Center for American Progress



Math Pathways

The Way Forward

By Ashley Jeffrey and Laura Jimenez September 2019

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Authors' notes: CAP uses "Black" and "African American" interchangeably throughout many of our products. We chose to capitalize "Black" in order to reflect that we are discussing a group of people and to be consistent with the capitalization of "African American."

Additionally, a "Latinx" person is any individual with origins in Latin America. This term is preferable to "Latino," which is not inclusive of gender or gender identity, as well as "Hispanic," which refers to people from Spanish-speaking countries—including Spain—whereas many Latin American countries are not predominantly Spanish-speaking. That said, "Latino" and "Hispanic" are used throughout the report when the underlying source uses such terminology.

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Introduction and summary

A high school education should prepare all students for their chosen next step after graduation, whether it be a two-year college, a four-year institution, or immediate entry into the workforce. Regardless of their choice, students' mastery of mathematics during their high school education is a gateway to success. Student scores on assessments such as the National Assessment of Educational Progress (NAEP), consistently document that well before high school, American students lack proficiency in math—and these low proficiency rates on the eighth-grade assessment continue in high school. Even on international tests, math proficiency for U.S. students, compared with those in other countries, is not as high as it should be.¹ These students must take remedial math classes in college to build the basic numeracy skills required to enter credit-bearing college courses.² Most of these students never progress to any credit-bearing coursework or to a degree, dooming them to low-wage jobs that cannot sustain a family and in many cases are being phased out of the 21st century economy.³ This pattern disproportionately affects students from families with low incomes and Black and Latinx students.⁴

The widespread and persistent placement of students into remedial math education in college calls into question how effectively American schools teach math in K-12 education, especially in high school. It also emphasizes the need for higher education and K-12 systems to work together to align their math instruction strategies and content in order to ensure academic continuity. To be sure, the question of rigor and relevance is important for every subject. However, math is often a gatekeeper subject in all fields; this is particularly the case for entry into high-wage science, technology, engineering, and math (STEM) fields, including physics and computer programming.⁵ Given the current racial and gender inequities in employment in these fields, math is a particularly critical area of focus, as equitable pathways would ensure access for all into these high-wage fields.⁶ Content and curricula need to evolve in order to keep up with the needs of these fields of study and economic demands.⁷ This report looks at lessons learned from research and innovation in math instruction to make recommendations that can help effectively scale new, more effective math pathways at the federal, state, district, and institution levels. These recommendations include the following:

- The U.S. Department of Education should conduct additional research on the development and impact of math pathways.
- Congress should increase funding for the State Longitudinal Data Systems, which collect data on remedial education rates.
- States should establish specific state work groups or task forces to oversee the development, scaled implementation, and monitoring of math pathways. They should also target professional development funding in math pathways implementation, create statewide articulation agreements, and continue to craft policies that support data-informed practices in math instruction.
- Districts should address equity and access through explicit curriculum policy, ensure that high-quality math courses and teachers are in every school, and ensure that math content is aligned with the content taught in postsecondary institutions. These actions will ensure that practitioners in classrooms focus on effective math instruction instead of antiquated teaching methods, using stronger curricula and relevant content.
- Institutions of higher education (IHEs) should ease implementation of math pathways by decentering college algebra as a gatekeeper course and creating articulation agreements with K-12 districts and with other two-year and four-year institutions.

To increase access to and adequately prepare all students for the future of work, relevant actors need to intentionally implement math pathways with equity at the center. Ultimately, these combined efforts will increase students' math proficiency and ease their progression through their chosen postsecondary pathways.

Glossary of terms

In this report, the authors use several technical terms for which definitions are provided below.

College- and career-ready standards: These are rigorous, high-quality standards for what students should learn in order to develop higher-order skills to "think critically, solve real-world problems, and be successful in the 21st century and beyond."⁸

Common Core State Standards (CCSS): According to the Common Core State Standards Initiative, the CCSS are "a set of clear college- and career-ready standards for kindergarten through 12th grade in English language arts/literacy and mathematics." They were "designed to ensure that students graduating from high school are prepared to take credit bearing introductory courses in two- or four-year college programs or enter the workforce."⁹

Corequisite remediation: This is an accelerated model in which students enroll directly into college-level, credit-bearing courses and concurrently receive academic support.¹⁰

Institutions of higher education: This is an umbrella term that refers to all institutions that provide postsecondary education, including two-year, four-year, vocational, and technical institutions.¹¹

Mathematics pathways: According to The Charles A. Dana Center at The University of Texas at Austin, these are "developmental and college-level course sequences that align to a student's academic and career goals, and that accelerate student completion of a gateway college-level math course."¹²

The history of math pathways

Initially designed to prepare students for calculus, college algebra courses focus on higher-level skills and have slowly become the default math courses for students, who are repeatedly pushed through the same process.¹³ However, few degree programs and only about 5 percent of today's professions use those skills.¹⁴ For years, math experts have said that having math education focus solely on college algebra and calculus is misguided.¹⁵

High school math courses follow this same trajectory. Traditionally, students need to complete Algebra I for entry into advanced math courses in high school,¹⁶ Algebra II for high school graduation,¹⁷ and college algebra for a postsecondary credential or degree.¹⁸ Additionally, each postsecondary institution's definition of college algebra differs, as some incorporate skills from Algebra II, some from precalculus, and others from a completely different mix.¹⁹ Despite this focus on algebra, around 80 percent of students do not need an algebra-intensive curriculum, nor calculus, to succeed in their degree programs.²⁰

