021).

Principals in schools who mostly serve students of color were less likely to report offering calculus compared with principals in schools who mostly serve white students; there was a 10-percentage point difference between the two groups. This finding remained statistically significant when we controlled for school-level characteristics.

We encourage the reader to consider the implications of these findings for schools that serve both students of color and students living in poverty, their differential meaning for students who live in different locales, and occasions in which access among certain student groups may be masked. For example, urban schools—which serve large concentrations of both students of color and students living in poverty—offered fewer advanced courses overall and were less likely to offer almost every advanced course we asked about. This finding underscores how students in high-poverty schools that also serve mostly students of color may be *doubly* disadvantaged by fewer course offerings. In rural communities especially, because of the unique underlying drivers of fewer course offerings, students living in poverty and students of color in these areas are likely additionally disadvantaged by fewer course offerings than their more-affluent or white peers. Even in suburban communities, students of color and students living in poverty are less likely to attend schools that offer some of the advanced math courses we asked about.

Uneven Access to Advanced Math Courses Starts with Uneven Access to Algebra I Before High School

The proportion of principals in schools with *middle grades* who said their school offered prerequisite courses for advanced math sequences differed dramatically by locale and student body demographics (Figure 4).[6] Specifically, urban principals in schools with middle grades were less likely than suburban principals to say their school offers algebra I, pre-algebra, or geometry, with large differences of 14 to 21 percentage points between the two groups. Likewise, the portion of principals who said they offered algebra was 13 percentage points less in schools that predominantly serve students of color. These differences remained significant when we controlled for all observable school characteristics, including student body demographics, school size, and other structural differences. It was more common for principals from these communities to report that their school offered basic math courses than algebra I.

To a lesser degree, although still significant, rural principals were also less likely to say their school offers algebra I or geometry compared with principals

FIGURE 4

What Courses Are Available to Prepare Middle School Students for Advanced Math?

	All	Locale			Student race/ethnicity		Student poverty levels		School size	
		Urban	Suburban	Rural	Majority SoC	Majority white	High poverty	Low poverty	Small	Large
Basic or general math	71	70	73	70	74	68	75	68	73	69
Pre-algebra	66	55**	73	69	58*	73	57**	74	63	69
Algebra I	74	65**	86	75**	68**	81	68*	81	68**	80
Geometry	27	26**	40	20**	28	27	24	30	23	31

NOTE: This figure is based on responses of principals in schools with middle grades to the following LTS item: "Do you offer the following math courses at your school, and if so, which students are eligible to take these courses?" (Responses in this figure are the weighted percentages of school principals who said they offered each respective course, $n = 569$.) The findings shown in this table were adjusted for principals who said their school also serves high school grades. Single asterisks (*) indicate that the percentage of principals in a subgroup who said they offered a course was significantly different ($p < 0.05$) from the percentage of principals in the counterpart subgroup who said likewise, before controlling for school-level characteristics. Double asterisks (**) indicate that the percentage of principals in a subgroup who said they offered a course was significantly different ($p < 0.05$) from the percentage of principals in the counterpart subgroup who said likewise, before and after controlling for school-level characteristics. Principals in suburban schools are the baseline comparison group for both rural and urban principals. SoC = students of color.

in suburban schools. They were also less likely to say their school offers geometry. Although very few students take geometry before high school, this difference suggests that, compared with both urban and rural schools, suburban schools with middle grades may be more likely to provide additional accelerated opportunities for students who they perceived might benefit from especially rigorous pathways.

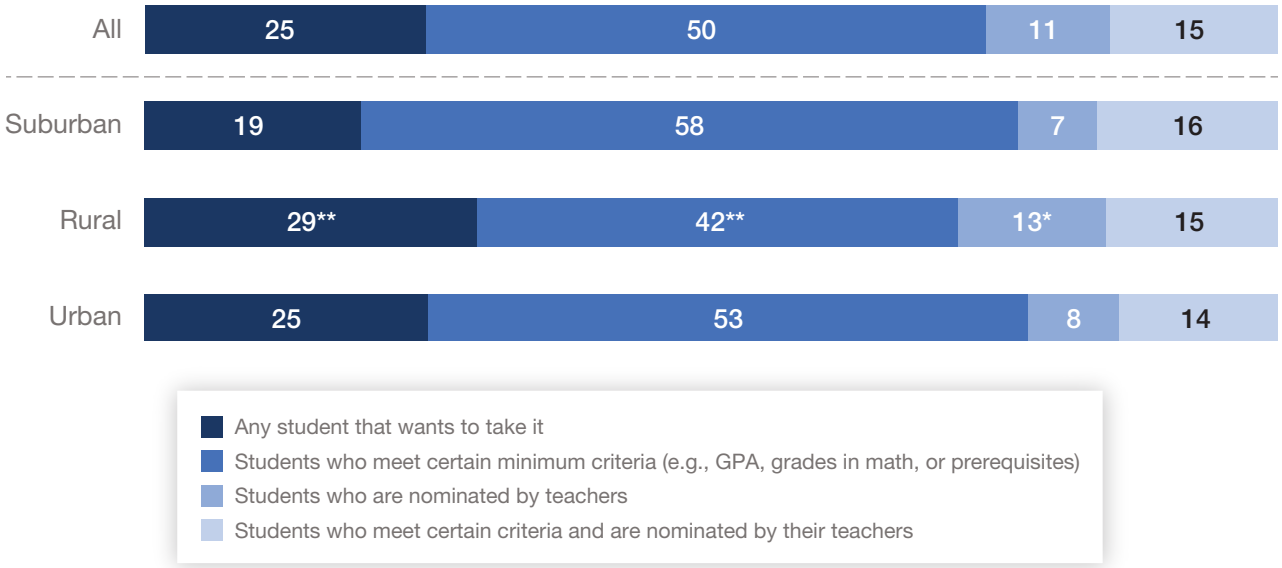
Overall, opportunities to take algebra I before high school were selective. Of those schools with middle grades that offered algebra I, only 25 percent said this course was open to any student who wanted to take it. (In contrast, 80 percent of high school principals said they offered algebra I to any student who wanted to take it.) The remaining principals said they based enrollment on certain minimum criteria (e.g., grade point average [GPA], grades in math, prerequisites), teacher nominations, or some combination of both. Compared with rural schools, suburban schools with middle grades were less likely to offer algebra I to any student who wanted to take it and were more likely to base their enrollment solely on some set of minimum criteria. This difference remained significant when we controlled for all school-level characteristics.

Teachers in Suburban and Low-Poverty Schools Were More Likely to Report That Students in Middle Grades Who Were Already Doing Well in Their Math Courses Were the Group Most Likely to Access Additional Supports to Prepare Them for Advanced Math Than Teachers in Urban, Rural, or High-Poverty Schools

The ability to take and succeed in advanced math courses in high school depends on students having access to the supports they need—such as tutoring—to prepare them for advanced math courses. When we asked teachers with students in middle grades which student group was most likely to receive access to such supports, 43 percent said that all students or students who expressed interest had access to these resources (Figure 6). Although a handful of teachers said these supports went to students who were nominated by a teacher or other staff, most of the remaining teachers were otherwise split: Nearly 20 percent each said that these resources went to either students who were doing well in their math courses or students who were not doing well in their math courses. Among the teachers who selected "other," a

FIGURE 5

Which Middle School Students Are Eligible for Early Algebra I?



