RE-ENVISIONING MATHEMATICS PATHWAYS TO EXPAND OPPORTUNITIES

The Landscape of High School to Postsecondary Course Sequences

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The University of Texas at Austin
Charles A. Dana Center

STUDENT ACHIEVEMENT PARTNERS

ESG Education Strategy Group
ACHIEVING GREATER IMPACT

CONTENTS

EXECUTIVE SUMMARY

For too many students, the misalignment of high school and postsecondary mathematics requirements is an unnecessary barrier to reaching their academic and career goals. Although the nature of careers has evolved over time, mathematics curriculum and instruction have largely remained unchanged in response to the modern landscape. Therefore, some states' postsecondary and K–12 systems have begun to adjust mathematics course sequences to better align to the variety of different fields of study available to students.

For K–12 education, states are grappling with the question of which high school mathematics content all students should have as a foundation and when students should transition to specific courses that will help them specialize their mathematical knowledge and skills for particular fields of study or areas of interest. Understanding the work that states have been doing in this area, what lessons can be learned from that work, and ultimately how to improve systems to better prepare students for success in postsecondary education and careers is prudent.

This report — co-developed by the Charles A. Dana Center, Student Achievement Partners, and Education Strategy Group — includes analyses of states' available middle and high school student course-taking data to examine whether recent high school mathematics pathways reforms have influenced students' mathematics course enrollment. It also examines how students' mathematics course-taking patterns vary within and across states and how state policy levers such as graduation course requirements might be influencing students' mathematics course-taking decisions. The report includes a discussion of recent changes to states' standards and policies for adopting instructional materials as well as updates on the student assessment landscape in mathematics. It also provides lessons learned and guidance from the field as well as recommendations and considerations for strategies to center equity and incorporate data into states' mathematics pathways efforts. Finally, the report includes noteworthy state-specific highlights, mathematics focus group insights, and key questions for additional research.

Key findings from the report include:

- **Course-taking data is not easily accessible and/or available in most states.** Eighteen states were able to provide data on students' progression through mathematics course sequences in middle school and high school, as well as mathematics course enrollment data for 11th and 12th grades. The remaining states cited various reasons for their inability to provide data, including staff capacity, state data request laws, timing, and data formatting issues. Some states also reported that course enrollment data is not collected at the state level.

- In middle school, the percentage of students following a traditional (enrollment in 6th-, 7th-, and 8th-grade mathematics courses), accelerated (completion of Algebra I or higher in 8th grade), or other course sequence varied widely across states. The traditional sequence was the most common. **The median across the states in each sequence in middle school was 64 percent traditional, 28 percent accelerated, and 8 percent other.** In the 11 states that provided data disaggregated by race/ethnicity and other student demographics, White students made up a higher percentage in the accelerated sequence than Black students and students experiencing poverty.

- **In high school, a median of 27 percent of students progressed through the traditional sequence** (completion of Algebra I in 9th grade, Geometry in 10th grade, Algebra II or an equivalent course in 11th grade, and another mathematics course in 12th grade), **13 percent of students followed the accelerated sequence** (completion of Algebra I prior to high school, Geometry in 9th grade, Algebra II or an equivalent course in 10th grade, an additional course in 11th grade, and a fifth mathematics course in 12th grade), and **56 percent of students were in other courses outside of these sequences.**[1]

- **In 27 states, students are required to take three mathematics courses in high school.**[2] **Seventeen states and the District of Columbia require students to take four mathematics courses** prior to graduation. The vast majority of states allow students substantial flexibility with a range of course options that satisfy mathematics requirements.

- States reported **the most common 11th-grade course to be Algebra II or Integrated III;** however, the percentage of students taking these courses varied widely. The median across states was 49 percent. The states with policies requiring students to take four mathematics courses in high school reported the highest percentages of students taking mathematics in 12th grade. States' data revealed students' **12th-grade course selections varied much more than students' 11th-grade selections.**

- An examination of changes to states' graduation requirements in mathematics over the past five years revealed **more flexibility and less specificity for students.** In many states, students have to "opt in" to taking a set of courses that meets the requirements for entering the large, public four-year postsecondary institutions that serve most graduates from their high schools.

- The state policy scan also revealed that **most states have one measure of student proficiency from a state assessment administered at a single point during a student's high school experience,** and most of these measures are not tied to specific courses.

- State mathematics leaders identified different potential barriers to planning and implementing mathematics pathways for students. **Some internal systemic barriers that state leaders identified were related to existing ideologies, structures, and capacity. Some external barriers were related to social contexts, equitable access, and building postsecondary connections.**

INTRODUCTION

The mathematics needed to engage in modern society increasingly relies on data analysis and quantitative reasoning. Yet, high school preparation for postsecondary mathematics remains largely centered on a pathway to Calculus at the expense of a wider array of more relevant (or useful) mathematics (Herriott & Dunbar, 2009).[3] Similarly, "traditional entry-level college mathematics programs fail to serve students well because they comprise disconnected courses whose content is misaligned to students' career and life needs," and the attrition rates are alarming (Liston & Getz, 2019, p. 1). Ample evidence shows that changes to mathematics pathways at the K–12 and postsecondary levels, both in terms of opportunities and content, would benefit students.

REIMAGINING MATHEMATICS IN POSTSECONDARY EDUCATION

In response to these challenges, postsecondary education institutions across the country are re-evaluating the content of their credit-bearing mathematics courses. College Algebra, a course originally intended to prepare students for Calculus, has been the dominant gateway mathematics course in higher education. But that need is no longer relevant. In fact, at most institutions, fewer than 20 percent of students in College Algebra are in programs that require a yearlong calculus sequence (Herriott & Dunbar, 2009). Each year, only 50 percent of postsecondary students pass College Algebra, and fewer than 10 percent of students who pass this course enroll in Calculus (Gordon, 2008). Furthermore, many incoming postsecondary students are placed into at least one developmental mathematics course each year. Of those students placed into developmental mathematics sequences, only 33 percent complete the sequence, and only 20 percent complete a credit-bearing college mathematics course (Bailey et al., 2010). These barriers to degree completion are unfortunate realities at both community colleges and four-year institutions (Liston & Getz, 2019).

To address the outdated requirements and equity barriers to degree completion, postsecondary institutions in many states have overhauled developmental education sequences and implemented mathematics pathways that are better aligned to the different fields of study available to students (Burdman et al., 2018). By 2015, more than half of two-year colleges had redesigned their developmental course sequences to provide students earlier access to college-level or credit-bearing courses. In addition to opening up access to credit-bearing mathematics courses, postsecondary education institutions are implementing corequisite models to support student success in those credit-bearing courses. Mounting evidence shows that a large majority of students, including those referred to developmental mathematics, can succeed in accelerated college-level mathematics courses at higher rates and in less time compared to students in traditional developmental sequences (Bailey et al., 2010; California Acceleration Project, 2015; Complete College America, 2016; Logue et al., 2016; Rutschow & Diamond, 2015; Sowers & Yamada, 2015; Tennessee Board of Regents, 2016).

Additionally, higher education institutions have shifted away from College Algebra for all to mathematics gateway courses related to students' majors and intended career fields (Blair et al., 2018). Growing evidence shows that when students engage with mathematics that is relevant to their programs of study, they are more motivated and more likely to succeed (Rutschow & Diamond, 2015). Students who take content-specific mathematics courses (e.g., social science statistics, quantitative reasoning mathematics-based courses for Humanities majors) are more motivated, earn higher grades, and are less likely to fail the course (Rutschow & Diamond, 2015).

IMPLICATIONS OF REIMAGINING K–12 MATHEMATICS

As postsecondary institutions across the country expand their offerings in credit-bearing mathematics coursework and strive to remove other barriers, what do these changes mean for K–12 mathematics? The reality is that the most common high school mathematics sequences in the United States — referred to as the "geometry sandwich" by Steven Levitt — still consist of Algebra I, Geometry, and Algebra II, with the goal of putting students on a path to Calculus (2019). The focus on Algebra II, Precalculus, and Calculus persists despite research suggesting that fewer than five percent of workers and a smaller percentage of community college students actually use the mathematics from these later courses (National Center on Education and the Economy, 2013). Additionally, research for this report shows that students traverse through the "geometry sandwich" and courses after Algebra II in more varied sequences than this linear progression suggests, but K–12 systems are designed with this assumption. According to the group Just Equations, the emphasis on Algebra II in high school can be primarily attributed to admissions requirements at colleges and universities rather than a need for students to master the content taught in the course (Burdman, 2019). One of the driving incentives for updating high school mathematics is simply that "our schools do not teach what their students need, while demanding of them what they don't need" (National Center on Education and the Economy, 2013).

One effort to increase mathematical opportunities for students and bridge the gap between higher education and K–12 in mathematics is being led by The University of Texas at Austin's Charles A. Dana Center (Charles A. Dana Center, 2020). This initiative, called the Launch Years, is directly aimed at improving mathematical learning opportunities for all students in high school and better aligning high school mathematics with students' postsecondary and career aspirations. Ultimately, Launch Years seeks to dismantle systemic barriers that have disproportionately limited equitable access, particularly for students who are Black, Hispanic, or experiencing poverty, to the high-quality and relevant mathematics courses needed to succeed in today's workforce and postsecondary education and training.

Access to clearly defined mathematics pathways is critical to ensure that all students and families have the option and information to select the mathematics courses that best align with students' college and career plans. States are in varying stages of redesigning high school mathematics pathways and course offerings, but there has yet to be an analysis of how state policy conditions and higher education requirements influence mathematics pathways implementation and students' course selections. As efforts to revise mathematics education in K–12 and higher education continue across the country, Education Strategy Group (ESG), the Charles A. Dana Center, and Student Achievement Partners (SAP) sought to benchmark how states are attending to related mathematics policies such as aligned standards and assessments, graduation expectations, and postsecondary transitions.

Defining Mathematics Pathways

The term "pathways" has different meanings across states and parts of the education system. For the purposes of this report, a mathematics pathway is a mathematics course or sequence of courses that students take to meet the requirements of their program of study. Mathematics pathways enable students to take different paths through the mathematics curriculum, making the mathematics students learn relevant to their programs of study and careers.

This report includes analyses of states' middle and high school student course-taking data that offer an early look at whether high school mathematics pathways reforms have influenced students' mathematics course enrollment. Lessons learned from focus groups with state mathematics leaders in various stages of implementing mathematics pathways provide guidance from the field. Finally, a set of recommendations and considerations are included to provide states with strategies to center equity and incorporate data into their mathematics pathways efforts.

MATHEMATICS STANDARDS AND INSTRUCTIONAL MATERIALS

To fully realize the goal of revising mathematics pathways for learners, education leaders must think about the practical implementation of pathways and existing state policy structures. State policies such as those guiding standards revisions and those designed to support district adoptions of high-quality instructional materials are two key related policies examined in this report.

A review of states' mathematics standards found that nearly a third of states (16 states) last reviewed or adopted their mathematics standards in 2012 or earlier. In 26 states, mathematics standards were last reviewed/adopted between 2013 and 2020. Nine states reviewed their mathematics standards in 2021 or are currently in the process of reviewing their standards. These states include Georgia, Idaho, Minnesota, Oklahoma, Oregon, Rhode Island, Tennessee, Virginia, and Wisconsin.