Given the saturation of algebra-centered math instruction, any efforts to shift away from it as a traditional gatekeeper, as well as scale a newer strategy, would require institutions of higher education to approve math courses at other IHEs as qualifying for college credit. This move would also require significant support from the state education agency, which enforces state high school graduation requirements, to ensure that any new state-approved high school math courses count toward those graduation requirements and are equally rigorous for all students.²¹

There is a long history of developing initiatives that attempt to improve math course content, rigor, and relevancy.²² The various initiatives have responded, in part, to the relatively low and minimal growth in math scores on the National Assessment of Educational Progress for all students from 1990 to 2017, as well as on the international Trends in International Mathematics and Science Study (TIMSS) from 1995 to 2015.²³ As shown in Figures 1 and 2, low NAEP scores persist among Black, Hispanic, and American Indian/Alaska Native students, compared with white and Asian/Pacific Islander students. Figures 3 and 4 also show persistently low NAEP math scores for students at schools with a higher percentage of students eligible for free and reduced-price lunch.

FIGURE 1 Black, Hispanic, and American Indian/Alaska Native 8th graders score consistently lower on the NAEP compared with their white peers

Grade 8 National Assessment of Educational Progress (NAEP) math scores by race/ethnicity



Note: Dashed lines indicate that reporting standards were not met. Either there were too few cases for a reliable estimate or the coefficient of variation was 50 percent or greater. For the eighth grade assessments, the scale ranges from 0 to 500. These data include public and private schools. For 1996 and later years, the data include students tested with accommodations (1 percent to 14 percent of all students, depending on grade level and year) and exclude only those students with disabilities and English-language learners who were unable to be tested even with accommodations (1 percent to 4 percent to 4 and students). Race categories exclude people of Hispanic ethnicity. Prior to 2011, separate data for Asian students, Pacific Islander students, and students of two or more races were not collected.

Source: National Center for Education Statistics, "The Nation's Report Card, Data Tools: NAEP Data Explorer," 1990, 1992, 1996, 2000, 2003, 2005, 2007, 2009, 2011, 2013, 2015, and 2017 mathematics assessments, available at http://nces.ed.gov/nationsreportcard/naepdata/ (last accessed September 2019).

FIGURE 2 Black, Hispanic, and American Indian/Alaska Native 12th graders score consistently lower on the NAEP compared with their white peers

Grade 12 National Assessment of Educational Progress (NAEP) math scores by race/ethnicity



Note: For the 12th grade assessment, the scale ranges from 0 to 300. These data include public and private schools. For 1996 and later years, the data include students tested with accommodations (1 percent to 14 percent of all students, depending on grade level and year) and exclude only those students with disabilities and English-language learners who were unable to be tested even with accommodations (1 percent to 4 percent of all students, depending on grade level and year) and exclude only those students with disabilities and English-language learners who were unable to be tested even with accommodations (1 percent to 4 percent of all students). Race categories exclude people of Hispanic ethnicity. Prior to 2011, separate data for Asian students, Pacific Islander students, and students of two or more races were not collected. Because of major changes to the framework and content of the 12th grade assessment, scores from 2005 and later assessment years (1990, 1992, 1996, and 2000). For data pertaining to scale score comparisons among earlier years, see National Center for Education Statistics, "Digest of Education Statistics, Table 138. Average mathematics scale scores of 4th-, 8th-, and 12th-graders, by selected student and school characteristics: Selected years, 1990 through 2009," available at http://nces.ed.gov/programs/di-gest/d09/tables/dtab_138.aps (last accessed September 2019).

Source: National Center for Education Statistics, "The Nation's Report Card, Data Tools: NAEP Data Explorer," 2005, 2009, 2013, and 2015 mathematics assessments, available at http://nces.ed.gov/nationsreportcard/naepdata/ (last accessed September 2019).

FIGURE 3 8th graders at schools with a higher percentage of free and reduced lunch-eligible students score lower on the NAEP

Grade 8 National Assessment of Educational Progress (NAEP) math scores by free and reduced lunch eligibility



Note: For the eighth grade assessments, the scale ranges from 0 to 500. These data include public and private schools. For 1996 and later years, the data include students tested with accommodations (1 percent to 14 percent of all students, depending on grade level and year). Source: National Center for Education Statistics, "The Nation's Report Card, Data Tools: NAEP Data Explorer," 2000, 2003, 2005, 2007, 2009, 2011, 2013, 2015, and 2017 mathematics assessments, available at http://nces.ed.gov/nationsreportcard/naepdata/ (last accessed September 2019).

FIGURE 4

12th graders at schools with a higher percentage of free and reduced lunch-eligible students score lower on the NAEP

Grade 12 National Assessment of Educational Progress (NAEP) math scores by free and reduced lunch eligibility



Note: For the 12th grade assessment, the scale ranges from 0 to 300. These data include public and private schools. For 1996 and later years, the data include students tested with accommodations (1 percent to 14 percent of all students, depending on grade level and year). Because of major changes to the framework and content of the 12th grade assessment, results from 2005 and later assessment years cannot be compared with results from earlier assessment years. Therefore, this figure does not include results from the earlier 12th grade assessment years (1990, 1992, 1996, and 2000). For data pertaining to comparisons between earlier years, see National Center for Education Statistics, "Digest of Education Statistics, Table 138. Average mathematics scale scores of 4th-, 8th-, and 12th-graders, by selected student and school characteristics: Selected years, 1990 through 2009," available at http://nces.ed.gov/programs/digest/d09/tables/dt09_138.asp (last accessed September 2019). Source: National Center for Education Statistics, "The Nation's Report Card, Data Tools: NAEP Data Explorer," 2005, 2009, 2013, and 2015 mathematics assessments, available at http://nces.ed.gov/nationsreportcard/naepdata/ (last accessed September 2019).