NOTE: This figure is based on responses of principals in schools with grades 7 and 8 who said they offered algebra I to the following LTS item: "Do you offer the following math courses at your school, and if so, which students are eligible to take these courses?" (Responses in this figure are the weighted percentages of school principals who said they offered each respective course, $n = 483$.) The findings shown in this table were adjusted for principals who said their school also offers high school grades. Single asterisks (*) indicate that the percentage of principals in rural schools who said they offered algebra I to a certain student group was significantly different ($p < 0.05$) from the percentage of principals in urban schools who said similarly, before controlling for school-level characteristics. Double asterisks (**) indicate that the percentage of principals in rural schools who said they offered a certain course was significantly different ($p < 0.05$) from the percentage of principals in urban schools who said likewise, before and after controlling for school-level characteristics.

large proportion explained that their school did not offer supports to prepare middle school students for advanced courses.

Although teachers were most likely to say that preparatory supports for advanced math could be accessed by all students or students who asked for help, suburban teachers and teachers in low-poverty schools were more likely to report that students who are doing well in their math courses typically get access to tutoring or other supports to prepare them for advanced courses in high school than their counterparts. Teachers in high-poverty schools were more likely than teachers in low-poverty schools to report that students who are not doing well in their math courses typically get access to these resources. These findings suggest that high-achieving students in some areas have differential access to opportunities to prepare for advanced high school courses before they start high school compared with their high-achieving peers in other areas.

Course-Level OTL Is Also Uneven from Kindergarten Through Grade 12

In the above sections, we described how students' access to advanced courses in high school and the opportunities they have in middle school to prepare for advanced courses might differ by school context. In this section, we explore some of the choices K–12 math teachers reported making about the content they covered during the 2021–2022 school year that may contribute to (1) differential levels of preparedness for advanced math courses among students from historically marginalized communities and (2) differential course-level OTL in middle and high schools. Specifically, we examine how frequently math teachers across different school contexts said they skipped standards-aligned content during the 2021–2022 school year and, among teachers that reported skipping standards-aligned content, what content they

FIGURE 6

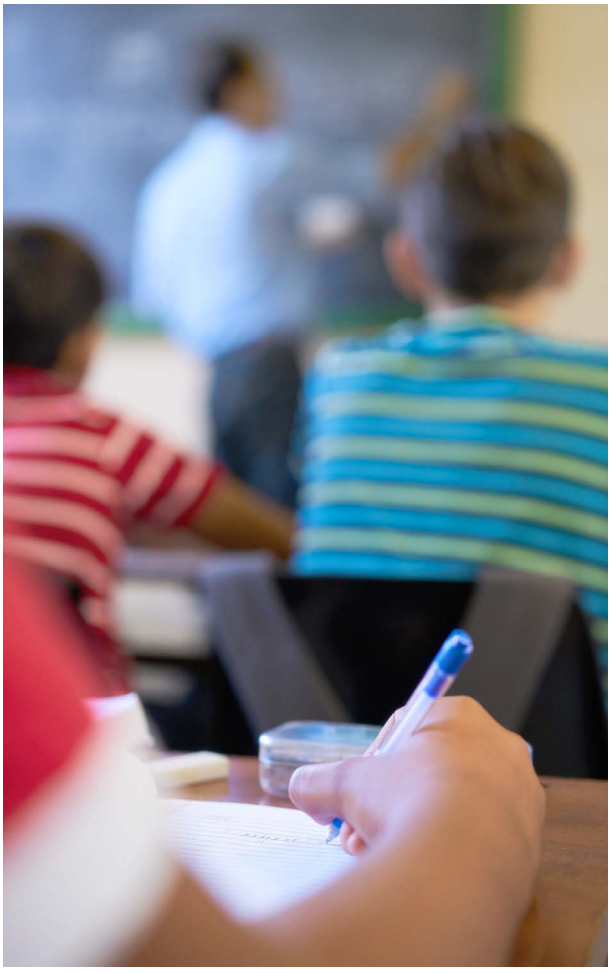
Which Student Group Typically Gets Access to Tutoring or Other Supports in Middle School to Prepare for Advanced Math Before High School?

	All	Locale			Student race/ethnicity		Student poverty levels	
		Urban	Suburban	Rural	Majority SoC	Majority white	High poverty	Low poverty
All students or students that ask for help	43	49	38	45	40	47	37	49
Students who are doing well in their math courses	19	12**	30	12**	17	20	12**	24
Students who are not doing well in their math courses or are at risk of failing	17	22	17	13	21	13	24**	11
Students who are nominated by teachers or other staff	7	5	2	13**	6	8	8	6
Other	15	12	13	17	16	13	19	10

NOTE: This figure is based on the following LTS item to teachers of grades 6 to 8: "Which of the following best characterizes which students at your school typically get access to tutoring or other supports to prepare them for advanced math courses in high school?" (Response choices in this figure are based on weighted percentages of teachers, $n = 269$.) Double asterisks (**) indicate that the percentage of teachers in a subgroup who selected a certain student group was significantly different ($p < 0.05$) from the percentage of teachers in the counter subgroup who said likewise, before and after controlling for school- or teacher-level characteristics. Teachers in suburban schools are the baseline comparison group for both rural and urban teachers. SoC = students of color.

reported teaching in place of the standards-aligned content they skipped.

Some of these findings build on an earlier report we published in spring 2022 based on 2021 LTS data, which we collected from middle and high school math teachers in spring 2021, one year into the COVID-19 pandemic (see Wolfe, Schweig, and Steiner, 2022). Where relevant, we offer findings from our previous report as additional context for teachers' responses in spring 2022 on similar items.