As states review, revise, and adopt new mathematics standards, and as they think about how the standards are organized into courses and pathways in middle and high school, districts and schools must review and update the instructional materials that teachers use to guide students' learning of the standards. High-quality curricula are a key component for supporting student learning (Ed Reports, n.d.). In most states, local education agencies (LEAs) decide which instructional materials will be used in their schools, but this review found a range of state approaches to supporting LEAs' decisions. On one end of the continuum, each LEA independently researches and decides which curricular materials to purchase with no guidance from the state education agency. On the other end of the continuum, states require LEAs to select textbooks from a state-approved list. Between these two extremes are differing degrees of state and LEA choice and responsibility. For example, Tennessee's State Textbook and Instructional Materials Quality Commission recommends an official list of textbooks and instructional materials, but LEAs may submit a waiver request if they wish to use textbooks or instructional materials that are not on the approved list. Massachusetts convenes panels of educators to review and rate evidence on the quality and alignment of specific curricular materials and then publishes their findings to support local decision-making processes (Massachusetts

Department of Elementary and Secondary Education, n.d.). The state also provides incentives, including statewide master service agreements for approved materials, that make these materials easier for districts to procure. Finally, the Massachusetts Department of Elementary and Secondary Education collects and publishes information about the curricular materials that are in use in districts and displays this information on a map.

In October 2021, the **Oregon** State Board of Education adopted the Oregon Mathematics Standards. Key revisions from the previously adopted mathematics standards included adding a K–12 data reasoning domain; merging measurement content with geometry content; revising the K–12 domains to reflect the learning pathways of Algebraic Reasoning, Numeric Reasoning, Geometric Reasoning & Measurement, and Data Reasoning; and identifying a core two-course requirement in high school that aligns to the Oregon 2+1 course design. Additional resources such as standards-level guidance documents, learning progressions, and crosswalks to the previous standards have been developed (Oregon Department of Education, n.d.).

MATHEMATICS COURSEWORK

Every mathematics education system decides what content is foundational for all learners and what content is better suited to prepare students with particular interests (e.g., a path toward science, technology, engineering, and mathematics [STEM] professions may diverge from others). The mathematics courses and course sequences students take may look relatively similar in middle school, but they often diverge in high school. They then may diverge even further in postsecondary education depending on a student's program of study and interest.

States are grappling with the pivotal question of if and when high school student course sequences should branch in mathematics. That is, should students stop taking the core mathematics that all students need as a foundation for higher-level mathematics and start taking courses that help them specialize their mathematical knowledge and skills for a particular field? And if so, when should they make that switch? Some states have decided to branch after the second year and some after the third year. Some states have decided to branch after Algebra II specifically, citing concerns about district capacity to offer multiple mathematics courses in the third and fourth year and concerns about equitable access to those courses. States including Georgia and Washington have instead chosen to add more mathematics content to Algebra II, such as modeling, statistics, and foundational concepts for data science. This approach to modernize Algebra II is meant to better prepare students for any course they choose to take following the third year of high school mathematics.

Upon learning content typically taught in Algebra II or an equivalent course, students have built the mathematical foundation to be successful in Statistics, Quantitative Literacy, and Precalculus or similar courses.[4] Rather than aiming for everyone to complete mathematics course sequences in preparation for Calculus, students should instead have opportunities to engage in high-quality mathematics experiences that better align to their desired program of study — or at least a broad category of programs. For example, a student may not know their exact major but be most interested in the social sciences, criminal justice, and psychology — all of which benefit from courses in statistics. On the other hand, the natural sciences, mathematics, and engineering benefit from courses on the path to Calculus. Given this changing landscape, students deserve the opportunity to access the courses that best prepare them for success in postsecondary requirements and to start on the mathematics pathway that best prepares them for their career aspirations while still in high school.

KEY TAKEAWAY

Although consensus on the best approach to designing mathematics pathways or the best way to branch course sequences is not universal, states should first gain a deeper understanding of the mathematical expectations of employers and postsecondary institutions. With this understanding, states can assess the mathematics content of current courses and sequences to ensure greater alignment with postsecondary education and workforce requirements. Creating mathematics opportunities aligned with college and career expectations can help counselors and families assist students with enrolling in mathematics courses that are aligned with their college and career aspirations.

Some states have been engaged in implementing mathematics pathways in higher education for more than 10 years. Mathematics pathways in higher education aim to ensure that students take the mathematics course(s) required for their program of study starting in their first year of postsecondary education and are able to more quickly access credit-bearing mathematics courses rather than trudging through long sequences of developmental mathematics courses. The shift in higher education from most students, regardless of their major, being required to take a gateway course in the path to Calculus — typically College Algebra — to taking the course that best prepares them for the content of their program and ultimately their career has implications for high school mathematics education as well.

Approximately 20 states have worked to better align K–12 mathematics, especially at the secondary level, with changes in higher education. In Arkansas, for example, higher education state leaders worked with faculty across the state to define postsecondary mathematics pathways (Charles A. Dana Center, n.d.). The Arkansas Division of Higher Education made recommendations for which programs should require College Algebra and which should require Quantitative Literacy based on a survey of faculty across disciplines. The changes in higher education prompted leaders from the Department of Elementary and Secondary Education to create a Math Alignment Task Force. Through the work of state leaders and this task force, the number of students taking Quantitative Literacy in high school has steadily increased over the past three years. Currently, 18 percent of 12th graders and three percent of 11th graders in Arkansas are enrolled in Quantitative Literacy. Arkansas leaders have also convened K–12 and higher education faculty to improve the alignment of the high school Quantitative Literacy course to the college-level course. Regional task forces of higher education and K–12 educators across the state worked to draft goals and recommendations to expand the implementation of mathematics pathways in K–12 districts and will implement the recommendations in the 2022–23 school year.

Regardless of postsecondary pursuits, students need access to high-quality mathematics courses and instruction throughout their elementary, middle, and high school education. This research sought to reveal how students are progressing through mathematics course sequences in middle and high school. It also examined whether students are taking 11th- and 12th-grade courses aligned to postsecondary mathematics pathways, whether enrollment in particular courses varies across different student demographic groups, and what policies and practices might influence students' course-taking patterns. The goal of this research effort was to understand how students' course-taking patterns vary within and across states, how state policy levers such as graduation course requirements might be influencing students' course taking, and ultimately how to improve systems to best prepare students for success in postsecondary education and their career aspirations.

BACKGROUND ON STATE DATA COLLECTION AND SUBMISSION

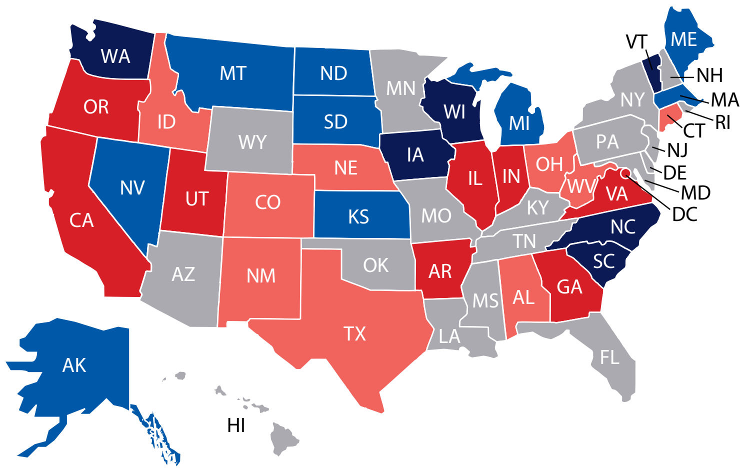
For this report, states were asked to submit data on students' progression through mathematics course sequences in middle school and high school, as well as mathematics course enrollment data for 11th and 12th grades. The data specifically focused on enrollment in courses and not students' success. See the Appendix for the data template sent to states and the methodology used in the data request process. The template and research assumed that states have data systems with varying capacity to pull the requested data and varying staff capacity to provide the data in the given timeframe. The years of the submitted data vary from state to state and are based on the most recent high school cohort with the most comprehensive data available.

Two categories of data were requested from states:

- The first category was course sequence data in middle school and high school. The goal was to gather data on what percentage of students progressed through particular sequences of mathematics courses and understand differences within and across states.
- The second category of data requested focused specifically on the distribution of students across 11th- and 12th-grade mathematics courses. The goal was to learn whether students were taking mathematics in these grades, which courses students were taking, and whether there were differences across states and across student groups.

Communication between the research team and various state agency staff began in December 2021 and continued through April 2022 to gather the data, revise the data request to align with data system and staff capacity, and learn why states were not able to provide the mathematics pathways data during this time period. States fell into one of five categories based on whether or not data is included in this report.

Figure 1: Number of States That Submitted Course-Taking Data



ALL DATA SUBMITTED: NINE STATES (Arkansas, California, District of Columbia, Georgia, Illinois, Indiana, Oregon, Utah, and Virginia) submitted all requested data, including data disaggregated by student groups.[5] Few states had systems in place that allowed them to examine data related to cohort course-taking sequences.

SOME DATA SUBMITTED: NINE STATES (Alabama, Colorado, Connecticut, Idaho, Nebraska, New Mexico, Ohio, Texas, and West Virginia) submitted some of the requested data; their data included mathematics course enrollment data for 11th and 12th grades and in some cases 8th grade.[6] Four of these states (Alabama, Nebraska, Texas, and West Virginia) were able to provide data disaggregated by student group — race/ethnicity, students with disabilities, English learners, and eligibility for the National School Lunch Program.

SUBMITTED RELATED DATA: SIX STATES (Iowa, North Carolina, South Carolina, Vermont, Washington, and Wisconsin) provided related course-taking data (e.g., as part of a state public report) but not in the format of the provided template that could be used for this analysis.

DATA NOT AVAILABLE: NINE STATES (Alaska, Kansas, Maine, Massachusetts, Michigan, Montana, Nevada, North Dakota, and South Dakota) either did not collect the course enrollment data requested or were unable to run the necessary reports to compile it in the way requested without excessive staff time devoted to the data assembly.

STAFF CAPACITY, TIMEFRAME, OTHER: Data from the remaining **18 STATES** (Arizona, Delaware, Florida, Hawaii, Kentucky, Louisiana, Maryland, Minnesota, Mississippi, Missouri, New Hampshire, New Jersey, New York, Oklahoma, Pennsylvania, Rhode Island, Tennessee, and Wyoming) is not included in this report, but the data may be available through future requests. The most common reason given was staff capacity devoted to other pressing priorities during the given timeframe — for example, a state legislative session or federal data reporting requirements. Other reasons for not being included are state data request laws that do not allow the state to fulfill the data request, difficulty in getting the request for data in the right format to the right staff member to consider the request in the given timeframe, or no stated reason (which could include that the requested data is not collected at the state level).