One of the most recent national initiatives, the Common Core State Standards, was created in 2010 to increase the rigor of academic standards in English language arts and mathematics in K-12 education in order to improve student preparation for college, career, and life.²⁴ The CCSS were developed through the collaboration and consensus of dozens of educational experts, who all agreed that students would benefit from a different approach to math instruction.²⁵ Within the CCSS math standards, experts anticipated the need for flexible quantitative reasoning and statistics infusion, both of which differ from algebra-heavy content but are equally rigorous.²⁶ These courses are also more directly applicable to the majority of other fields of work.

Subsequently, the CCSS developers embedded building blocks that would allow for the creation of math pathways, defined as "developmental and college-level course sequences that align to a student's academic and career goals, and that accelerate student completion of a gateway college-level math course."27 However, chances for successful CCSS implementation by teachers in the classroom suffered as a consequence of the pushback against standardized testing as well as a lack of adequate professional development and sufficiently rigorous or aligned curricular materials.²⁸ Additionally, not every state adopted the CCSS, and many states still have different assessments, which makes it difficult to compare student progress in algebra and other courses across states.²⁹ The foundation and standards for a rigorous math education that goes beyond algebra are now mostly in place in the states that did adopt the CCSS or other college- and career-ready standards. However, there seems to be a gap between those standards and the quality of their implementation.³⁰ The CCSS intentionally defined standards but did not specify how teachers should teach in order to allow for practitioner interpretation and autonomy in instruction.³¹ Additionally, states are responsible for providing teachers with professional development on CCSS implementation, which can vary in funding, quality, and consistency.³²

While the CCSS are a K-12 education initiative, most other efforts to improve math instruction started as remedial education reform efforts in community colleges.³³ Remedial education courses build students' basic skills in reading and math but do not offer college credit. Community college faculty and administrators began math pathways initiatives to disrupt the alarming rates of dropout from remedial courses—and subsequently college altogether.³⁴ Data from the National Center for Education Statistics from the 2015-16 school year show that about 56 percent of undergraduates at two-year institutions and 41 percent of those at four-year institutions took a remedial course after high school.³⁵ Moreover, Table 1 notes that American Indian, Black, and Hispanic students are overrepresented in remedial courses, especially in math.

TABLE 1 In the 2015-16 school year, students of color, on average, took more remediation classes than their white peers

Race/ethnicity*	Took any remedial course at any point after high school	Took any remedial courses in 2015-16	Took one remedial math course in 2015-16	Took more than one remedial math course in 2015-16	Took one remedial reading/writing course in 2015-16
White	33.7%	10.5%	5.9%	1.6%	3.3%
Black	47.5%	15.9%	8.6%	2.7%	5.6%
Hispanic	46.9%	16.4%	8.7%	2.8%	5.6%
Asian	39.1%	12.3%	6.0%	2.1%	4.3%
American Indian	49.5%	19.7%	9.7%	2.2%	9.1%
Pacific Islander	41.4%	14.0%	5.3%	2.1%	+
Two or more races	37.3%	12.5%	7.4%	1.6%	4.2%

Percentage of undergraduate college students in 2015-16 who reported taking a remedial course after high school graduation

*American Indian includes Alaska Native, Asian/Pacific Islander includes Native Hawaiian, Black includes African American, Hispanic includes Latino, and the two or more races category includes respondents having origins in more than one race. Race categories exclude people of Hispanic origin unless specified.

* Reporting standards were not met. Either there were too few cases for a reliable estimate or the coefficient of variation was 50 percent or greater.

Source: National Center for Education Statistics, "Web Tables, Profile of Undergraduate Students: Attendance, Distance and Remedial Education, Degree Program and Field of Study, Demographics, Financial Aid, Financial Literacy, Employment, and Military Status: 2015–16" (Washington: U.S. Department of Education, 2019), available at https://nces.ed.gov/pubs2019/2019467.pdf.

Math pathways give students the option to enroll in college-level math courses that are relevant to their majors and as rigorous as traditional college algebra.³⁶ This strategy is deployed through a model called corequisite remediation, in which students are concurrently placed into two courses: an appropriate credit-bearing, collegelevel math course and a related support course.³⁷ There are different corequisite remediation models, as the instructors, types, and lengths of support courses can vary.³⁸ These models have shown significant promise for increasing math proficiency. West Virginia Community & Technical Colleges (WVCTC), for example, implemented a tailored corequisite remediation model, and within a year, the number of students enrolled in remedial math who also completed an associated, credit-bearing gateway course rose from 14 percent to 62 percent.³⁹ Other institutions in Georgia, Texas, Tennessee, and other states saw comparable results using similar corequisite models.⁴⁰ The consistent success of math pathways as a remedial education reform effort points to its ability to transform how math is taught in high school, as well as in grades K-8. At the high school level, there are a few math pathways variations. One such model is the integrated math model—which consists of Mathematics I, II, and III—in which academic standards within algebra, geometry, probability, and statistics are addressed concurrently over three years.⁴¹ Other common models consist of a variation of Algebra I, Geometry, and Algebra II.⁴²

At the postsecondary level, the most common math pathways models are an algebra pathway that leads to calculus, a pathway for statistics, and a pathway for quantitative reasoning.⁴³ While the algebra pathway is important for students pursuing science, technology, engineering and mathematics careers, other high-wage STEM and non-STEM careers, such as nursing and law, require proficiency in statistics and quantitative skills.⁴⁴ Figure 5 offers examples of pathways from ninth grade to career that demonstrates how math pathways prepare students for their futures.