More Math Teachers in High-Poverty Schools Reported Skipping Standards-Aligned Content Occasionally or Frequently Than Teachers in Low-Poverty Schools

In the United States, more than three-quarters of math teachers reported skipping standards-aligned content during the 2021–2022 school year. Although most math teachers who said they skipped standards-aligned content did so only rarely, nearly one-third of all math teachers reported skipping standards-aligned content occasionally or frequently (Figure 7). We cannot quantify the rigor or depth of the grade- or course-level instruction students did receive based

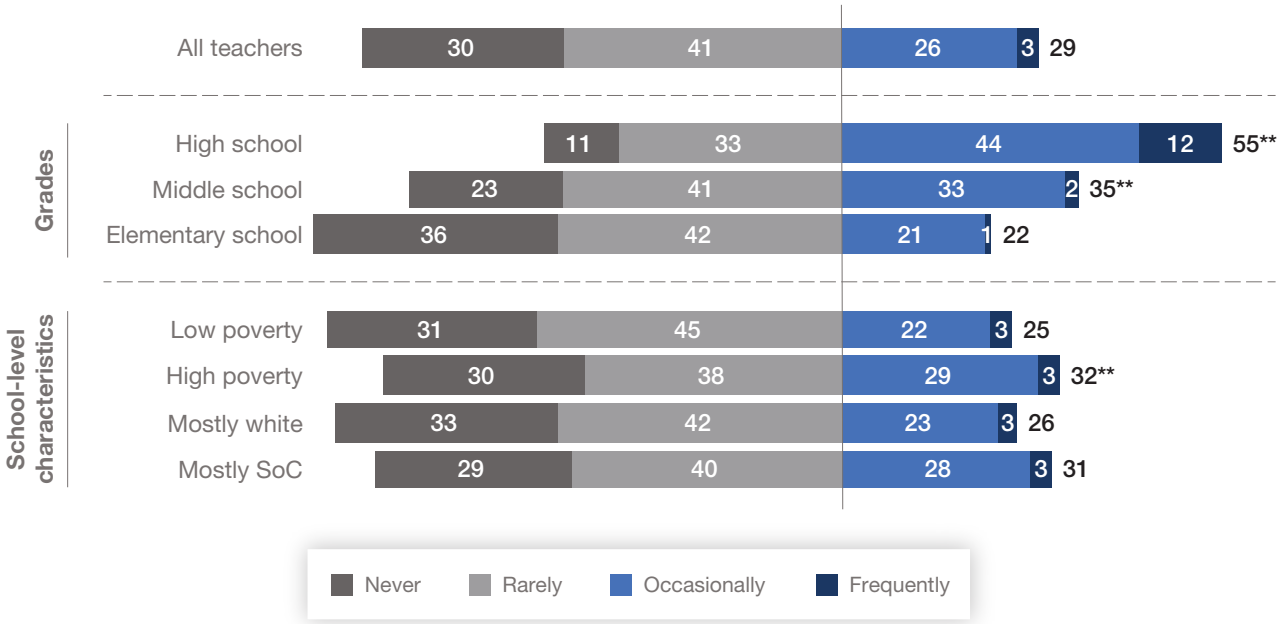
on this survey item; however, we reasoned that teachers who said they skipped standards-aligned content frequently or occasionally likely skipped more content than teachers who said they never or rarely skipped standards-aligned content.

High school teachers were more likely than middle or elementary school teachers to report skipping standards-aligned content occasionally or frequently. Likewise, middle school teachers were more likely to report skipping standards-aligned content occasionally or frequently than elementary school teachers. Fifty-five percent of high school teachers reported skipping standards-aligned content occasionally or frequently compared with 35 percent of middle school teachers and just 22 percent of elementary school teachers. On previous iterations of the LTS, we observed a similar trend between high school and middle school teachers.[7] Together, these findings suggest that as students move into higher grade levels, their exposure to grade- or course-level math content increasingly varies from their peers, depending on their assigned classroom.

There are many reasons why high school and middle school teachers may have reported skipping more content than teachers who teach lower grade levels. For example, on previous surveys, teachers who skipped standards-aligned content reported doing so in order to review or reteach content from prior grade levels and because standards-aligned content does not address basic math skills (Wolfe, Schweig, and Steiner, 2022). We hypothesize that one reason teachers in upper grades may be more likely than teachers in lower grades to skip standards-aligned content is because a higher

FIGURE 7

How Frequently Did Math Teachers Report Skipping Standards-Aligned Content During the 2021–2022 School Year?



NOTE: This figure shows math teachers' responses to the following LTS item: "Do you ever skip standards-aligned math content in your instruction?" Respondents could indicate never, rarely, occasionally, or frequently (Response options in this figure are based on weighted percentages of teachers, n =1,585.) The blue bars to the right of the vertical axis show the percentage of teachers who selected occasionally or frequently. The gray bars to the left indicate the percentage of teachers who selected never or rarely. Double asterisks (**) indicate that the proportion of teachers who selected occasionally or frequently in a subgroup was significantly different ($p < 0.05$) from teachers in the counterpart subgroup, before and after controlling for school- and teacher-level characteristics. Elementary school teachers were the baseline comparison group for high school and middle school teachers. The difference between the proportion of middle school and high school teachers that occasionally or frequently skipped content was also significant ($p < 0.05$). SoC = students of color.

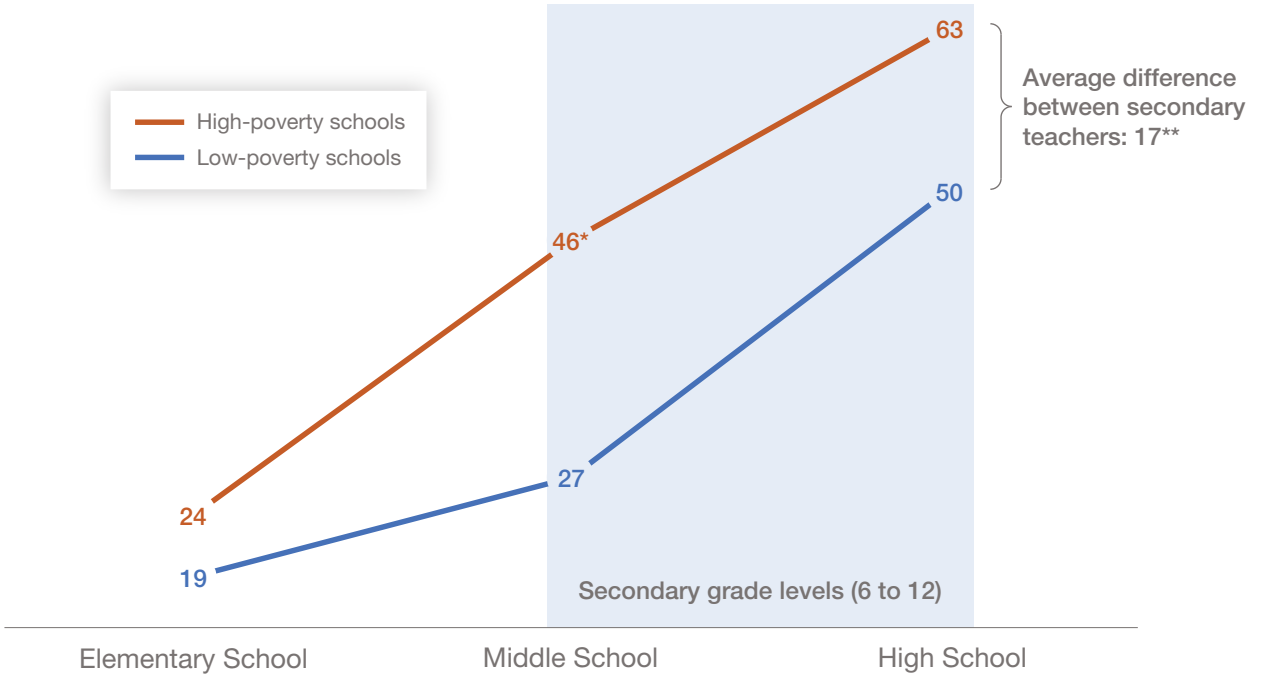
proportion may need to spend more time reviewing foundational content or exploring content at grade level than anticipated by their state standards.