MIDDLE SCHOOL MATHEMATICS

The mathematics courses states expect students to complete as part of their middle school experience are relatively standardized and stable across states. Federal law requires students to be tested in mathematics at the end of 6th, 7th, and 8th grades. Students' middle school mathematics courses are important for positioning students to complete secondary, and eventually postsecondary, mathematics pathways.

MIDDLE SCHOOL COURSE SEQUENCES

States were asked to provide data on students' course sequences in 6th, 7th, and 8th grades. Researchers wanted to learn more about which students were taking grade-level 6th-, 7th-, and 8th-grade mathematics sequences and which students were taking something more or less accelerated. Researchers also wanted to know whether certain student groups were overrepresented or underrepresented in particular course sequences. Middle school course sequence data was broken into three categories — traditional, accelerated, and other.

- The traditional course sequence is defined as students taking 6th-, 7th-, and 8th-grade mathematics courses in those grades.
- Students who progressed through an accelerated sequence took Algebra I or above, including Geometry or Algebra II, in 8th grade.
- Other course sequences include sequences that students took that differ from the ones described in traditional or accelerated (e.g., students repeated a course or courses, students took a mathematics course under special education services).

Few states had systems in place that allowed them to provide data related to cohort course-sequencing data, which requires following a cohort of students across several grades based on the mathematics courses they took. Twelve states (Alabama, Arkansas, California, District of Columbia, Georgia, Illinois, Indiana, Oregon, South Carolina, Texas, Utah, and Virginia) provided this data. In the case of the District of Columbia and South Carolina, their data is included in this set based on 8th-grade course enrollment rather than following a cohort from 6th through 8th grade.

States reported a wide range in the percentage of students following each sequence. The traditional sequence was the most common, with anywhere from 49 percent to 84 percent of students following this sequence across different states. States reported a range from three percent to 50 percent of students following an accelerated middle school course sequence. The range in the percentage of students who did not follow either of these sequences ("other") varied from zero percent to 38 percent across states. The median across the states in each sequence was 64 percent traditional, 28 percent accelerated, and 8 percent other.

Table 1: Percentage of Students in Each State That Progressed Through Middle School Mathematics Course Sequences

COURSE SEQUENCE	RANGE	MEDIAN
Traditional Middle School	49%–84%	64%
Accelerated Middle School	3%–50%	28%
Other Middle School	0%–38%	8%

Notably, the states with the lowest percentages of students completing other course sequences were Arkansas (less than one percent), Texas (less than one percent), and Virginia (less than three percent). Virginia also reported the highest percentage of students in the accelerated sequence at 50 percent of students. The percentage of 8th-grade students taking Algebra I or higher in middle school is one of the performance measures for the current Virginia Board of Education Comprehensive Plan (Virginia Board of Education, 2017). In Virginia, all middle schools are required to offer Algebra I. In addition, the state's Algebra Readiness Initiative provides funding to every school district to address readiness for Algebra I in middle school (Virginia Department of Education, n.d.).[7]

Student Subgroup Results

In the 11 states (Alabama, Arkansas, California, District of Columbia, Georgia, Illinois, Indiana, Oregon, Texas, Utah, and Virginia) that provided data disaggregated by race/ethnicity and other student demographics in middle school, White students made up a relatively higher percentage in the accelerated sequence. Black students and students experiencing poverty made up a lower percentage of the students in the accelerated sequence as compared to the traditional or other sequences. Hispanic students in each state most often made up a lower percentage of the students in the accelerated sequence. In Georgia, Hispanic students made up a slightly higher percentage of the students in the accelerated sequence (18 percent) than in the traditional sequence (17 percent). This data point is worth noting given that Georgia is an outlier from other states and also should not diminish the urgency needed to address equitable access to an accelerated pathway.

For Additional Research

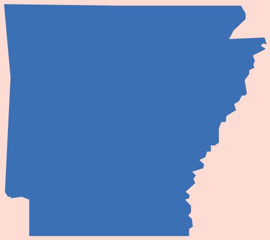
Why are middle school students taking courses other than the 6th-, 7th-, and 8th-grade mathematics sequence or something more challenging? How do middle school courses affect high school and postsecondary courses? State-level data most certainly masks district and school differences in course-taking patterns. States able to generate this data should take a closer look to determine how course-taking patterns vary by district, school, and student groups within their states.

HIGH SCHOOL MATHEMATICS

Most states require three or four years of mathematics in high school. Students who take Algebra I in 9th grade and who have learned the content that is commonly found in Algebra I, Geometry, and Algebra II or an equivalent course are well positioned to access college-level courses (if available) in high school. Furthermore, taking a third year of mathematics that includes most of the content found in Algebra II in many cases means that students are prepared to take a college-level Quantitative Literacy, Statistics, and Precalculus courses. States should encourage and support districts to provide students access to college-level courses (i.e., through dual credit, Advanced Placement, or International Baccalaureate) in high school.

State policies for high school mathematics requirements differ in the number of graduation options available to students, the number of courses required, and the content of those courses. In all states, the state sets the graduation minimum; districts, schools, and students may supplement the state minimum with additional coursework or experiences, though this flexibility assumes that students know which courses and experiences they need to be successful in preparing for their postsecondary goals (e.g., two- or four-year college, technical training, apprenticeship, or the military) and that students are able to access these courses and experiences. Students may face barriers in accessing rigorous coursework, especially if the courses are not required by the state (U.S. Department of Education Office of Civil Rights, 2018).

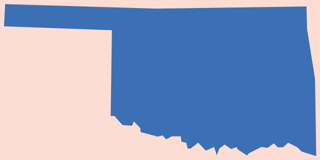
To ensure that students have access to courses, **Arkansas** has a list of 38 required courses that must be offered in high school. For mathematics, four of the courses schools must offer include Algebra I, Geometry, Algebra II, and Precalculus. Schools must also offer two of the following courses: Advanced Topics and Modeling in Mathematics, Algebra III (Transitional), Calculus, Statistics, Quantitative Literacy (Transitional), Transitional Math Ready (Transitional), and Technical Math for College and Career. At least one Advanced Placement course and one transitional course from this content area must also be offered (Arkansas Division of Elementary and Secondary Education, 2021).



Number of Graduation Options

Some states offer a single option for graduation while others offer several diploma options. Nationally, states offer more than 115 different high school graduation options for students, an increase from the 95 high school graduation options available for the class of 2015. These graduation options may take many forms, including endorsements, seals, or distinct diplomas. High school graduates in 18 states had three or more paths to graduation in 2022. Eleven states offered two paths to graduation, and 21 states and the District of Columbia had one state-defined path to graduation in 2022. As states continue to offer students more options, it is crucial that they take the necessary steps to ensure that these options lead to quality postsecondary opportunities — whether at a two-year college, four-year college, technical school, etc. The analysis that follows focuses on the graduation requirements that students — absent any action on their part — are expected to complete. In other words, these are the "default" graduation expectations for students.

Oklahoma defaults students into its College Ready/Work Ready curriculum but allows students to "opt out" with parental consent into the Core curriculum. The consent letter is transparent and direct: "The Core curriculum does not meet college entrance requirements, nor requirements for the Oklahoma's Promise scholarship available to students whose family income is $55,000 or less annually and who earn a 2.5 GPA in the college preparatory/work ready curriculum."



KEY TAKEAWAY

States should communicate the benefits and potential drawbacks of specific graduation options. These choices, made in early high school and even in middle school, may affect students' college admissions and scholarship eligibility. Students and families need clear communications about the ripple effects of decisions to choose one pathway over another.

States can make better policy and practice decisions — and ultimately improve student outcomes to achieve equitable results across student groups — when they have information about how students are doing. Understanding whether a student enrolls and succeeds in specific high school course sequences is one key measure for informing adjustments along the way to ensure that the student is ready for the next steps after graduation. Moreover, if states are investing in reimagining mathematics pathways, they must understand the courses students are actually enrolling and succeeding in.

HIGH SCHOOL COURSE SEQUENCES

For this analysis, states were asked to submit the percentages of students completing traditional, accelerated, and other course sequences in high school.

- The traditional high school sequence includes Algebra I in 9th grade, Geometry in 10th grade, Algebra II or an equivalent course in 11th grade, and another mathematics course in 12th grade.
- The accelerated high school sequence includes Algebra I prior to high school, Geometry in 9th grade, Algebra II or an equivalent course in 10th grade, an additional course in 11th grade, and a fifth mathematics course in 12th grade. For both the traditional and accelerated sequences, Integrated I, II, and III are treated as Algebra I, Geometry, and Algebra II or an equivalent course for categorization purposes.[8]
- The other high school sequences include any sequence of courses that students took that differ from the traditional and accelerated sequences. This category includes "super accelerated" students who took Algebra II in 9th grade. Students who did not take mathematics in 12th grade are also part of the other category. This report goes into greater depth in subsequent sections about whether or not students took mathematics in 11th and 12th grade and provides analysis of which mathematics courses students typically took.

Based on data from nine states (Arkansas, California, District of Columbia, Georgia, Illinois, Indiana, Oregon, Utah, and Virginia), a median of 27 percent of students progressed through the traditional sequence, 13 percent followed the accelerated sequence, and 56 percent were in other courses outside of these sequences. Of the states that were able to compile and submit this data for the report, the percentage of students in each of the sequences varied widely. Note especially that states reported a range of zero percent to 74 percent of students who took courses in a sequence outside of the traditional or accelerated sequences as defined by this report.

In the data request, researchers attempted to further break down the percentage of students who are captured in the table below in the other category. For example, researchers requested the percentage of students who took the traditional high school and accelerated high school sequences through 11th grade but then did not take mathematics in 12th grade. Unfortunately, this and other sequence descriptions that would have provided more information as to the variation between states in the other sequence category were either not possible to parse out in data systems or otherwise represented in ways that were not comparable across states.

Table 2: Percentage of Students in Each State That Progressed Through High School Mathematics Course Sequences

COURSE SEQUENCE	RANGE	MEDIAN
Traditional High School	13%–88%	27%
Accelerated High School	3%–29%	13%
Other High School	0%–74%	56%

Of the states that submitted high school course sequence data, Georgia and Arkansas had the highest percentage of students taking the combined traditional and accelerated sequences at 100 percent and 92 percent, respectively. In other words, these states had few students taking other course sequences. From a policy perspective, one reason may be that both states require students to take four mathematics courses in high school, and while students have some flexibility in which courses they take, the state's expectation is that students will complete at least an Algebra I, Geometry, and Algebra II (or Mathematics I, II, and III) sequence. From a practical perspective, Arkansas and Georgia have both built robust statewide course code management systems that assist them in understanding which students are taking which courses. Generally speaking, states reported that Black and Hispanic students and students who are eligible for the National School Lunch Program made up a higher percentage of the traditional sequence than the accelerated sequence. For White students, it was the reverse. Furthermore, the students eligible for the National School Lunch Program in most cases had the biggest difference in representation from traditional to accelerated sequence.