FIGURE 5 Students can navigate through equally rigorous math pathways to be successful in their chosen major

Programs of study and the mathematic pathways that support them

↑ Direct path — — Some additional coursework required, such as a corequisite course



* Year 13 represents the first year at an institution of higher education.

Source: Doug Sovde, director of K-12 education strategy, policy, and services, Charles A. Dana Center at the University of Texas at Austin, personal communication with authors via email, August 23rd, 2019, on file with authors.

Themes from effective math pathways examples

In the authors' review of effective math pathways programs across the country, three main themes emerged:

- 1. Effective design of math courses in grades K-12 and at the postsecondary level has shown increased academic proficiency and success in postsecondary courses.
- 2. Reducing disparities in Black and Latinx students' placement in postsecondary remediation could address a persistent achievement gap.
- 3. Faster access to credit-bearing courses through a method such as corequisite remediation increases math proficiency and reduces students' failure rates in traditional, prerequisite remediation courses.

These three themes highlight effective methods that schools, districts, institutions of higher education, and states can implement to ensure that math pathways increase proficiency and prioritize access and equity for all students. The next subsections delve into each theme and successful case studies of math pathways implementation, as well as legislation that eased scaled implementation.

Theme 1: More effective design of and instruction in math courses

Implementation of math pathways in high school classrooms and postsecondary institutions is most effective when focused on intentional and effective instruction: how practitioners teach, what they teach, and how relevant the content is. Unfortunately, there have been a few barriers to effective pathway implementation.

Some teachers across the United States still use antiquated and ineffective teaching methods for math, such as rote memorization and noninteractive lecturing.⁴⁵ Additionally, there is some evidence that in the No Child Left Behind era of school accountability requirements, teachers were pushed to teach to the existing lowerquality standardized tests, instead of being encouraged to employ inquiry-based lessons that focused on high-level mathematical thought.⁴⁶ Teachers may also receive little support to design coherent curricula to ensure mathematical relevance for all students.⁴⁷ To improve instruction and course design, districts and schools should implement well-facilitated professional development in which teachers can discuss and update pedagogy, foster engagement and buy-in to the concept of math pathways, and increase collaboration between practitioners at high schools and two-year and four-year institutions. Districts and schools can also ensure curricular relevance by implementing flexible quantitative reasoning, statistics, and algebra-equivalent math pathways. The following example shows how a Massachusetts high school intentionally and effectively designed curricula in its math pathways development to increase student success and math proficiency.

Case study:

Marlborough High School, Marlborough, Massachusetts

In its pathway implementation strategy, Marlborough High School (MHS) engaged staff and teachers to redesign all curricula, including math and English, to include a pipeline trajectory with college expectations.⁴⁸ The redesigned curricula adhere to the Massachusetts Curriculum Framework for Mathematics, and MHS offers flexible math pathways to ensure that students enroll in math courses relevant to their future career.⁴⁹ Additionally, MHS offers concurrent support courses that reteach older concepts and preteach new concepts to increase students' understanding and comfort level with foundational algebraic concepts.⁵⁰ As students near the end of their sophomore year, each English class utilizes ACCUPLACER, a system of computer-adaptive assessments that assess reading, math, and writing skills, to determine if students might need remediation in college.⁵¹ MHS then uses those data to determine which class the student will need for their junior year of high school to put them on track to avoid remediation in college. This means that, at minimum, any 11th-grade MHS student on a remedial pathway will take a math course that will prepare them for college-level math before graduation.⁵²

To continue postsecondary progression, the school has a memorandum of understanding with a nearby community college. Select MHS faculty who are also accredited adjunct professors teach credit-bearing college courses at the high school, ensuring that courses are physically close for students. These courses include college math, such as algebra, precalculus, or trigonometry; English composition; psychology; and more.⁵³ To emphasize equity in the process, Marlborough gave first-access priority to historically marginalized subgroups including English language learners, students with disabilities, students from families with low incomes, and more.⁵⁴ These joined efforts ease student progression through pathways aligned with existing rigorous standards and postsecondary institutions.