Additionally, secondary teachers tend to rely on different sources of guidance than teachers in primary grades. On our survey, one-half of high school teachers (52 percent) said they decided what content to teach in collaboration with other teachers compared with 36 percent of middle school teachers and 19 percent of elementary school teachers. In contrast, most elementary school teachers (70 percent) said that their districts were the primary decisionmaker about the mathematics content they taught compared with 44 percent of middle school teachers and only 27 percent of high school teachers. Moreover, we know from previous studies that (1) high school teachers are less likely to use textbooks or other curricular materials that are aligned with their state content standards than teachers of other grade levels (Kaufman, Doan, and Fernandez, 2021) and (2) teachers who rely on standards-aligned materials are more likely to implement standards-aligned teaching practices (Kaufman, Steiner, and Baird, 2019).

In addition to the differences we noticed by grade band, teachers in high-poverty schools were also more likely to report skipping standards-aligned content frequently or occasionally compared with teachers in low-poverty schools (Figure 7). The gap between the proportion of teachers in high- and low-poverty schools who reported skipping content occasionally or frequently widens substantially as students move from elementary grade levels into secondary grade levels (Figure 8). Whereas the difference by school poverty level between the percentage of elementary teachers (kindergarten to

FIGURE 8

What Proportion of Elementary, Middle, and High School Teachers Reported Skipping Standards-Aligned Math Content Occasionally or Frequently?



NOTE: This figure is based on math teachers' responses to the following LTS item: "Do you ever skip standards-aligned math content in your instruction?" Respondents could indicate *never*, *rarely*, *occasionally*, or *frequently* (Response options in this figure are based on weighted percentages of teachers, n =1,585.) Single asterisks (*) indicate that the proportion of teachers in high-poverty schools who chose occasionally or frequently was significantly different ($p < 0.05$) from teachers in the counterpart subgroup, before controlling for school- and teacher-level characteristics. Double asterisks (**) indicate that the responses of teachers in high-poverty schools were significantly different ($p < 0.05$) from teachers in the counterpart subgroup, before and after controlling for school- and teacher-level characteristics.

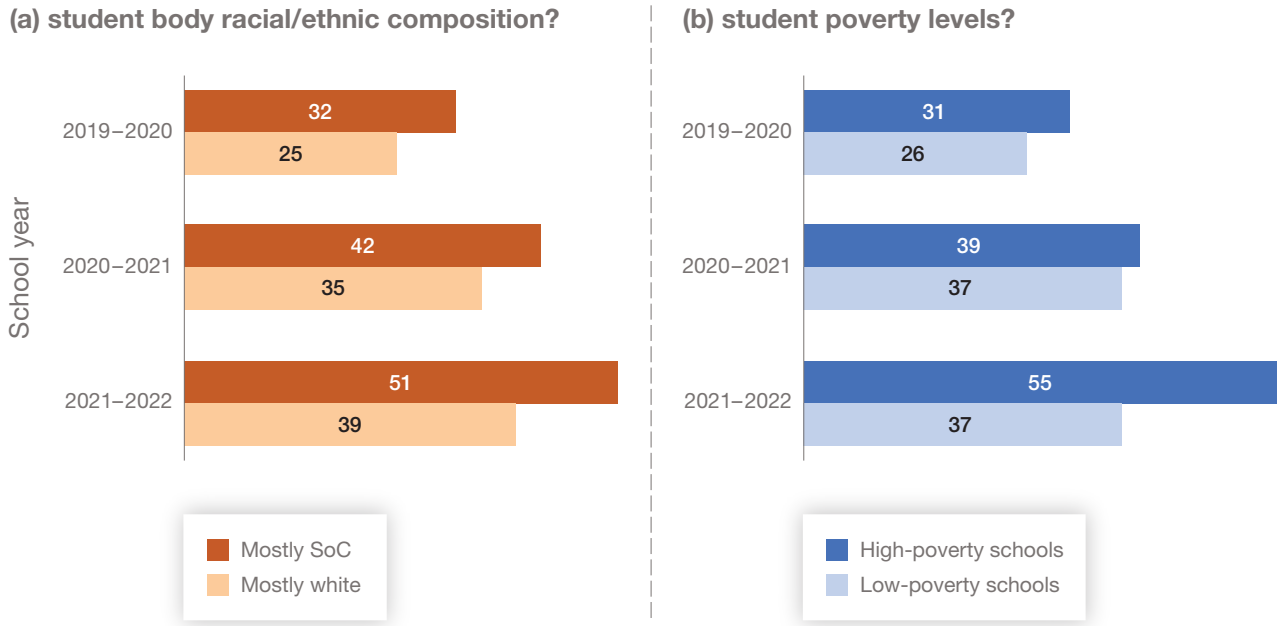
grade 5) who reported skipping content occasionally or frequently was 5 percentage points, the difference between the percentage of secondary teachers (grades 6 to 12) who reported skipping content at higher frequencies averaged 17 percentage points. The proportion of middle school teachers in high-poverty schools who said they skipped content at higher frequency levels was 19 percentage points greater than the proportion of middle school teachers in low-poverty schools who reported skipping content at these levels. This large descriptive difference suggests that middle school could mark the beginning of stark differences in the amount of standards-aligned math content to which students in high-poverty schools are exposed through graduation.

Compared with Previous School Years, a Greater Proportion of Secondary Teachers in High-Poverty Schools and Schools That Serve Mostly Students of Color Reported Skipping Standards-Aligned Math Content at Higher Rates in Spring 2022

In spring 2022, one year after most students had returned to school for in-person learning, a larger proportion of the middle and high school teachers we surveyed in high-poverty schools reported skipping standards-aligned content frequently or occasionally than the teachers in high-poverty schools we surveyed during the previous two years (see Figure 9).

FIGURE 9

What Proportion of Secondary Math Teachers in Spring 2020, Spring 2021, and Spring 2022 Reported Skipping Standards-Aligned Math Content Occasionally or Frequently by…



NOTE: This figure shows the proportion of middle and high school math teachers (i.e., secondary teachers) who reported skipping content occasionally or frequently by (a) student poverty levels and (b) student body racial/ethnic composition in spring 2020 (*n* =790), spring 2021 (*n* = 593), and spring 2022 (*n* = 438) based on the survey item: "Do you ever skip standards-aligned math content in your instruction?" We distributed our spring 2020 surveys just as schools began closing in response to the COVID-19 pandemic. We interpret these results as reflective of a prepandemic context. The displayed percentages were produced using separate weights specific to each survey. Although the cross-sectional comparisons we make between years are useful for describing trends, the weights we employed do not properly account for changes across years or overlap among the sampling pools. Due to rounding, the difference between the proportion of secondary teachers in high- and low-poverty schools during the 2021–2022 school year who reported skipping frequently or occasionally (17.4 percentage points), appears slightly exaggerated by this graph.