For Additional Research

An original assumption of this research effort was that the findings would help make the case that in states where students are required to take courses X, Y, and Z, students in fact take courses X, Y, and Z. Or it would make the case that states with policies that allow for students to choose a third- or fourth-year mathematics course that aligns with their postsecondary and career goals would be able to provide data on which students were choosing which courses. Unfortunately, many states' data systems were either not able to follow students' course-taking sequences or the lift to generate this information was too onerous. Especially as many states have created policies that permit students to substitute a litany of courses for mathematics courses, this information is critical to ensuring that the policy is serving students' best interests. The findings show that states are, for the most part, in a space of "trust but cannot verify."

MATHEMATICS COURSE TAKING IN 11TH AND 12TH GRADES

Most states (27) require students to take three mathematics courses in high school.[9] Seventeen states and the District of Columbia require students to take four mathematics courses prior to graduation. Three states require students to take two mathematics courses, and three states do not specify how many courses students are required to take — these decisions are set by individual districts. This research examined whether these state policy differences in the number of required courses would yield substantive differences in the percentages of students taking mathematics courses in their final years of high school.

In the 13 states that submitted this data (Arkansas, California, District of Columbia, Georgia, Illinois, Indiana, Nebraska, New Mexico, Oregon, Texas, Utah, Virginia, and West Virginia), a median of 90 percent of students took a mathematics course in 11th grade, and 74 percent did so in 12th grade. The percentages varied considerably among the states, as shown in Table 3 on p. 20. Georgia, Arkansas, Texas, and the District of Columbia reported the highest percentages of students taking mathematics in 12th grade. Georgia, Arkansas, and the District of Columbia require students to take four mathematics courses in high school.

Table 3: Percentage of 11th and 12th Graders Enrolled in a Mathematics Course

STATE	11TH GRADERS	12TH GRADERS	NUMBER OF MATHEMATICS COURSES REQUIRED
Arkansas	96%	87%	4
California	84%	63%	2
District of Columbia	90%	82%	4
Georgia	99%	98%	4
Illinois	96%	76%	3
Indiana	87%	64%	3
Nebraska	95%	72%	3
New Mexico	90%	74%	4
Oregon	90%	56%	3
Texas	98%	85%	3
Utah	92%	59%	3
Virginia	90%	65%	3
West Virginia	82%	80%	4
Median	90%	74%	3

Note: States may offer students more than one graduation option with different numbers of required mathematics courses. For purposes of this analysis, the "default" number of courses is included.

In some states, dozens of course options are available to students to satisfy graduation requirements. This flexibility could be beneficial when well aligned with a student's career interests and high-quality career pathways, but it should not result in placing students into a lower (or less rigorous) track. States are not serving students' best interests by allowing them to graduate not having taken an appropriately rigorous course of study or not having demonstrated that they are ready for their next steps. Further, navigating the myriad options without strong student advising and counselor supports, particularly for students from underserved populations, can be a challenge.

Looking exclusively at top-level mathematics course requirements (e.g., "three mathematics courses") is insufficient because these three courses look very different across states and within states that allow districts to decide. While states may "require" a set of mathematics courses for graduation, the vast majority allow students flexibility with a range of course options that satisfy mathematics requirements. What qualifies as a "mathematics" course depends on the state or the district in which a student resides. For example, a state that requires Algebra II might also allow the requirement for the third course covering Algebra II to be met by a mathematics course with content comparable to Algebra II or by a computer science, career and technical education/vocational education, economics, science, or arts course as determined by the local school district governing board or charter school. In another state, the third-year mathematics course may be replaced by Accounting, Mathematics of Personal Finance, Medical Mathematics, Modern Mathematics, Introductory Statistics, or Computer Programming. In other words, students have a tremendous amount of flexibility. This review found that 21 states allow computer science to be substituted for a mathematics course; 15 states permit career and technical education courses to substitute for mathematics. At least seven states count financial literacy/consumer mathematics courses toward a student's required mathematics coursework.

TYPES OF MATHEMATICS COURSES IN 11TH AND 12TH GRADES

States reported that postsecondary mathematics faculty and leaders are often surprised by the large percentage of students that do not take a mathematics course in grade 12. Higher education leaders and mathematics faculty in state and regional mathematics alignment task forces indicated that they see continuous mathematics course taking through 12th grade as important given the high percentages of students that enter postsecondary programs needing supplemental support to succeed in college-level mathematics. More than two-thirds of community college students and 40 percent of students enrolled in four-year universities take at least one developmental mathematics course (Ganga & Mazzariello, 2019). The use of multiple measures for placement, including grade point average, and the use of corequisite models for remedial support are gaining traction and improving students' access to and success in college mathematics for students who enter college underprepared (Complete College America, 2021; Ganga & Mazzariello, 2019). Still, the goal of K–12 systems should be that students graduate from high school prepared for success in credit-bearing mathematics courses immediately upon enrollment in postsecondary education institutions.

States reported the most common 11th-grade course to be Algebra II or Integrated III; however, the percentage of students taking these courses varied widely. In the 17 states that reported this data (Arkansas, California, Colorado, Connecticut, District of Columbia, Georgia, Idaho, Illinois, Indiana, Nebraska, New Mexico, Ohio, Oregon, Texas, Virginia, Washington, and West Virginia), between 21 percent and 82 percent of students in each state took these courses, the vast majority being Algebra II or Integrated III, in 11th grade of the year reported. Even in the state where just 21 percent of students took Algebra II in 11th grade, this percentage was higher than any other course. The median across states was 49 percent.

Students' 12th-grade course selections varied much more than their 11th-grade selections. Twelfth-grade course-taking data in a comparable format includes data from 16 states and the District of Columbia. Table 4 on p. 22 includes the median percentage of students taking these courses across the states.

Table 4: Percentage of 12th Graders Enrolled in Selected Mathematics Courses

STATE	ALGEBRA II OR INTEGRATED III	PRECALCULUS	STATISTICS	QUANTITATIVE LITERACY/ REASONING
Arkansas	8%	6%	6%	18%
California	9%	8%	15%	1%
Colorado	16%	12%	14%	n/a
Connecticut	6%	14%	25%	n/a
District of Columbia	7%	12%	52%	n/a
Georgia	<1%	38%	21%	18%
Idaho	13%	6%	15%	n/a
Illinois	7%	13%	27%	7%
Indiana	11%	26%	26%	9%
Nebraska	15%	13%	15%	n/a
New Mexico	8%	9%	8%	n/a
Ohio	30%	15%	21%	3%
Oregon	9%	6%	10%	n/a
Texas	17%	29%	13%	9%
Virginia	7%	6%	17%	21%
Washington	6%	8%	8%	n/a
West Virginia	4%	8%	3%	n/a
Median	8%	12%	15%	9%

Note: States offer a wide variety of mathematics courses in 12th grade. The courses included in this table were those that had the highest enrollment and were comparable across states. Thus, state-specific courses such as 12th-grade transition courses are not included. Students also may be taking more than one mathematics course and thus may be captured in the data in more than one course. "Statistics" includes a high school-level statistics course, Statistics for dual credit, and Advanced Placement Statistics. Additionally, Georgia's reported enrollment data for Precalculus and Statistics includes percentages of 11th and 12th graders.

Notably, all states reporting course enrollment data for 12th graders had a relatively significant number of students enrolled in Statistics. The review of state statutes and approved course lists found references in at least 17 states to Probability and Statistics courses.

Quantitative Literacy or Quantitative Reasoning is one of the commonly required gateway mathematics courses for programs of study in higher education institutions in states that have defined their mathematics pathways. States reported that a smaller percentage of students take Quantitative Literacy compared to Statistics in high school. Eight of the 17 states providing 12th-grade enrollment data reported students enrolled in Quantitative Literacy or Reasoning. In Arkansas, for example, the percentage of students across the state taking Quantitative Literacy increased by 58 percent from the 2017–18 school year to the 2020–21 school year. The review of state statutes and approved course lists found references in at least eight states to Quantitative Literacy or Reasoning courses that were approved as mathematics courses.

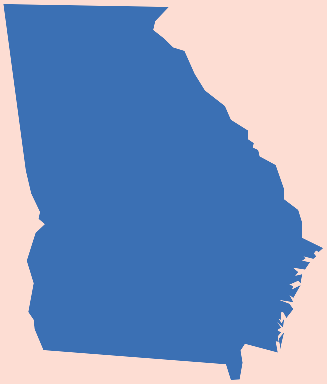
States working to reimagine mathematics pathways and encourage specific courses such as Statistics and Quantitative Literacy or Reasoning need to have course-taking data to understand the extent that these courses are being offered by districts and schools and taken by students. Given the tremendous variation in mathematics course requirements, graduation pathways, and student flexibility within and across states, it is important for state leaders to know which students are completing which graduation options and taking which sequences of courses and how their outcomes differ within and beyond high school. Absent attention to students' course-taking experiences in high school, states will be unable to pinpoint where students and schools are successful — and replicate and scale those efforts as needed — and where policies may need to be adjusted to better serve students.

NOTE: In future presentations of this data, it would be useful to present the data in a way that mirrors the most common postsecondary pathways — the path to Calculus, Statistics, and Quantitative Reasoning. Combining Precalculus, College Algebra for dual credit, and Calculus, for example, would give a clearer picture of the percentage of students on that mathematics pathway rather than just breaking the data down by course. The researchers did not request data on Calculus but rather on courses that follow Algebra II or an equivalent course for comparison.

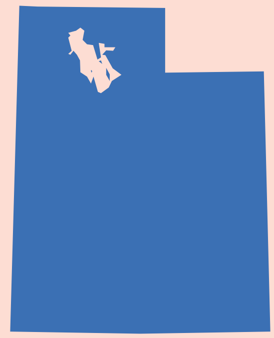
For Additional Research

Which districts and schools are offering new(er) courses such as Statistics and Quantitative Literacy or Reasoning? Why are states offering different types of these courses? Why would students take high school-level Statistics rather than a college-level dual credit Statistics course? What purpose does each course serve, and how are students counseled into them? What systemic policies, practices, and supports need to be in place to avoid mathematics pathways becoming a new form of biased tracking? For states with clear mathematics pathways in higher education institutions, are students being advised into Statistics or Quantitative Literacy or Reasoning based on their well-informed program of study and career aspirations?

Georgia has created a number of policies that have resulted in strong consistency in course-taking patterns through the 11th-grade year. For example, Algebra II, now Advanced Algebra, is a required course for all students. Eighty-two percent of 11th graders in Georgia took Advanced Algebra. The course is also offered with corequisite supports for students who need it. All other states reporting this data had between 21 percent and 56 percent of students taking Algebra II in 11th grade. Additionally, Georgia requires four years of mathematics and reported that 98 percent of 12th graders took a mathematics course; the other states' reported data ranged from 56 percent to 87 percent. Because most students in Georgia take Advanced Algebra by the end of 11th grade and because four years of mathematics are required as part of the state's graduation requirements, students have the opportunity to take a mathematics course in 12th grade that is college and career aligned. Georgia's 12th-grade course-taking patterns revealed that students were distributed across the path to Calculus, Statistics, and Quantitative Literacy or Reasoning courses. Some of the course-taking data includes both 11th and 12th graders and some only 12th graders, so the data cannot be directly compared. Still, there was clear distribution across the three mathematics pathways with 18 percent of 12th graders in Quantitative Literacy or Reasoning and 21 percent of 11th and 12th graders in Statistics.