Theme 2: Reduce inequities in rates of remediation for students of color

High rates of remediation placement in college sustain disparate academic outcomes between white students and students of color, particularly Black, Native American, and Latinx students, who are often overrepresented in remedial courses. Reduced postsecondary remediation placement for these students, including alternative math pathways, shows promise to minimize the gap in educational achievement between Black and Latinx students and their white peers.⁵⁵

To add context, although 80 percent of eighth-grade public school students nationwide had access to Algebra I, only 24 percent were enrolled in the course in the 2015-16 school year.⁵⁶ What's more, there are wide gaps for specific groups of students. While 34 percent of Asian students and 24 percent of white students took Algebra I in the 2015-16 school year, those numbers drop to 14 percent for Pacific Islander students, 13 percent for Hispanic and American Indian/Alaska Native students, and 12 percent for Black students.⁵⁷ At the high school level, these same students have even less access to algebra and advanced math classes.⁵⁸ In fact, the U.S. Department of Education's Civil Rights Data Collection (CRDC) data from the 2015-16 school year show that 1 in 4 high schools with high populations of Black, Latinx, American Indian, and Pacific Islander students do not offer Algebra I or higher.⁵⁹ This lack of access and enrollment at both the middle and high school levels means that certain groups of students are more likely to be underprepared for the algebra-intensive, credit-bearing courses that most students are funneled into in college.⁶⁰

Subsequently, those students are disproportionately placed into remedial college courses that are ineffective in helping students grasp algebraic concepts and skills.⁶¹ Around 50 percent of American Indian students, about 48 percent of Black students, and about 47 percent of Hispanic students enroll in remedial courses in math, writing, and reading, compared with about 34 percent of white students.⁶² The following example highlights a statewide policy that aimed to reduce inaccurate remediation placement and subsequently eased the implementation and scaling of math pathways across community colleges in California.

Case study: California's remediation bill

In California's community colleges, nearly 85 percent of African American and 85 percent of Latinx students take remedial math courses, compared with 72 percent of white students and 52 percent of Asian American students.⁶³ To help reduce inaccurate remediation placement and ensure students' timely completion of college-level math courses, California enacted Assembly Bill (AB) 705 in 2017.⁶⁴ The legislation's requirements mandated colleges to use evidence-based strategies to help students get out of remediation quickly. Several colleges redesigned existing curricula, policies, and practices, including by using math pathways as potential strategies to help students avoid remediation.⁶⁵

AB 705 also requires community colleges to use multiple placement measures to ensure that students are placed in a pathway in which they can enter and successfully complete a transfer-level, credit-bearing math course related to their education goals within one year.⁶⁶ This means that students will have to enroll in a math course closely aligned with their future postsecondary or workforce goals and with the goals of math pathways.

Additionally, colleges must prove that a student is "highly unlikely" to succeed in a gateway course without remedial course placement before placing the student in a remedial course, a move that could help significantly reduce racial disproportionality in remediation.⁶⁷ Otherwise, Black and Latinx students are more likely to take remedial courses compared with white students.⁶⁸ One study of early implementers of placement using multiple measures—such as high school records, GPA, or other relevant measures of success—and corequisite remediation saw a stark increase in Latino and African American access to transfer-level math courses across California.⁶⁹ Around 48 percent of Latino students and 46 percent of African American students completed those math courses in one year, compared with statewide averages of 19 percent and 13 percent, respectively.⁷⁰ While extensive data from AB 705 implementation and scaling are still pending, there is hope that the legislation will effectively help address equity, access, and course completion gaps for Black and Latinx students across the state.⁷¹

Theme 3: Earlier access to credit-bearing math courses in college

Providing earlier access to credit-bearing math courses increases math proficiency and reduces failure rates in traditional remediation courses. According to The Charles A. Dana Center at The University of Texas at Austin, it is critical to develop math pathways in which students "engage immediately with mathematics content that supports their program of study,"²² and effective math pathways in college use a corequisite remediation model to do so. Instead of the traditional model that pushes students toward a standard, prerequisite remedial course, students in corequisite remediation concurrently enroll in a credit-bearing math course and support course relevant to their majors.⁷³ Although corequisite remediation varies by an institution's model, it generally provides students with additional supports such as extra time to ask questions, supplementary practice work, and group activities to ensure collective mastery of the material.⁷⁴ This practice has dramatically increased math proficiency, as exemplified by programs in Indiana, discussed below.⁷⁵

Case study:

Indiana's Ivy Tech Community College

Placing students in any traditional remedial math education, even with corequisite support, is less successful than placing them directly into a credit-bearing course with corequisite support. After receiving a Completion Innovation Challenge grant from Complete College America, Ivy Tech Community College worked with the Indiana Commission for Higher Education to add corequisite courses in math and create three new math pathways: algebra to calculus, quantitative reasoning, and technology and real-world applications.⁷⁶ After three years, gateway math course success increased from 29 percent to 64 percent.⁷⁷ The newly implemented math pathways increased the number of students placed directly into one of the credit-bearing math courses, reducing placement in remedial math from 77 percent to 34 percent.⁷⁸ Subsequently, in conjunction with other related systemic changes, Ivy Tech doubled its graduation rate within two years.⁷⁹ These efforts highlight the importance of maneuvering away from traditional remediation courses toward math pathways implementation through which students have advanced access to credit-bearing courses.

Given its efficacy at the postsecondary level to hasten access to credit-bearing courses, a corequisite-like model effectively designed and implemented for high school students could help them avoid remediation in college altogether. Such a model could be implemented alongside authentic math pathways for students who are ready to take rigorous math courses in high school.

Recommendations

Research around math pathway development, implementation, and scaling highlights several lessons learned that can be applied to cultivate new and more effective math pathways. The following recommendations highlight actions that can be instituted at the federal, state, district, and institution levels.