$\vec{v} = (-2, 2)$
$\vec{w} = (0, 1)$
$\alpha = \arccos\left(\frac{-2}{2\sqrt{2}}\right)$
$= \arccos\left(\frac{-1}{\sqrt{2}}\right) = 135°$
$\alpha = 135°$
$\vec{v}$

The proportion of teachers in high-poverty schools who reported skipping standards-aligned content at higher frequencies was 16 percentage points greater in spring 2022 than it was for teachers in high-poverty schools in spring 2021 and 24 percentage points greater than it was in spring 2020. In contrast, the proportion of teachers who reported skipping standards-aligned content occasionally or frequently in low-poverty schools did not increase between spring 2021 and spring 2022. We noticed a similar trend between secondary teachers in schools that serve mostly students of color and those that serve mostly white students.

During the 2021–2022 School Year, Teachers in High-Poverty Schools Were More Likely to Replace Grade-Level Content with Content from Prior Grade Levels Compared with Teachers in Low-Poverty Schools

Among teachers who reported skipping standards-aligned content, nearly half said that they typically replaced the content they skipped with content from prior grade levels (Figure 10). Twenty-one percent of teachers who skipped standards-aligned content did not report replacing it with any other additional content, suggesting that they spent more time covering fewer concepts than anticipated by state content standards.

There were some differences by grade band. Middle school teachers were less likely to replace the content they skipped with content outside state standards compared with elementary or high school teachers. High school teachers were less likely than either middle or elementary school teachers to preview content from the next grade level. Compared with elementary teachers, high school teachers were less likely to replace the content they skipped with any additional content.

In addition to skipping standards-aligned content more frequently, teachers who worked in high-poverty schools were more likely to report replacing the content they skipped with content from prior grade levels. Our findings comport with those of a previous study demonstrating that students living in poverty have a higher chance of being assigned to teachers who devote more instructional time to reviewing old content in place of grade-level content (Lambert and Sassone, 2020).

Although this analysis provides simple measures of relative content exposure, which have implications for students' readiness for advanced math, it does not inherently ascribe fault or blame to teachers or students. This is because higher levels of skipping coupled with more time spent on below-grade-level concepts also provides a critical signal about where students may benefit from additional supports, including out-of-classroom supports. It may also reveal opportunities where teachers might benefit from additional resources.

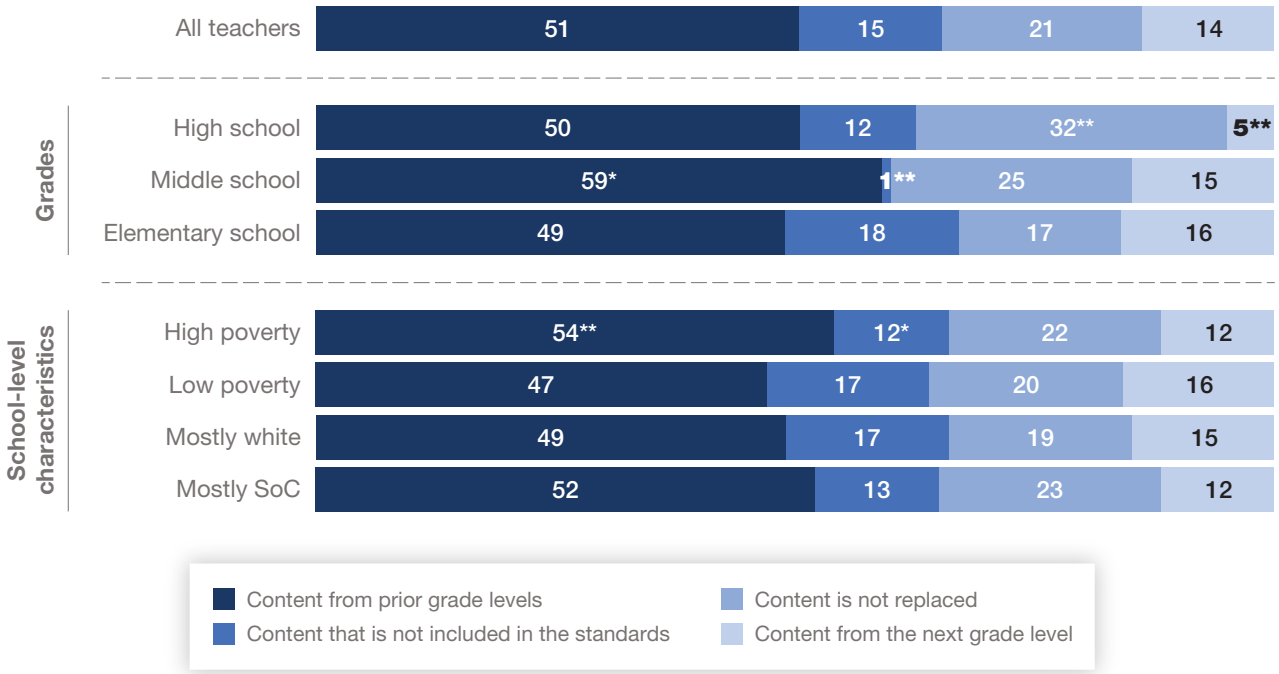
We know that the COVID-19 pandemic disproportionately disrupted the learning of students from economically disadvantaged backgrounds—from the lack of equitable access to technology to its disparate social and economic impacts on families (Goldhaber et al., 2022). Math teachers who support these students have subsequently been left to make up for significant lost ground; many of whom are likely facing a daily dilemma of how much time they should devote to foundational content before moving into grade-level content, especially if their students are not ready.

During the 2021–2022 School Year, Teachers Reported Multiple Challenges to Their Math Instruction

To understand why math teachers were skipping standards-aligned content to review content from previous grades, we examined their expectations for student learning, their perceptions of student preparedness for their courses, whether they felt they had enough time, and the right resources and supports to provide high-quality math instruction. We present these findings next.

FIGURE 10

When Teachers Skip Standards-Aligned Content, What Do They Typically Teach in Place of the Content They Skipped?



NOTE: This figure is based on the following LTS item to math teachers who reported skipping standards-aligned content: "Please select the statement you most agree with: (a) I replace the standards-aligned mathematics content I skip with content from prior grade levels, (b) I replace the standards-aligned mathematics content I skip with content from the next grade level, (c) I replace the standards-aligned mathematics content I skip with content that is not included in the standards, and (d) I do not replace the standards-aligned mathematics content I skip with any other content" (Response options in this figure are based on weighted percentages of teachers, n = 1,134.) Single asterisks (*) indicate that the responses of teachers in a subgroup were significantly different ($p < 0.05$) from teachers in the counterpart subgroup, before controlling for school- and teacher-level characteristics. Double asterisks (**) indicate that the responses of teachers in a subgroup were significantly different ($p < 0.05$) from teachers in the counterpart subgroup, before and after controlling for school- and teacher-level characteristics. Elementary school teachers formed the baseline comparison group for high school and middle school teachers; however, emboldened values were significantly different from both elementary teachers (the baseline group) and the other non-baseline grade band. SoC = students of color.