Utah has an innovative approach to the Integrated pathway with two secondary mathematics pathway options. Given the uniqueness of Utah's approach, it is not comparable to other states and thus not represented in Table 4, but it is a model worthy of consideration. Students can choose to take Integrated I, II, and III foundation courses or Integrated I, II, and II courses plus extended topics. If students choose the extended option, they will complete the content typically found in Algebra I, Geometry, Algebra II, and Precalculus in a three-year period through the Integrated I, II, II "extended" mathematics pathway. Of 12th graders in Utah, 49 percent took Integrated III, which includes those in the foundation and extended paths. For an imperfect comparison, in the other states that submitted 12th-grade course-taking data, a median of 8 percent of students took Algebra II or Integrated III, and a median of 12 percent of students across states took Precalculus.



NOTE: Iowa, Vermont, and Wisconsin could not be included in the report data tables because the data provided was outside of the template. Key data shared by these states includes:

- In **Iowa,** 76 percent of students took four years of mathematics, six percent of students took less than three years of mathematics or contained an interruption, 18 percent of students were accelerated to Algebra I or above in 8th grade, and 12 percent of students took Calculus.
- **Vermont** follows the course-taking patterns of other states that submitted data, with Algebra I, Geometry, Algebra II, and Precalculus being the highest enrolled courses. After those courses, the most common courses Vermont students took were Advanced Placement Calculus, Advanced Placement Statistics, Statistics, and Consumer Math at similar rates.
- In **Wisconsin,** districts have the authority to choose which course codes to assign to courses, making aggregating information across the state extremely difficult. For example, districts have a wide variety of course codes even for the courses that most students in Wisconsin take, such as Algebra I and Geometry. Trying to gather data for this report prompted state leaders in Wisconsin to create a list of recommended codes for mathematics courses so that they could compare data across districts. Other states with local control governance in which districts make most decisions about courses to offer, course codes, and instructional resources expressed similar challenges.

RECENT REVISIONS TO MATHEMATICS COURSEWORK REQUIREMENTS

For mathematics pathways to be effectively implemented in states, students will need to be able to access and succeed in specific coursework. Students must understand which courses are appropriate for specific pathways. One approach states can use to increase access is to ensure that the courses are approved as mathematics courses for students. However, a review of trends in changes to states' graduation requirements in mathematics over the past five years revealed more flexibility and less specificity. The most substantive changes are in states where students now complete two core years of mathematics during the first half of their high school experience (e.g., Algebra I and Geometry), followed by one or two "personalized" courses. Kentucky, Oregon, South Dakota, Washington, and West Virginia have adopted this model in recent years with Texas doing so in 2013. This approach is a departure from the more typical model in which students are generally expected to take a commonly defined sequence of three or four mathematics courses. Another common trend in states such as Kentucky, South Dakota, Washington, and West Virginia is the removal of the requirement — or default expectation — that students complete an Algebra II course or its equivalent to graduate. These states also are shifting to policies that allow students more flexibility around their options for their third and/or fourth mathematics course and, in some places, creating policies for students to add "endorsements." See Table 5 on p. 27 for examples of these changes.

Table 5: Notable Changes to State Mathematics Graduation Course Requirements

STATE	MATHEMATICS THEN …	… AND MATHEMATICS NOW
Kentucky	Students entering grade 9 in 2018–19 and earlier (2022 graduates) are required to take three credits: Algebra I, Geometry, and Algebra II; a mathematics course or equivalent must be taken each year.	Students entering grade 9 in 2019–20 and thereafter must take four credits: Algebra I, Geometry, and two other personalized credits covering the remaining required Kentucky Academic Standards for Mathematics.
South Dakota	Students must take three units, which must include one unit of Algebra I, one unit of Algebra II, and one unit of Geometry. With school and parent/guardian approval, a student may be excused from Algebra II or Geometry, but not both, in favor of a more appropriate course.	In 2018 the mathematics requirements were revised to include three units of mathematics, which must include one unit of Algebra I.
Washington	Students must take three credits, which must include Algebra I or Integrated Mathematics I, Geometry or Integrated Mathematics II, and Algebra II or Integrated Mathematics III. A student may elect to pursue a third credit of mathematics other than Algebra II or Integrated Math III if the elective choice is based on a career-oriented program of study identified in the student's High School and Beyond Plan and the student, parent or guardian, and a school representative meet, discuss the plan, and sign a form.	Beginning with the class of 2019, students must take three credits, which must include Algebra I or Integrated Math I, Geometry or Integrated Math II, and a third credit of mathematics that aligns with the student's interests and High School and Beyond Plan, with the agreement of the student's parent or guardian.
West Virginia	Students must take four credits, including Math I; Math II; Math III STEM, Math III Liberal Arts, or Math III Technical Readiness; and Math IV, Math IV Technical Readiness, Transition Mathematics for Seniors, or any other fourth course option.	In July 2020 the mathematics requirements were revised to include four credits, including Math I or Algebra I, Math II or Geometry, and two additional personalized credits from course options.

FACILITATING STUDENTS' SEAMLESS TRANSITIONS TO POSTSECONDARY

A high school graduate's path to and through postsecondary education is not always linear. One student might graduate from high school, enter the workforce, and later decide to return to higher education while working full time. Another student might enlist in the military, serve for a number of years, and decide to pursue an associate or bachelor's degree. Another student might enroll full time in a two- or four-year institution, scale back to part time, and then switch majors. Still other students might accrue postsecondary credit in high school and look to build upon those credits at a technical college. Because students' experiences are so different, there must be on-ramps and off-ramps to support students' choices and provide flexibility and support where needed. And students must have access to the information they need to make the best choices for their own career goals.

One of the goals of this research was to better understand how states are creating policies to support and streamline students' educational experiences, including through allowing dual credit course taking in high school, administering high school assessments that signal to students their readiness for credit-bearing postsecondary coursework, and expecting students to complete coursework in high school that aligns with the coursework required for entrance into postsecondary education opportunities.

States offer a wide variety of mathematics courses that students can take to earn credits toward graduation from high school. The list of courses, however, is not necessarily vetted to ensure that students will be best prepared for a postsecondary credential, two-year degree, or four-year degree. Students also can often take course sequences that include courses that are a lower level than a previous course they took, so they are not advancing and expanding their mathematical knowledge and skills. Students may not even be aware of dual credit course options that would better support them in their education goals.

DUAL CREDIT COURSEWORK IN HIGH SCHOOL

States reported minimal course-taking data regarding the mathematics courses students take for dual credit. Some states shared that the K–12 agency or department does not collect and/or have access to this data. Other states shared that pulling data on specific courses for dual credit or just mathematics courses was difficult. One key finding is that for states reporting student enrollment in dual credit, students most frequently enrolled in College Algebra. In Georgia, of the 11th and 12th graders who took any mathematics course, 10 percent took College Algebra for dual credit. The state also reported disaggregated data on students enrolled in the following mathematics courses for dual credit: Precalculus (three percent), Statistics (two percent), Calculus (one percent), and Quantitative Literacy or similar course (one percent). While these percentages of students taking courses for dual credit are small, the data indicates that the infrastructure is in place to offer a range of gateway college mathematics courses for dual credit in high school, as well as to monitor and report data. Eight states provided data on the percentage of students taking "all other mathematics courses that require Algebra II as a prerequisite course or have a prerequisite requirement like a score on a standardized test." States reporting this data had between three percent and 29 percent of 12th graders who took a mathematics course categorized this way.

KEY TAKEAWAY

The use of data and the ability of state systems to pull relevant data to guide dual enrollment offerings and advisement on what dual enrollment courses align with postsecondary gateway courses and requirements vary widely across states. This fact hinders the progress that can be made toward increasing equitable access to and success in postsecondary-aligned mathematics courses and pathways.

For Additional Research

Which dual credit mathematics courses are available to students? Are dual credit options available to students in a range of courses, and do they align with students' career interests? To what extent are students exercising choice when electing to take a dual credit course in Calculus?

HIGH SCHOOL MATHEMATICS ALIGNMENT WITH HIGHER EDUCATION REQUIREMENTS

In many states, students have to "opt in" to taking a set of courses that meets the requirements for entering the large, public four-year postsecondary institutions that serve most graduates from their high schools. This approach means that the graduation expectations for many students are set lower than what is needed for admission into four-year schools. Students may be left scrambling to make up coursework later in their high school experience as this misalignment between state requirements and college entrance expectations becomes more evident. Given other equity gaps, this gap between high school graduation requirements and college admissions requirements undoubtedly disadvantages Black and Hispanic students and those experiencing poverty. States should do more to ensure that all students are required to take courses in high school that do not limit the opportunities available to them after they graduate.

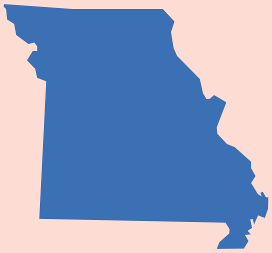
This review found that states take a number of different approaches when it comes to the transition between high school exit and postsecondary entrance requirements:

1. The state requires students to complete X, Y, and Z mathematics courses to graduate, and the higher education system also requires X, Y, and Z mathematics courses to be considered for admissions.
2. The state requires students to complete X and Y mathematics courses to graduate but offers at least one graduation endorsement/pathway that requires students to complete X, Y, and Z mathematics courses. Students who elect to complete this more rigorous option will meet the higher education system admissions requirements.
3. The state requires students to complete X and Y mathematics courses to graduate, but the higher education system requires X, Y, and Z mathematics courses to be considered for admissions. Students interested in pursuing postsecondary education at the higher education system are responsible for understanding the gap between K–12 exit and higher education admissions requirements and address it accordingly in high school.
4. In many states the flexibility for the courses a student may take in K–12 and/or the lack of specificity about students' required coursework for admission to the higher education system make knowing whether students are experiencing gaps extremely challenging. The K–12 system specifies courses that students may take that count toward their mathematics or science courses for graduation, but whether the higher education institution would count those same courses as meeting its admissions requirements is unclear. A student who completes the specified K–12 coursework may fall short of the coursework needed for entry into many or all institutions of higher education and also may find themselves unprepared because of the courses they did or did not take.

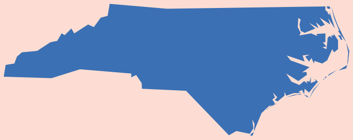
KEY TAKEAWAY

More states now offer varying high school diploma options that have implications for postsecondary opportunities for students. Therefore, states should be explicit in their communications and advising that opting out of particular mathematics course sequences or failing to complete particular courses may affect a student's eligibility for certain postsecondary institutions.

The **Missouri** Department of Elementary and Secondary Education's guidance for high school graduation requirements crosswalks the requirements to graduate from high school with the standard diploma and the additional courses/content that are necessary for students to meet the Missouri Coordinating Board for Higher Education's Recommended High School Course Work (Missouri Department of Elementary and Secondary Education, n.d.).



North Carolina has created charts detailing what courses are required for admission into a University of North Carolina System institution, admission into community college, or direct entry into a career after high school (North Carolina Department of Public Instruction, n.d.).