The federal government's role in successful implementation and scaling of math pathways

Impactful federal support for math pathways includes funding for pathway implementation and research on implementation issues and successes. There is an appropriate role for both Congress and the U.S. Department of Education to play. Congress has already authorized the use of some federal funds to support educator professional development in effective math instruction using Title II and Title IV funds from the Every Student Succeeds Act. Congress could authorize more funding for this purpose. The U.S. Department of Education should document examples of how these and other federal funds could be used for math pathways implementation through nonregulatory guidance. Additionally, the department's Institute of Education Sciences should conduct research on effective implementation of math pathways. Finally, in issuing regulations for competitive discretionary grants, the department should create competitive preference priorities for programs such as the Education Innovation and Research Program to implement or scale existing local math pathways efforts.

Furthermore, to ensure proper data collection, the receipt of federal student aid dollars by colleges and universities should be tied to better reporting of student data in remedial programs, including enrollment, placement, progress, and completion rates.⁸⁰ These efforts would bolster data collection, funding distribution, and the implementation of statewide strategies to improve the impact of math pathways.

State education agencies' role in successful implementation and scaling of math pathways

Through pathway implementation, state education agencies can ease academic continuity from K-12 districts to postsecondary institutions at scale and, ultimately, to the workforce. States need an accountable body dedicated to addressing the quality, content, and implementation of math pathways, while simultaneously incorporating the needs and concerns of actors such as teachers and faculty members on the ground. Additionally, states need explicit policies to ensure those actors are adequately prepared to deliver high-quality math content and curricula. Finally, to facilitate pathway scaling and increase student preparedness and proficiency, states need to employ evidence-based reform strategies such as data collection and analysis.

Create an accountable body to implement math pathways

States can benefit from a specific, diverse work group or task force made up of stakeholders such as educators, administrators, policymakers, and employers. To guarantee that pathways work for all students, the group needs to embed access and equity at the inception of pathway development. The Arkansas Math Pathways Task Force (AMPTF), for example, was made up of math faculty from all public two-and four-year institutions across the state. The AMPTF worked with the Arkansas Department of Education and created recommendations to scale and implement math pathways and determine transferability of math credits to ensure that students have equitable access to a relevant math course.⁸¹ The AMPTF can serve as a model for states interested in creating an accountable body dedicated to math pathways.

Prepare teachers to deliver high-quality math

Relatedly, states should curate statewide teacher professional development that devotes time and funds to improve student learning and update teacher practices in new math pathways.⁸² To do so, policymakers should use federal dollars authorized under Title II and Title IV of the Every Student Succeeds Act for adequate math professional development for teachers. This would ensure that practitioners are equipped to deliver high-quality math content and curricula.

Employ evidence-based reform strategies

Finally, to ensure student preparedness, states should dedicate funds for a longitudinal statewide data collection system. A high-quality data system could identify underprepared high school students and enable schools to employ data-informed intervention strategies prior to graduation.⁸³ Additionally, the data system would allow states to match student transcripts and records between K-12 and postsecondary systems.⁸⁴ This would facilitate students' K-16 pathway progression, as postsecondary officials would be better positioned to fully assess students' college and career readiness.⁸⁵ These data would not be used to supplant the college admission process, as postsecondary institutions would still need to follow federal privacy laws. Although practitioners, schools, and districts are primarily responsible for implementing data-informed change, states can facilitate that process through state work groups; professional development funding and policies; and thorough data collection, analysis, and application.

Districts' role in successful implementation and scaling of math pathways

Districts play a significant role in the successful implementation of high-quality math pathways, as they can create policies around curriculum quality and implementation and address equity and access in K-12 schools. Districts can also cultivate partnerships and ensure curriculum alignment with local two-year and four-year institutions and provide funds for adequate professional development for practitioners.

Develop policy on curriculum quality, selection, and implementation

There is a need for policy on curriculum quality and potential flexibility in practitioner implementation of math pathways.⁸⁶ Districts empowered to adopt the math curricula of their choice should clearly define the selection, adoption, and implementation process of high-quality instructional materials and rigorous math curricula aligned with their standards, whether the Common Core State Standards or other college- and career-ready standards.⁸⁷ As districts increase transparency, they should also explain what flexibility practitioners and schools have in implementing math courses. For example, if a district is mandated to use a specific math textbook, schools that want to implement math pathways should be given a waiver to utilize alternative or even additional yet sufficiently rigorous and high-quality materials. These explicit policies and processes will facilitate the math pathways implementation process for institutions.

Increase availability of high-quality math to ensure equity

Districts need to address issues of equity in access to higher-level math content and courses by ensuring that high-quality math is available to all students. Black, Latinx, Native American, and Pacific Islander students have limited access to advanced math in high school and are disproportionately placed into remediation in college.⁸⁸ To increase both equity and access at the postsecondary level, at minimum, districts should offer Geometry, Algebra I, a rigorous algebra equivalent, or higher-level math

courses in all high schools. In doing so, districts will avoid inefficient attempts to retrofit equity at the postsecondary level, an ineffective effort that offers remediation as a solution to close students' gaps in math proficiency rather than avoiding those gaps to begin with. Additionally, districts need to identify ways to allocate more funding for professional development to adequately prepare practitioners to teach these math courses for effective implementation of the CCSS or other college- and careerreadiness standards.⁸⁹ These combined efforts will help increase math proficiency by deepening students' understanding of mathematical skills and concepts.