Very Few Math Teachers Perceived That All Their Students Had the Foundational Skills They Needed to Succeed in Their Math Classes, Especially Teachers in Schools That Serve Students Living in Poverty

Although most teachers expected their students to work hard at math during the 2021–2022 school year and believed that their students could master key math concepts, very few teachers perceived that all their students started the year with the foundational skills they needed to succeed in their math class (Figure 11). This finding is important because, as suggested by previous research, teachers' perceptions of whether their curriculum provides students with an appropriate level of challenge is one of the key determinants of whether a teacher will modify their curriculum (Wang et al., 2021).

Compared with teachers who work in low-poverty schools, teachers in high-poverty schools were less likely to say their students came into their classes with the foundational skills they need to succeed in their class. Of course, this is understandable in the wake of the COVID-19 pandemic because these are the teachers whose students were most profoundly affected by COVID-19–related disruptions (Goldhaber et al., 2022).

Teachers in low-poverty schools were slightly more likely to say that they expected all their students

to work hard at math, that all their students see math as relevant to their futures, and believed that all their students could master key math concepts. We did not observe any other significant differences in teachers' perceptions about students' preparedness and interest in math across student body racial/ethnic composition or locale.

There were some differences by grade level. Specifically, middle and high school teachers were less likely to believe that their students (1) enjoyed learning math (68 percent of elementary teachers compared with 34 percent and 25 percent of middle and high school teachers, respectively); (2) saw math as relevant to their lives (68 percent compared with 46 percent and 33 percent, respectively); or (3) believed they could master key math concepts (67 percent compared with 40 percent and 35 percent, respectively). These comparisons remained statistically significant when we controlled for school- and teacher-level factors. Our results are consistent with some prior research, which suggest a drop in student motivation and interest in learning math in middle school (Pajares and Graham, 1999). However, they may also be indicative of the additional challenges secondary students are experiencing in the face of COVID-19–related learning loss.

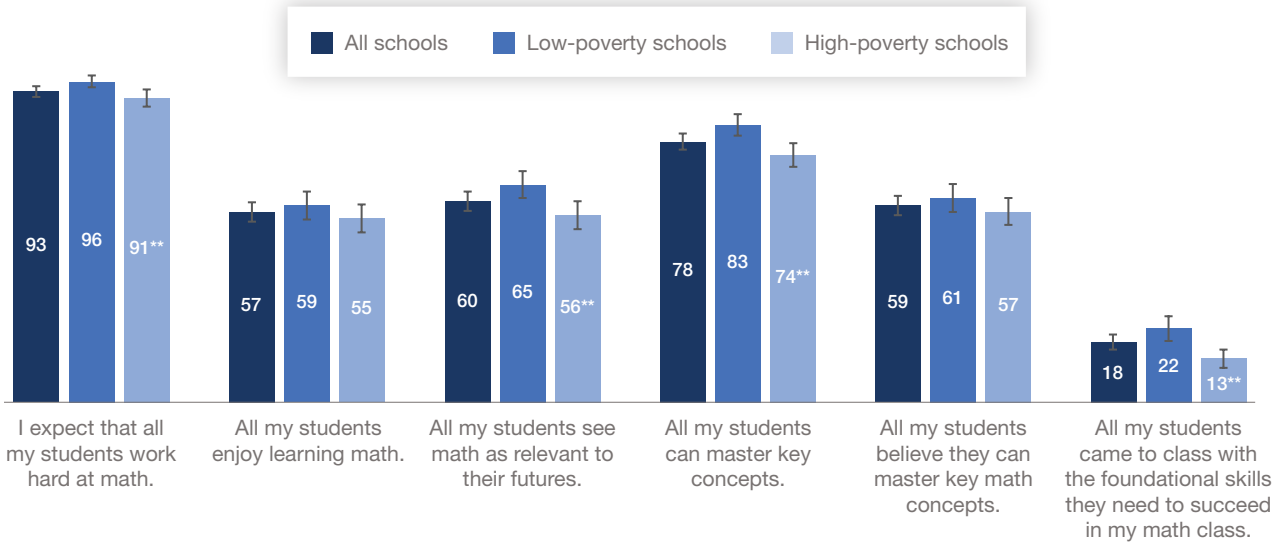
Regardless, the implication is that middle school and high school teachers likely face additional challenges to the delivery of standards-aligned instruction compared with elementary teachers. We hypothesize that teachers who perceive their students as struggling with confidence, not enjoying math, or asking questions about the relevancy of math may also perceive the need to spend additional time finding ways to support their students.

Many Math Teachers Were Not Able to Devote as Much Time as They Would Have Liked to Math Instruction; Nearly Half Said They Needed More Support

About 80 percent of math teachers said they have the curriculum materials and resources and all the tech-

FIGURE 11

What Were Math Teachers' Expectations for Student Learning and Their Perceptions of Students' Preparedness and Math Identity During the 2021–2022 School Year?



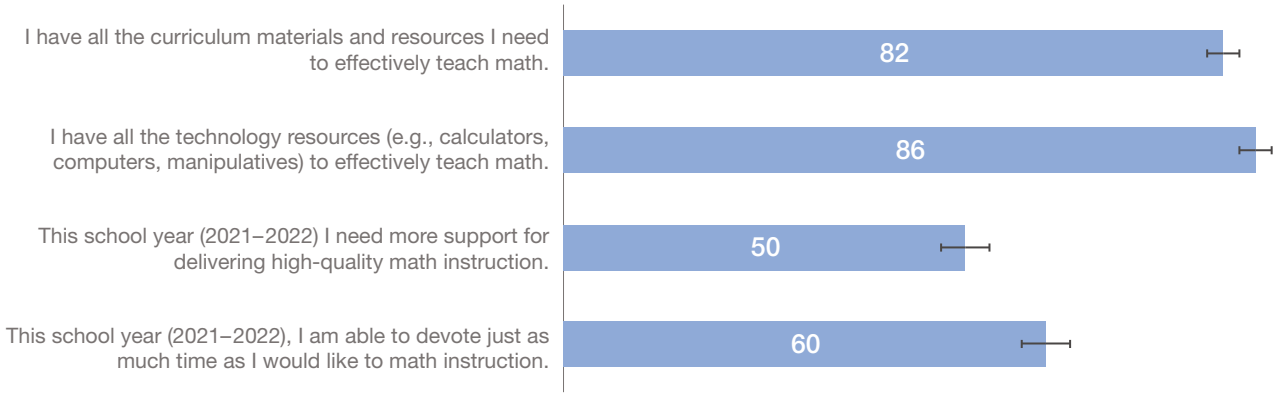
NOTE: This figure is based on math teachers' responses to the following LTS item: "Please indicate your level of agreement or disagreement with the following statements." Respondents could select strongly disagree, somewhat disagree, somewhat agree, or strongly agree. The bars show the proportion of teachers who somewhat or strongly agreed with the selected subitems (response options in this figure are based on weighted percentages of teachers, n = 1,576). Double asterisks (**) indicate that the responses of teachers in a subgroup were significantly different ($p < 0.05$) from teachers in the counterpart subgroup, before and after controlling for school- and teacher-level characteristics. The vertical lines (whiskers) indicate standard error.

nology resources (e.g., calculators, computers, manipulatives) to effectively teach math (Figure 12). Sixty percent of teachers reported being able to devote just as much time as they would like to for math instruction, and half said they needed more support for delivering high-quality math instruction. Although we did not ask teachers specifically how these factors affected their instruction, their responses suggest that a large proportion of teachers may have felt crunched for time or that they were unable to provide high-quality instruction to the extent they would have preferred. These findings are consistent with other research that identified supporting students' academic learning because they have lost instructional time during the COVID-19 pandemic as a top-three source of job-related stress for nearly half of all teachers (Steiner et al., 2022).