ASSESSING STUDENTS' UNDERSTANDING OF MATHEMATICS

In addition to reviewing course-taking data, how can states understand the ways students are moving through their K–12 mathematics courses, whether these students are successfully meeting expectations, and what interventions and supports are necessary to ensure their success? Given the variation in the mathematics courses students take in high school, how different are the assessments states use to monitor how students are progressing in their mathematics journeys? This report aims to understand which assessments states administer for federal accountability, when students are being assessed, which mathematics content is assessed, and whether the assessments have consequences for students. The policy scan revealed that most states have one data point on students from one assessment administered at a single point during a student's high school experience, and most assessments are not tied to specific student coursework.

MATHEMATICS ASSESSMENT(S) USED FOR FEDERAL ACCOUNTABILITY

The Every Student Succeeds Act requires states to assess students' academic achievement in mathematics at least once in high school for federal accountability, but it gives states the flexibility to decide how often students are assessed, at what grade(s) students are assessed, the content and type of assessment(s) used, and where to set proficiency benchmarks. One approach to categorizing states' assessments is by end of year (e.g., at the end of 11th grade) or end of course (i.e., tied specifically to a course upon completion of that course, regardless of the grade the student is in).

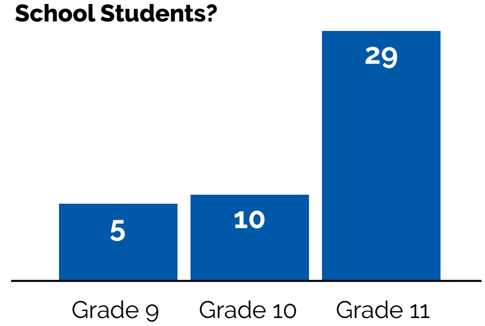
This review of states' high school assessments *used for federal accountability* revealed the following:[10]

- Twenty-one states administer the ACT or SAT assessments.
- Three states administer the ACT Aspire or PSAT assessments.
- Seventeen states administer state-developed end-of-year assessments. This number includes seven states that administer the Smarter Balanced Assessment Consortium assessment.
- Fifteen states administer end-of-course exams to students. Each of these 15 states administers an Algebra I assessment. Eight of these states also administer assessments in Geometry and/or Algebra II for accountability, though participation may not be required for all students. One state requires all students to be assessed using an Algebra II end-of-course assessment. One state requires all students be assessed with a Math III end-of-course assessment.

WHEN DO STATES ASSESS STUDENTS' MATHEMATICS ACHIEVEMENT?

States most commonly assess students in high school mathematics in grade 11 (28 states) and grade 10 (seven states). Two states assess students in grade 9; two states assess students in grades 9 and 10; and one state assesses students in grades 9, 10, and 11.[11] The remaining states assess students using an end-of-course assessment (or assessments).

Figure 2: When Do States Assess High School Students?



Note: Categories not mutually exclusive.

RECENT REVISIONS TO MATHEMATICS ASSESSMENT REQUIREMENTS

States' assessment systems are not fixed. The past three years have brought substantive changes to some states' assessments that meant changing types of systems, most commonly moving from end-of-course exams to the use of college admissions tests: the ACT and/or SAT. Arizona, Indiana, and New Mexico replaced their state-developed end-of-course or end-of-year exams with the SAT as the state's high school mathematics assessment. New Jersey has moved to replace the state's longer end-of-course exams with a single end-of-grade assessment in grade 11. Maine no longer administers the SAT to students, opting to use the NWEA assessment for high school mathematics. Other states have made more minor but substantive changes, reducing the number of high school mathematics assessments students take. For example, Georgia no longer administers statewide end-of-course assessments in Analytic Geometry or Geometry.

Outside of what is required for federal accountability, at least four states have added national assessments in the early part of students' high school experience: Arizona (ACT Aspire), Hawaii (PreACT), North Carolina (PreACT), and South Carolina (PSAT, PreACT, or ACT Aspire). Each of these four states also administers the ACT/SAT to students in grade 11.

More states than ever before are administering the ACT and SAT assessments. In 2021–22, 31 states administered the ACT or SAT to students (including a few that fund but do not require the assessment), an increase from 26 states in 2018–19. This review further found that 14 states administered the ACT Aspire/ACT or PSAT/SAT assessment suites in 2021–22, an increase from nine states in 2018–19.

Which States Have Stakes for Students Associated with Assessments?

This review found that less than a third of states (15 states) place student stakes on high school mathematics assessments — i.e., students must pass state assessment(s) to graduate and/or the assessment(s) are factored into the course grade.

- In 2021–22, nine states (Florida, Louisiana, Maryland, Massachusetts, Mississippi, New Jersey, New York, Texas, and Virginia) required students to meet certain assessment thresholds, typically in Algebra I, to graduate from high school. However, even among these nine states, some offer students flexibility in how they reach the minimum thresholds and provide alternatives to meeting specific assessment thresholds. For example, a student might need to accumulate a certain number of points across multiple subject-area tests, allowing them to compensate for a lower score in one content area with a higher score in another.
- Six states (Florida, Georgia, Louisiana, North Carolina, South Carolina, and Tennessee) factor assessment results into a student's final grade in a course, most commonly in Algebra I. In these states, the assessments comprise 15 percent to 30 percent of the student's final course grade. Two of these states administer assessments that students must pass to graduate and that are also factored into students' course grades.

There has been a noteworthy shift in states removing assessment stakes for students. For example, New Mexico allows students to use assessment performance as one way among many to satisfy graduation requirements. Indiana, Pennsylvania, and Washington joined Ohio in creating policies whereby assessments are only one of several ways for students to demonstrate readiness to graduate.

LESSONS FROM THE FIELD

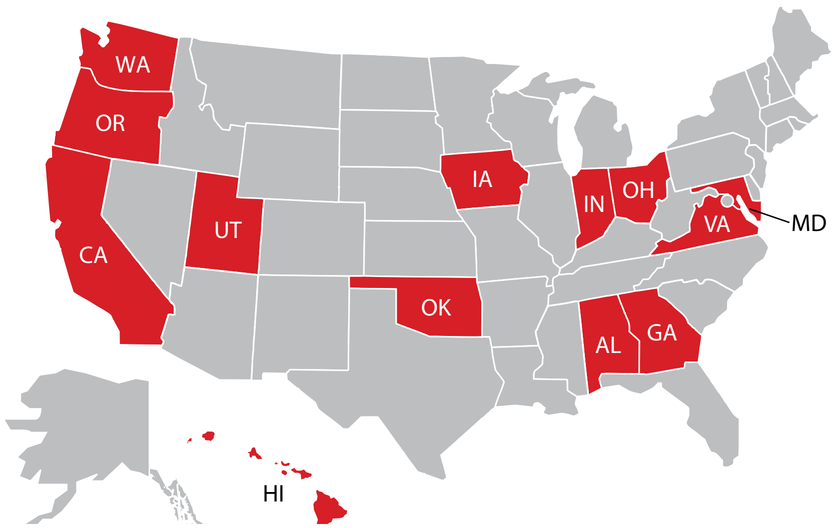
RECOMMENDATIONS AND CONSIDERATIONS FOR REIMAGINING K–12 MATHEMATICS

In March 2022, SAP conducted a series of stakeholder engagement efforts to understand the successes and challenges states have encountered throughout their work to implement or attempt to implement high school to postsecondary mathematics pathways. Furthermore, SAP also completed several interviews with students and mathematics educators to gain insight into how they experience mathematics education policies and practices within the classroom and while preparing for postsecondary transitions. This next section consists of findings from focus groups with representatives from states at different stages of mathematics pathways work. The findings are accompanied by quotes that also raise awareness of the impacts of particular decisions or barriers.

In total, individuals from 13 states representing various policy and political contexts participated in the focus groups. Additionally, states were purposely sampled to represent one of the following two scenarios to try to better understand the specific challenges that might arise at various stages of the planning and implementation process:

- **Scenario 1:** States are early in the work of implementing high school to postsecondary mathematics pathways.
- **Scenario 2:** States have made substantial progress in implementing high school to postsecondary mathematics pathways.

Figure 3: States Included in Participant Interviews



Throughout the focus groups, questions centered on:

- Understanding the decisions that states made about which high school mathematics content was non-negotiable in redefining high school to postsecondary mathematics pathways;
- The unexpected challenges that surfaced during the planning and implementation phases; and
- The lessons learned that might benefit other states that are considering launching work related to reimagining mathematics pathways.

Additional attention was paid to issues that arose related to reimagining mathematics pathways through an equity-oriented lens.

DECIDING ON THE MATHEMATICS COURSES AND CONTENT STUDENTS NEED TODAY

Prior to deciding on a path toward implementation, states generally took a step back to investigate how they might revise their high school mathematics standards and content in a manner that was different from "business as usual." State leaders that participated in the focus groups considered multiple career pathways students might take after high school and the variations in specific content and mathematical skills that might be needed for different groups of students. More specifically, they asked themselves some of the following questions:

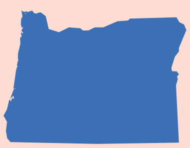
- Which mathematics is good for a particular pathway [after high school] versus which mathematics is needed for all high school students regardless of their specific future goals?

- Should there be multiple versions of Algebra II, or should we reimagine and update Algebra II for all students?
- How much mathematics beyond grade 8 do students need?
- How do we leverage the guidance and essential concepts in the National Council of Teachers of Mathematics book *Catalyzing Change in High School Mathematics: Initiating Critical Conversations* to support content selections and to help students discover the wonder, joy, and beauty of mathematics?
- What would you be willing to withhold a high school diploma for? (This question was posed by one state to get a content committee to be extremely selective in the choices they were making.)

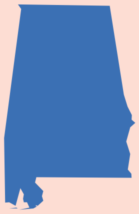
These questions, and others, allowed states to shift their mindset going into decisionmaking about mathematics pathways and provide a model for how to start conversations aimed at reimagining mathematics pathways at the high school level. States described these questions as key to reframing a conversation that would have otherwise been limited to the more traditional ways of thinking about mathematics courses and pathways. Additionally, such questions led to a different set of non-negotiables in terms of content and academic standards than what they currently had in place because states were now thinking critically about what mathematics content students might need across the spectrum of postsecondary opportunities available to them.

> "Start with encouraging the mathematics students need for their careers."
>
> — High School Mathematics Teacher

Within a minimum requirement of three courses of mathematics, **Oregon** chose to establish a two-course core for all students consisting of algebra, geometry, and data science to be followed by a third course aligned with students' postsecondary goals.



Alabama decided to reduce the number of standards by about 10 per course, emphasizing statistical reasoning and modeling in alignment with the mathematical skills students need in today's postsecondary landscape.



With a focus on multiple postsecondary paths, states decided content such as quadratic functions and polynomial long division might be less critical for all pathways and could be opted into, especially when thinking about the "core" of mathematics that all students should have access to. However, other content areas and courses were deemed non-negotiables for high school students. More specifically, these non-negotiables fell into two categories:

1. Content or courses that needed to be added or expanded to better round out mathematics pathways for students in today's technological world.
2. Content or courses that needed to be reimagined to provide students with a better foundation for a STEM postsecondary pathway.