Colleges and universities' role in successful implementation and scaling of math pathways

Institutions of higher education can ease math pathways implementation by decentering algebra as a gatekeeper course and concretizing transfer policies between K-12 institutions and IHEs, as well as between two-year and four-year institutions. These efforts will help inform students that algebra is not the only course needed to prepare them for their future careers. Additionally, K-12 systems and IHEs need to designate which courses and curricula from K-12, two-year, and four-year institutions are equivalent and will allow students to earn credit. This coordination will ensure that students do not lose postsecondary credits, which can especially affect transfer students who may have attended a number of schools.⁹⁰

Decenter algebra as a gatekeeper course

Intentional math pathways implementation should decenter algebra and the race to calculus. Colleges and universities have historically adhered to traditional math sequences that place algebra as the gatekeeper and center calculus as students' final goal at the expense of not teaching them the types of math more relevant to their postsecondary plans.⁹¹ In order to disrupt this trajectory, IHEs need to invest in effective development and implementation of broader and equally rigorous math pathways to give students access to the specific mathematical content they need. In doing so, IHEs will prepare students for their chosen postsecondary pathways, and subsequently, their future careers.

Concretize transfer policies among relevant institutions

Effective and formalized transfer policies among K-12, two-year, and four-year institutions can ease students' pathway progression by articulating college credit and curriculum exchange.⁹² These are important because uncoordinated transfer policies between two-year and four-year institutions can cause students to be placed

into remediation at higher rates, which increases their likelihood of dropping out.⁹³ Specific policies are particularly important in the context of math pathways, to ensure that all institutions are clear on the rigor and quality of courses outside of the typical algebra pathway. One type of transfer policy is an articulation agreement, a formal contract between two postsecondary institutions that details which credits and courses will count toward degree programs.⁹⁴ Coordinated statewide articulation agreements are especially important, as they incorporate multiple postsecondary institutions and facilitate pathway implementation on a larger scale.⁹⁵ The following example notes how Illinois implemented statewide articulation agreements, as well as state legislation, to facilitate student transfer among public K-12, two-year and four-year institutions.

Case study:

Illinois' statewide articulation agreements

Statewide articulation agreements make the transfer process significantly easier for students. The Illinois Articulation Initiative (IAI) is a statewide transfer agreement among more than 100 colleges and universities across Illinois.⁹⁶ The agreement states that participating colleges and universities will accept transfer students' general education credits. This means that if a student completes an associate degree and wants to transfer to a four-year institution, their general education requirements will be accepted in that school's bachelor's degree program.⁹⁷ The IAI ensures course equity across institutions and helps students avoid losing credits when they transfer to a fully participating institution.

Additionally, to ease student transition from high school districts to postsecondary institutions, the state's Postsecondary and Workforce Readiness (PWR) Act established that fourth-year transitional math courses would be offered in all Illinois high schools.⁹⁸ The math courses are a part of one of three pathways most applicable to students' future career goals: STEM, technical fields, and quantitative literacy/statistics.⁹⁹ Created through joint partnerships between high schools and colleges, the courses are designed to ensure that students who are underprepared by their senior year are guaranteed to be ready for college and career by graduation. Additionally, completion of the course guarantees students' placement into a credit-bearing math course at a participating Illinois community college without a placement test.¹⁰⁰ Under the PWR Act, courses are approved at the state level and an established portability panel of secondary and postsecondary faculty ensures college readiness and course fidelity in maintaining content rigor and consistency.¹⁰¹

Conclusion

A high school education must prepare students for their postsecondary pathway of choice. High-quality math pathways implementation has the potential to significantly increase math proficiency and ensure that students are better prepared for the future of work. Through evidence-based math pathways, high schools can offer students faster access to credit-bearing college math courses, reduce inequities in remediation rates for Black and Latinx students, and allow for effective design and instruction of math content, curricula, and courses. Institutions, practitioners, districts, states, and Congress and federal agencies should prioritize investment in highquality math pathways development and its successful implementation in order to guarantee the relevance of a high school education and academic continuity through postsecondary education.

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Acknowledgments

The authors would like to thank the following individuals for participating in interviews and providing additional context on math instruction in K-12 and postsecondary institutions and systems: Kathleen Almy; Lexi Barrett; Pamela Burdman; Leddy Bustillos; Tristan Denley; Christina Hebert; Rebecca Martin; Anna O'Connor; Brea Ratliff; Dan Riley; Nancy Shapiro; Doug Sovde; Uri Treisman; and Sarah Tucker.

Methodology

The authors interviewed key actors in various stages of the development and implementation of math pathways—including practitioners and administrators at the K-12, two-year, and four-year levels—as well as national organizations that assist in math pathways development and implementation at the university and state levels. Appendix A lists researched programs and relevant outcomes. The authors split interview questions by associated organizations; they had one list for current and former practitioners and another list for intermediary organizations that worked with teachers, professors, schools, colleges, universities, districts, and state-level education organizations. Interviewees were asked about their pathways' development and implementation processes, including relevant challenges and successes; how they considered equity in access to pathways; and any policy recommendations that could simplify and strengthen the implementation process. These questions are on file with the authors.

Interviews occurred both in-person and through phone calls. The authors attended "High School to College Mathematics Pathways: Preparing Students for the Future," a forum hosted on May 6 to 7, 2019, by the Conference Board of the Mathematical Sciences, to learn about new research in the field and talk with current practitioners.