Consistent with our findings from the previous section, teachers who worked in high-poverty schools were more likely than their counterparts to indicate they needed additional support for delivering high-quality math instruction (54 percent versus 44 percent).

FIGURE 12

What Did Teachers Say About Their Need for Additional Supports or Resources for Providing High-Quality Math Instruction?



NOTE: This figure is based on teachers' responses to two separate LTS items that began with the same prompt: "Please indicate your level of agreement or disagreement with the following statements." Respondents could select *strongly disagree*, *somewhat disagree*, *somewhat agree*, or *strongly agree*. The bars show the proportion of teachers who somewhat or strongly agreed with each subitem (response options in this figure are based on weighted percentages of teachers, n =1,586). The horizontal lines (whiskers) indicate standard error.

Implications and Recommendations

In this report, we found that high schools that predominantly serve students from historically marginalized populations, high schools in rural communities, and small high schools provided fewer opportunities for students to take advanced math courses. High-poverty schools offered fewer advanced courses overall and were less likely to offer AP math courses. Schools that serve predominantly students of color were less likely to offer calculus. In addition to offering fewer advanced courses, high schools in rural communities were less likely to offer courses in probability and statistics or AP math courses. Small high schools, which are disproportionately located in rural communities, were less likely to offer any of the advanced courses we asked about—including precalculus and calculus. Access to these two courses is especially important because most students who want to major in STEM-related disciplines in college will likely need to take these courses to satisfy their core requirements.

Likewise, urban schools with middle grades, rural schools with middle grades, and schools with middle grades that serve predominantly students of color were less likely to offer algebra I than their counterparts. Schools that offered algebra I tended to be selective about who they enrolled. Although most schools relied on certain criteria to determine enrollment—including GPA, grades in math, or prerequisites—nearly one-quarter of schools also included teacher nominations in this process. This finding could be a cause for concern because scholars consistently find that enrollment procedures based primarily on subjective measures like teacher nominations are a known contributor "to persistent

racial disparities in representation in advanced academic programs" (Schweig et al., 2021).

Unfortunately, research has yet to fully delineate an equitable approach for assigning students to algebra I; however, it seems that a reasonable approach could involve offering this course at all schools with middle grades to students who meet external criteria (e.g., thresholds based on state testing) while also providing intensive supports for those who may struggle. Of course, some students may not be ready for algebra before high school. These students should likewise have access to high-quality opportunities tailored to their learning needs that prepare them for advanced math in high school, even if they do not plan on taking calculus.

Additionally, we found that course-level OTL is likely uneven, especially in the years leading up to advanced math courses (i.e., middle school). Although all students will experience variability in the quality and depth of the math instruction they receive, students living in poverty appear to be systemically less likely than students in economically advantaged communities to be exposed to all the math content standards they are supposed to be learning at grade level across their school careers and more likely to be reviewing content from previous grade levels. Our findings comport with those of other studies that have found that students in low-income communities are likely exposed to less math content at grade level (Schmidt et al., 2015).

We hypothesize that a focus on below-grade-level math may compound over time, which has two consequences for students' cumulative OTL. First, students can only learn the mathematical concepts and skills they have been exposed to. When elementary and middle school teachers skip or replace grade-level content they are intended to cover, their students will lack some of the foundational knowledge required for the next grade level. The more teachers perceive that students are lacking the requisite knowledge and skills for math at grade level, the more likely they will be to replace standards-aligned content with below-grade-level content. This hypothesis is consistent with that from a 2020 TNTP report that found that students living in poverty have a higher chance of being assigned to a teacher who devotes more instructional time to reviewing old content in place of grade-level content (Lambert and Sassone, 2020).

Second, by the time they reach grade 8, students who have been exposed to fewer concepts in kindergarten to grade 7 may be underprepared for algebra I or unable to meet the academic standards required to enroll. That is, if they attend a middle school that offers algebra I. From our data, we observed that the course-level OTL gap appears to widen substantially beginning in middle school among teachers who work in high-poverty schools compared with their counterparts—which is exactly the time when schools should be ramping up preparation for advanced math. Although we cannot tell from our data which schools track students into courses based on their prior performance, this practice often begins in middle school. We know from previous studies that even when students from historically marginalized communities attend schools with advanced courses, they are disproportionately more likely to be tracked into remedial courses where they are exposed to less challenging math content (Berry, 2015).

Math teachers do not bear the sole responsibility for the achievement gap or for gaps in cumulative OTL. Many teachers, particularly those who work in schools that serve predominantly students of color and students living in poverty whose learning was disproportionately interrupted by the COVID-19 pandemic, have worked exceptionally hard to ameliorate COVID-19–related learning loss. Indeed, on our survey, more than half of the teachers who responded said they need additional support for delivering high-quality math instruction, especially teachers who work in schools that serve predominantly high-poverty students.

It is in acknowledgement of this request for support and of the work being done in classrooms every day to support math learning that we make the following recommendations to policymakers and education leaders to guide their decisions about critical resources to increase students' OTL advanced math, particularly for those from historically marginalized communities.

Recommendation 1

School districts should invest federal and state funding into high-dosage tutoring programs for economically disadvantaged middle schoolers. These programs should provide high-quality support to eighth-graders enrolled in algebra I and promote algebra readiness among students not yet enrolled in algebra I.

Math teachers' ability to focus on grade-level content hinges—at least in part—on student readiness. As numerous advocates have explained, high-dosage tutoring is *one of the only* proven interventions with the potential to help accelerate the learning of students whose instruction was disproportionately affected by online and hybrid learning (Kane, 2022; Kraft et al., 2022; Robinson et al., 2021).

Even before the pandemic, students in high-poverty communities were less likely to start high school academically prepared for advanced math (Irizarry, 2021). Now, without intensive and strategic academic supports, middle schoolers from low-income households are especially unlikely to recover the math learning that they missed during two years of disrupted learning (Mervosh, 2022; Kane, 2022). Because of algebra I's central importance in preparing students for success in advanced math and its historical role as a "gatekeeper" class, district leaders should consider creating or expanding the role of the tutoring programs available to middle school students with the goal of preparing them for algebra I, supporting them through algebra I, and helping them transition to high school math.