For the first category, states overwhelmingly pointed to the incorporation of data literacy, data science, and mathematical modeling content for high school students. Furthermore, states emphasized the need to provide more opportunities for students to develop mathematical reasoning skills related to specific content pieces. Georgia even connected this line of thinking to the broader K–12 mathematics pipeline, emphasizing that some of these general concepts could be introduced as early as kindergarten to provide the building blocks for students in later years. These shifts in which content or courses states prioritized for students reflect a substantial deviation from the historical trends in the content of high school mathematics courses, taking a strong position on the need for a more updated approach to teaching and learning in high school mathematics.

For the second category, states most noticeably pointed to reimagining Algebra II for high school students, noting that "everyone deserves a modernized version of Algebra II" regardless of their postsecondary pathway. Washington also noted that it found that the current version of Algebra II was not adequately preparing its students for subsequent college courses. Key to the work in Washington is seeking to answer the question, "What mathematics do all students need to see before they get to mathematics not all students need?" Additionally, related to the previous category of non-negotiables, Algebra II was seen as a course in which data science and statistical reasoning content might be incorporated.

Finally, for some states, the reimagining of mathematics pathways was undergirded by a desire to adequately prepare students for the various STEM fields that exist in the current economy as well as for occupations created in the future. Some states noted they specifically wanted students to have access to precalculus-level material in their high school mathematics courses as a way of better preparing students for different STEM careers, while also acknowledging that not all pathways require the traditional calculus route in college. The state representative from Ohio elaborated on how this was done in their state, saying, "We partnered with higher ed[ucation] to define what was needed to be prepared for a college credit-bearing mathematics course. If I want calculus-based STEM, I need a traditional path. If I want to go into cyber security, I may be able to take a non-calculus-based pathway." This broader goal was connected to how states decided on the required number of courses for students, the depth versus breadth of content standards per course, and the shift in the emphasis of course taking toward relevance for students' future career aspirations. More often than not, these decisions resulted in the paring down of standards within courses. Alabama, for example, decided to reduce the number of standards by about 10 per course but noted that the state now emphasizes statistical reasoning and modeling — in line with the previous category of adjustments made to content and courses.

BARRIERS TO REIMAGINING MATHEMATICS PATHWAYS

While states had clear goals for reimagining mathematics in hopes of creating better pathways for high school students, they had to contend with substantial barriers before and during implementation. In most cases, these barriers slowed planning and implementation. The barriers that states grappled with, and continue to grapple with, during the planning and implementation stages of this work can best be summarized as internal and external systemic barriers. There were also important nuances in state-level context that have implications for how to engage in this work moving forward. The following section further discusses the internal and external barriers that were true across states as well as a handful of state-specific circumstances that led to additional barriers in reimagining mathematics pathways.

Types of Barriers

- Internal barriers refer to the series of challenges that states encountered related to the ideologies, policy and practice structures, and capacity of states' educational systems and school districts.
- External barriers refer to challenges states encountered related to social contexts, equitable access, and building postsecondary connections.

Internal Barriers Related to Existing Ideologies, Structures, and Capacity

As most states represented in these conversations set out to reimagine the current mathematics pathways in their schools, they first had to examine how existing structures and resources for mathematics education in their states did not necessarily align with or support their aspirational goals for new mathematics pathways. Multiple states spoke about the long history of mathematics education in their states that shaped traditional understandings of mathematics pathways for educators and other stakeholders, which included a strong emphasis on promoting a path to Calculus for all students and as the standard of rigor.

Such histories meant that getting mathematics education stakeholders to envision a modernized Algebra II or understand that additional mathematics course options would be viable in the long run was difficult. Relatedly, states at varying stages of mathematics pathways implementation also discussed general pushback they received about detracking and expanding access to higher level mathematics classes given the aforementioned histories of mathematics ideologies regarding rigorous education in their states.

One state went on to describe people in its education systems trying to hold onto mathematics as "an elite social club" of sorts, in which multiple stakeholders were invested in limited access to more accelerated mathematics classes. In the same vein, states were forced to defend the rigor of their new proposed pathways or consider if opening up access to advanced mathematics classes would reduce the rigor of these classes. To be clear, these oppositions came from educators and non-educators alike. Some states have addressed this barrier by listening to and responding to the opposition, generating clearer communication about the comparable rigor across different pathways, and more clearly articulating the alignment of different pathways to the particular mathematical skills needed for a wide variety of career options.

In addition to the persistent and counterproductive ideologies noted previously, states were beholden to the resource and staffing constraints that were in place at the onset of their efforts. States that were further along in the process and states that were early in the process both described challenges related to staffing and professional learning for their teachers across the K–12 spectrum. The bulk of the conversation centered on the fact that many school districts did not have the staff they would need to support new coursework — a problem that was further exacerbated by heightened turnover during the COVID-19 pandemic as well as the challenges of staffing mathematics classrooms generally, especially in rural, more isolated locations. Additionally, the staff that did remain in schools were not necessarily trained in the approach to mathematics education that was required under these reimagined pathways. States such as Utah attributed this lack of the necessary training to their existing teacher education and certification processes, which were largely competency based and, thus, were in tension with the reimagined vision of mathematics education. There was evidence across states that changes needed to be made throughout the teacher education pipeline in tandem with their efforts related to mathematics pathways if there is any hope that these changes will become systematically implemented and sustainable in the future.

The final point that came up in several states' comments with respect to staffing and training was related to the building blocks of mathematics instruction that students received prior to high school. In most cases, a major theme that states drew out of their planning conversation was that there was a need to address the mathematics education that was happening in K–8 classrooms at the same time that they were trying to change the mathematics content and standards in high school classrooms. For example, one state noted that elementary school teachers were not well trained in number sense and were not teaching students number sense. This gap in content, of course, then had ripple effects for whether students were prepared for certain types of mathematics education by the time they reached high school. Another state discussed implementing mathematics pathways as early as kindergarten to allow caregivers to be brought on board with supporting their child's mathematics education earlier in the process. Regardless of the context, there was overwhelming consensus that what was decided for high school to postsecondary mathematics pathways would have an impact on the mathematics content in earlier grades.

External Barriers Related to Social Contexts, Equitable Access, and Building Postsecondary Connections

In addition to the internal barriers states contended with as they tried to reimagine mathematics pathways for students, several external factors outside of the education system inevitably influenced the planning and implementation of new mathematics pathways at the state level. While states worked to prioritize equity, incorporating diverse perspectives and the needs of all student communities in meaningful ways, the most often cited external barrier included the states' sociopolitical climate and opposition to equity-driven strategies. The extent of pushback states received was the most surprising for those that were already engaged in mathematics pathways work that was previously fully supported by state educational leaders. As such, mathematics initiatives that are not designed to teach about race or racism can be wrongfully categorized as being related to race and culture-related studies. This miscategorization was the case for the mathematics pathways efforts in Georgia because the state emphasized how mathematics could be used to explain things in the world with particular phrases such as "mathematics in everyday life" and "contextualizing" mathematics. The use of such language meant the state's efforts fell under policymakers' anti-critical race theory legislation. When situations such as this arose, states were forced to make compromises they were not initially anticipating with respect to content, strategy, and framing.

These circumstances hindered progress in responding to the needs of communities that have historically been underserved in K–12 schools and in incorporating diverse perspectives on mathematics education. The challenge to this end became how to meaningfully incorporate the perspectives of different community groups in ways that were not performative. States described this effort as making sure "the right people were in the room" when decisions were made and initiatives were planned. For example, Oklahoma described bringing Native communities into the conversation early on as this practice was common in the state with respect to educational initiatives. The state typically looked at Native student data at various levels before making decisions and switched to virtual meetings to be more inclusive about who could attend the meetings. During the focus group, Oklahoma leaders discussed needing to now consider how to incorporate feedback from Native communities, as they were in the early stages of taking on the work of reimagining mathematics pathways.

> "Leading with equity without context makes it very easy to target and weaponize mathematics redesign efforts. We lead with words like 'modern,' 'rigorous,' 'flexible,' and 'opportunity.'"
>
> — State Mathematics Lead

In addition to incorporating the perspectives of different racial and ethnic communities, other states described wanting to incorporate the perspectives of K–8 educators for the reasons highlighted in the previous section on internal barriers. While states often had large committees of multiple stakeholder groups reviewing materials and student data, there was a sense that K–8 educators were not well represented in the decision-making process for mathematics pathways. As multiple states were interested in exploring the idea of K–12 mathematics pathways as a precursor to high school to postsecondary pathways and in bridging the divides in teacher education and content between elementary schools and later grades, this concern was pressing for states across contexts.

The final external barrier that rang true across multiple contexts was the misalignment — or perceived misalignment — between the mathematics curriculum and testing requirements imposed by colleges and universities and the aspirations states had with respect to reimagined mathematics pathways. In addition to states encountering basic communication challenges, there was a concern that higher education institutions across some states still required traditional Algebra II, even though not all Algebra II courses sufficiently prepare students for success. In other instances, states noted that universities expressed concern that a shift in mathematics content and requirements would result in "lower standards" for mathematics education that would have ripple effects for postsecondary education outcomes. Some postsecondary mathematics faculty and administrators strongly assumed that mathematics pathways are designed to reduce the rigor of mathematical options to address inequity and prohibit acceleration.

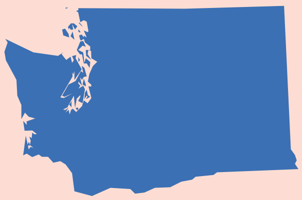
ACTIONABLE STEPS AND OPPORTUNITIES TO MOVE FORWARD

Despite the challenges that states faced in reimagining mathematics pathways, they remained strategic and hopeful that they would be able to meet their goals with the support of local partners and other states engaged in this work. States were steadfast because, as highlighted in the Introduction, there was a consensus that this work was essential to best meet the needs of all students. As such, in that same collaborative spirit, they shared various lessons learned during the process thus far that might be helpful for other states looking to take on similar work. These takeaways from participating states ranged from big-picture lessons about how systemic change happens to advice about the pace of work and where to seek collaborative partners.

1. Build Collaborative Bridges with Higher Education and Mathematics Networks

Because of the multiple barriers to doing this work, it is strongly encouraged that states collaborate with higher education partners and networks that are ready to support their efforts. States that were further along in the process urged their counterparts who are earlier in the mathematics pathways implementation process to recognize this reality early on and strategically build partnerships. Working to expand mathematics pathways in high school requires attention to a range of cross-sector policies that have the potential to help or hinder student access to and enrollment in courses and particular programs. These policies include defining the entrance criteria for high school students to access early postsecondary opportunities such as Advanced Placement, International Baccalaureate, and dual credit; determining how to define success in a course; and guaranteeing credit transferability across public systems. Across states, the mismatch between the mathematics states required for high school graduation and postsecondary admissions and the gateway expectations for college-level mathematics was a barrier. It is advantageous to hold discussions with high school and higher education partners to collaboratively decide on the mathematics content and skills students need for equitable access to higher education opportunities that align most with their college and career aspirations. A suggestion for future work is for states to convene K–12 and higher education faculty leaders to review the list of approved K–12 mathematics courses in the state and limit the list to those courses that prepare students for success in postsecondary mathematics and students' ultimate career fields. States that do not have approved lists but leave it to districts to determine what to offer should create an inventory of all of the courses offered and work to better understand which students are taking which courses — and why. These intrastate decisions can have interstate implications that can hinder student progression if students need to move to a different state.

In **Washington,** conversations with two- and four-year colleges highlighted that the content students were receiving in traditional Algebra II classes was not serving them well in those institutions — a finding that supported the need for a modernized Algebra II.



Additionally, having conversations earlier rather than later helped underscore the need to align work that K–12, higher education, and intermediary stakeholders were already doing. These early conversations provided states an opportunity to identify allies that were interested in and ready to do this work. States at various stages of the process noted that they leverage mathematics networks or have formed teams to attend learning opportunities related to mathematics pathways, such as participating in the Conference Board of the Mathematical Sciences, the State Collaborative on Assessments and Student Standards, and the Math Pathways Special Interest Group in the Association of State Supervisors of Mathematics, to make great strides in implementing pathways. Each of the aforementioned spaces allowed states to gather information that could inform their own work while forming collaborative networks with others engaged in the same work. States were hopeful that continuing to engage in such networks and spaces would eventually lead to deliverables states could use in their day-to-day work, such as a communications package.

2. Center Equity and Leverage Data

Few states were able to provide cohort sequence data; just 12 states submitted that data for this report. Some states' data systems did not collect or were not able to access this data in this format. In other states, the process for a staff member to aggregate data in this way would have been too time consuming. However, course enrollment data by grade and student demographic groups was available in many states; 16 states submitted that data for this report. Requesting mathematics course enrollment data by student demographics for 8th through 12th grade would likely yield higher participation from states relative to course sequence data; this data request is clearer and easier to execute for state data systems staff. This data also is an indicator of where most students start and end as they progress through secondary mathematics courses. Course data for 11th and 12th grades may indicate whether the mathematics pathways that are implemented are aligned to postsecondary mathematics pathways. Additionally, future research should organize courses by those that align with the most common emergent secondary mathematics pathways — the path to Calculus, Statistics, and Quantitative Literacy or Reasoning.

Both states that were early in mathematics pathways implementation work and states that were more advanced in this process urged others to be intentional in their efforts to dismantle deep systemic inequalities in mathematics education. Some states noted that the inequities related to access to technology and grade-level content that were highlighted and exacerbated during the COVID-19 pandemic provided an avenue through which to have these conversations. Though unexpected and under dire circumstances, the ability to have conversations about inequitable access to COVID-19-related resources proved helpful and provided opportunities for states to grapple with how they would engage in such discussions to maintain momentum moving forward.

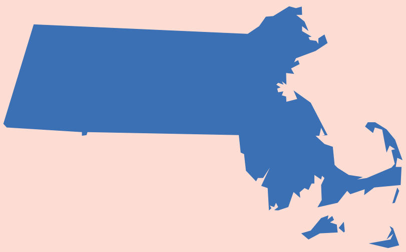
The policy and state data analysis findings in the previous section signal a need for clearly defined mathematics pathways and data to monitor and assess students' progress in each pathway. If mathematics pathways are implemented, a state should have the data to determine which students enroll, which students succeed, and which students are hindered by courses along each pathway. Furthermore, clearly defined mathematics pathways can help reduce uncertainty about mathematics course selections and ensure that students have accessible guidance that clarifies which mathematics courses will best prepare them for their college and career plans.

In states where students can opt out of or modify particular course sequences, knowing which courses and course sequences students complete would be instructive. Are these students enrolled in courses of study that align with postsecondary pathways and/or technical training programs leading to career opportunities? Do some courses of study disproportionately leave students poorly prepared for postsecondary success and ultimately lead to less successful postsecondary outcomes?

States need to build longitudinal data systems that routinely collect the information necessary to enable them to analyze both enrollment and success in course-taking patterns. This information enables state education leaders to answer questions such as:

- Are there gaps in successful participation in and completion of specific mathematics pathways based on race, ethnicity, gender, family income, English language status, and special education status? Are the gaps closing?
- Are there significant differences within and across districts in the number of students who participate in and complete specific mathematics pathways?
- Are the students who have completed specific mathematics pathways better prepared to enter and succeed in credit-bearing courses in postsecondary institutions? Are students less likely to need remediation?
- Are there mathematics pathways that disproportionately leave students poorly prepared for postsecondary success — and with less successful postsecondary outcomes?

The **Massachusetts** Department of Elementary and Secondary Education annually reports through the District Analysis Review Tool for Success after High School the number and percentage of 12th graders who have successfully completed a full year of mathematics coursework (Massachusetts Department of Elementary and Secondary Education, 2022). The data can also be disaggregated by student groups. Four years of high school mathematics is an admissions requirement for Massachusetts four-year public postsecondary institutions and a meaningful measure. This dashboard empowers districts, schools, parents, and advocates to conduct their own analyses, within and across schools, as well as over time.



3. Highlight Progress

Finally, states urged others interested in this work to understand that change happens incrementally at times and that this reality does not discount the progress being made on reimagining mathematics pathways. Put another way, given the pace of the work, states should acknowledge the small changes as well as larger, systemic shifts in mathematics content and courses. Such a perspective requires states to be flexible and responsive to the ever-changing context of education in the United States. As the representative from Oregon said at the end of one of the focus groups, “Reimagining a system means not building within the system that exists.” This type of work requires persistence, clarity of purpose, and intentional collaboration to achieve the intended, systemic changes that states aim to make for the benefit of students and their postsecondary goals.

CONCLUSION

Access to clearly defined mathematics pathways is critical to ensure that all students and families have the option and information to select the mathematics courses that best align with students' college and career plans. A growing number of states are working to better align high school mathematics course content and offerings to higher education mathematics pathways to increase relevance for students and increase equitable access to and success in the courses needed for postsecondary and career-field training. However, there is little consistency or consensus on the best approach to creating relevant and rigorous mathematics pathways. Ultimately, researchers and state mathematics leads found that increased collaboration between K–12, higher education, and the workforce is necessary to allow for better alignment between high school mathematics content and postsecondary expectations.

Furthermore, the use of data and states' ability to access and analyze relevant data to guide decisions about improving student success in postsecondary-aligned mathematics in high school varies widely across states. This fact hinders the progress that can be made to increase equitable access to and success in postsecondary-aligned mathematics courses and to assess course enrollment and success with an equity-centered lens. State policies and practices have a drastic influence on the mathematics course-taking patterns of students (e.g., when four years are required, higher percentages of students take four years of mathematics compared to states that require fewer courses). This report raises a few implications for future research from a policy perspective:

- How do mathematics educators and leaders continue to improve collaboration structures so that states benefit from learning about work that is clearly providing students with better opportunities?
- What can be done to improve access to relevant mathematics pathways data and encourage its use for expanding equitable access to and success in postsecondary-aligned mathematics courses in high school?

As more states move to adopt modernized traditional mathematics sequences, these answers are critical to ensure modern mathematics sequences are indeed equipping students for postsecondary success and to meet today's college and career expectations.

APPENDIX

METHODOLOGY

- **Policy Analysis:** In January–March 2022, ESG collected publicly available information on statewide high school mathematics standards and instructional materials, graduation requirements, summative assessments, dual enrollment, and postsecondary admissions policies from state education agency websites.

- **State Mathematics Course-Taking Data:** Outreach to states began in mid-December 2021. Initial communication was sent to state mathematics supervisors or staff in similar roles in state agencies. The Dana Center, ESG, and SAP have relationships with many leaders in these roles. Given the complexity of the data request, outreach began with leaders who would be willing to shepherd the data request through state departments of education to the benefit of their work at the department. Most states required formal data requests or other formal channels to obtain the data. As needed, formal requests were made to states in February and March 2022. Given that data collection varied in the past two years due to the COVID-19 pandemic and that states have different lag times for compiling the most recent data, researchers believed capturing data in the most recent year with the best data available would best serve the purpose of the research, though this approach has limitations. For example, some of the data is from school years that were affected most by the pandemic whereas other data is prepandemic. **View the data template/request to states.**

- **State Mathematics Leadership Focus Groups:** During March 2022, SAP conducted a series of focus groups with representatives from state education agencies, institutions of higher education, and district leaders as part of the Math Pathways project with the Dana Center and ESG. The intent of conducting focus groups with representatives from different states was to gain a deeper understanding of the successes and challenges states have encountered throughout their work implementing or attempting to implement high school to postsecondary mathematics pathways. In total, 13 states representing various policy and political contexts were included in the focus groups. Additionally, states were purposely sampled to represent one of two scenarios — they were early in the work of implementing high school to postsecondary mathematics pathways, or they had made substantial progress in this process — to try to better understand the specific challenges that might arise at various stages of the planning and implementation process.

ENDNOTES

1. Many states have written "Algebra II or an equivalent course" into their education code. Equivalent courses vary and can include Integrated III or courses with content that is intended to prepare students equally well for follow-on courses that are considered "above Algebra II" or that require "Algebra II" as a prerequisite. The language of "or an equivalent course" is common enough that to get comparable data across states, it was important to include these courses in addition to Algebra II.

2. States approach graduation requirements differently, with some states defining student course requirements by units, courses, or years. For the purposes of this report, the term "course" refers to a full year, unit, and/or course for consistency.

3. The "path to Calculus" refers to courses that prepare students specifically for success in Calculus, such as Precalculus and College Algebra, through Calculus itself.

4. Many states have written "Algebra II or an equivalent course" into their education code. Equivalent courses vary and can include Integrated III or courses with content that is intended to prepare students equally well for follow-on courses that are considered "above Algebra II" or that require "Algebra II" as a prerequisite. The language of "or an equivalent course" is common enough that to get comparable data across states, it was important to include these courses in addition to Algebra II.

5. This report includes data from students enrolled in District of Columbia Public Schools (DCPS). DCPS serves approximately 52 percent of K–12 public school students in Washington, D.C. Public charter schools serve approximately 48 percent of students. See https://osse.dc.gov/sites/default/files/dc/sites/osse/page_content/attachments/School%20Year%2021-22%20Annual%20OSSE%20Enrollment%20Audit.pdf.

6. Texas data was obtained from the Texas Education Research Center through a related research initiative.

7. Similar to school districts in other states.

8. Some states shared data that followed students from 8th-grade mathematics through the traditional sequence or Algebra I in 8th grade through the accelerated sequence, while other states captured this cohort of students starting in 9th grade.

9. States approach graduation requirements differently, with some states defining student course requirements by units, courses, or years. For the purposes of this report, the term "course" refers to a full year, unit, and/or course for consistency.

10. States may appear in more than one category because they administer more than one mathematics assessment for federal accountability; numbers will not sum to 51 states (including the District of Columbia). For example, Rhode Island administers both the PSAT and the SAT to students as part of its accountability system.

11. These numbers reflect assessments used for federal accountability.

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