Because of long-standing inequities, temporarily enhancing access to algebra I in middle school with short-term tutoring is just the start. Although many school districts invested COVID-19 related funding to provide tutoring in the wake of the pandemic, with the expiration of COVID-19 relief funds, some districts are forecasting a "fiscal cliff" that may make continued investment challenging (Diliberti and Schwartz, 2022). School and district leaders need to think creatively about leveraging external partnerships or identifying additional funding to keep high-quality algebra I readiness and support programs permanently in place for the long term.

Recommendation 2

State, district, and school leaders should provide teachers with standards-aligned curriculum materials and high-quality training to support teachers' understanding of which content is essential for future learning.

Many teachers lack centralized guidance about the content they should prioritize and the instructional materials they should use in their classrooms, including access to vetted core curricular materials (e.g., textbooks, online learning platforms). Even fewer have access to curricular materials that are aligned with their state's content standards (Polikoff, 2022). This matters because teachers' knowledge about grade-level content and their ability to engage students in standards-aligned practices are shaped by the guidance or cues they receive from their curriculum.

Providing teachers and school leaders with high-quality standards-aligned curriculum materials—and training to make sure they understand how to use these materials—is a critical step toward helping teachers align their instruction with the intended curriculum. Evidence suggests that statewide promotion of standards-aligned curricular material is associated with increased use of these materials among teachers, a better understanding of content standards, and increased implementation of standards-aligned practices with students (Kaufman, Thompson, and Opfer, 2016; Kaufman, Doan, and Fernandez, 2021).

At the same time, education leaders should be realistic about the challenges imposed on instruction, including the COVID-19 pandemic. If teachers perceive that their core curricular materials are too challenging or not engaging for students, they are more likely to modify or supplement with external content (Wang et al., 2021). Math teachers may be more inclined to use instructional materials that incorporate scaffolds to support student learning, which allow students to "build confidence or that

support students in practicing more concrete or procedural steps before tackling a concept that is more abstract" (Wang et al., 2021). Moreover, education leaders should provide clear guidance on how to bridge grade-level content for students who lack the foundational knowledge and how to increase student engagement.

Recommendation 3

District leaders should work with regional postsecondary institutions to identify creative solutions to making high-quality advanced courses accessible for all high school students, especially those that attend schools in small, geographically isolated, or underresourced communities.

Students who have the potential to succeed in advanced math courses should have access to them. Some research suggests that schools are less likely to offer these courses when they perceive too few students with the requisite levels of prior achievement to justify the expenditure, which is a challenge more commonly experienced in small schools compared with large schools (Iatarola, Conger, and Long, 2011). In other contexts, including schools in southern states, Title I schools, and schools that predominantly serve students of color, the challenge of offering high-quality advanced courses may be compounded by a dearth of qualified math teachers, especially in the wake of the COVID-19 pandemic (Carver-Thomas and Darling-Hammond, 2019). Even before the pandemic, rural schools struggled to recruit and retain high-quality teachers, especially smaller schools with limited resources (Monk, 2007).

District leaders should think creatively about ways to (1) leverage dual enrollment or online learning opportunities and (2) identify opportunities to collaborate with regional universities to create specialized training opportunities for math teachers and credit opportunities for students that bridge the transition from secondary to postsecondary learning in STEM. Moreover, policymakers should create and expand financial incentives—such as higher starting salaries, school loan forgiveness, or scholarship programs—to provide and retain critical staff in high-need areas (Hansen and Feng, 2020; Carver-Thomas and Darling-Hammond, 2019; Podolsky and Kini, 2016).

Recommendation 4

School districts, school leaders, and teachers should provide transparent messaging around the importance of course-taking—the earlier, the better.

Research shows that one of the most important predictors of success in advanced math is parental involvement and expectations (Ing, 2013; Strayhorn, 2010). Research also shows that socioeconomic status is a significant predictor of parent behaviors that may result in a child enrolling in higher-level math courses (Degner, 2013). Indeed many parents, especially those from historically marginalized communities or those who did not complete high school, may be unfamiliar with the long-term benefits of taking advanced math courses. Moreover, the utility of new math course options (e.g., data science) may prove confusing to some families without clear messaging about where these courses lead.

Therefore, it is essential that school districts adopt a systematic approach to educating parents early about the importance of advanced math, provide them with transparent information about where math courses lead, and be able to offer families resources that they can use at home to support their children's interest and learning in math, especially for caregivers whose own experiences in taking math courses were negative. It is critical that parents and caregivers across all demographic categories are equally and optimally situated to help their children make a decision about which math courses are best suited to their goals.

Notes

[1] According to the NAEP, the terms *precalculus*, *statistics*, and *trigonometry* include mathematics courses usually taken after algebra II and before calculus, including such courses as trigonometry, precalculus, mathematical analysis, elementary functions, and probability and statistics (The Nation's Report Card, 2019a). However, the NAEP reports that very few students (3 percent) take a stand-alone trigonometry course. Therefore, we do not include trigonometry in our course sequence model. Elsewhere, the NAEP notes that 39 percent of students earned credits in precalculus, and 17 percent earned credits in a statistics course over the duration of their high school career.

[2] These school size numbers are based on a different cut of points (i.e., 1,000) used in Nowicki (2018) compared with the cut of points in our study (i.e., 450).

[3] Other estimates were as high as 47 percent in 2011. This figure included all students enrolled in algebra I or a more advanced course (Brown Center, 2013).

[4] This report follows Associated Press Stylebook conventions for the capitalization of *Black* and *white* as categories of race. See the "Race-Related Coverage" section of the Associated Press Stylebook and Daniszewski, 2020, for more detail.

[5] The difference could be due to our conceptualization of "any calculus," which includes schools whose principals offer AP Calculus. When we remove schools that said they offered AP Calculus from the "any calculus" responses, the proportion of principals who said they offered calculus dropped to 81 percent—which is closer to estimates from other studies.

[6] We use this terminology to underscore that our analysis looked at course offerings in all schools that offered grade 7 and grade 8, regardless of their configuration (e.g., K–12, K–8, grades 6 to 8).

[7] We have not previously reported this finding.

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About This Report

In this report, we examine how students' opportunities to take and prepare for advanced math courses in the United States differ by school context. We draw on January 2022 surveys of teachers from the American Teacher Panel (ATP), which is a nationally representative sample of more than 22,000 teachers across the United States. The ATP is one of three survey panels that comprise the American Educator Panels, which are nationally representative samples of teachers, school leaders, and district leaders across the country. The panels are a proud member of the American Association for Public Opinion Research's Transparency Initiative. For more information about any one of the survey panels, visit www.rand.org/aep.

For technical information about the surveys and analysis in this report, see *Learn Together Surveys: 2022 Technical Documentation and Survey Results* (RR-A827-9, www.rand.org/t/RRA827-9). If you are interested in using AEP data for your own surveys or analysis or in reading other publications related to the American Educator Panel, email aep@rand.org or visit www.rand.org/aep.

RAND Education and Labor

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