Limitations of this report include the limited number of people in the field that the authors were able to connect with, including a limited number of staff members at state education agencies. The next section highlights themes from the interviews, provides historical context around math pathways, and illuminates successful math pathways implementation efforts.

Appendix A: Description of researched programs

California Acceleration Project:¹⁰² The California Acceleration Project was founded in 2010 and supports the state's 114 community colleges to "implement reforms that increase student completion of transferable, college-level English and math requirements."¹⁰³ The organization initially recommended two-course pathways but switched to endorse corequisite pathways after reviewing attributed student success results.¹⁰⁴

Cuyamaca College, for example, was one of the first California colleges to implement different math pathways for different majors. In just one year, the school saw significant results for students enrolled in math pathways with corequisite remediation. In the 2015-16 school year, only about 10 percent of students in traditional remediation completed a transferable college math course within one year. In the 2016-17 school year—the year the program went in effect—however, that number rose exponentially to 67 percent for students enrolled in a transferable college math course with corequisite support. For students in business and science, technology, engineering, and math pathways, completion increased from 10 percent to 59 percent. For those in the statistics pathway, the number grew from 10 percent to 69 percent. Additionally, for Latinx students, the number grew from 15 percent to 65 percent, and for Black students, completion was ninefold, jumping from 6 percent to 55 percent.¹⁰⁵

University System of Georgia:¹⁰⁶ In January 2013, Complete College America and The Charles A. Dana Center at The University of Texas at Austin worked with the University System of Georgia (USG) to create a statewide task force and implementation plan to explicitly address math course offerings, student success in those courses, and college completion.¹⁰⁷

Within a year of math pathways implementation with corequisite support, the USG saw marked success. In 2016, only 28 percent of students in the traditional remediation course successfully completed their gateway mathematics class. In the same year, 63 percent of students in the course with corequisite support completed the same gateway mathematics class.¹⁰⁸

Illinois Transitional Math Pathways: Illinois' Postsecondary and Workforce Readiness Act, passed in 2016, aims to ease student transition from high school to postsecondary institutions and the workforce. As a part of the PWR Act, transitional math courses and pathways are offered in high schools to ensure all that 12th-grade students will be ready for college prior to graduation. The transitional courses were also employed as a strategy to reduce remediation rates in college.¹⁰⁹

Currently, there are three math pathways options: one for STEM, one on quantitative literacy and statistics, and one for technical math. Upon course completion, students are guaranteed placement at any Illinois community college. The effort is still being scaled, so curricula and other relevant competency standards are still being fine-tuned.¹¹⁰

Ivy Tech Community College:¹¹¹ As Indiana's largest public postsecondary institution, Ivy Tech Community College was a leader in reimagining its math courses. The school partnered with Complete College America and The Charles A. Dana Center to collect data, plan, and implement new math pathways that would reduce remediation rates and increase math proficiency.¹¹²

In 2014, Ivy Tech Community College restructured and eliminated certain math courses to decenter college algebra as a gatekeeper course and created three new math pathways. The tech pathway emphasizes real-world applications, while the quantitative reasoning pathway supports students in public and social service fields, as well as in most health programs. Finally, the algebra-to-calculus pathway is tailored for majors in STEM, business, and specific liberal arts majors. Through corequisite remediation provided in these math pathways, student success rates in gateway math courses have increased from 29 percent to 64 percent.¹¹³

Marlborough High School:¹¹⁴ In 2014, Marlborough High School expanded its early college STEM career pathway to focus on grades six through 14. To do so, the school utilized grant funds and partnered with Jobs for the Future's Pathways to Prosperity Network,¹¹⁵ an initiative dedicated to coordinating cross-sector actors to build and expand career pathways.

Just two years later, the STEM pathway program saw large gains: 92 percent of students were math proficient, compared with 57 percent of their peers.¹¹⁶ As the program gained steam, the school expanded partnerships to include a local community college, a workforce development board, and local employers. Now, the school offers flexible math pathways for every student to ensure that they are enrolled in their chosen, relevant math course that will make them college and career ready.¹¹⁷

Maryland Mathematics Reform Initiative: The Maryland Mathematics Reform Initiative (MMRI) is dedicated to developing and implementing high-quality math pathways that better align with students' college major and ready them for careers. Made up of the University System of Maryland and the two-year community colleges in the state, the MMRI received a First in the World grant from the U.S. Department of Education to create a new developmental statistics pathway.¹¹⁸

The MMRI is still gathering data and conducting analysis to determine how to scale math pathways to all Maryland public institutions.¹¹⁹ However, the process is a model worth following to see how the MMRI will shift remedial math outcomes for students who need it most.

Ohio Mathematics Initiative:¹²⁰ In 2013, the Ohio Mathematics Steering Committee and the Ohio Department of Education started the Ohio Mathematics Initiative (OMI) to shift student success in degree programs and transferability among institutions. The OMI is led by math faculty who developed three pathways tailored to degree majors: statistics, quantitative reasoning, and STEM preparation.¹²¹

The OMI has helped higher education institutions redesign course outcomes for math transfer courses, including algebra and statistics. The program is also working to create and pilot a 12th-grade transition course, as well as slowly phasing out the lengthy developmental course sequence.¹²²

Oregon Math Project:¹²³ Under the Oregon Department of Higher Education, the Oregon Math Project aims to create multiple math pathways to offer students relevant math courses that align with their future career goals.¹²⁴ The proposed 2+1 Model under the Oregon Mathways Initiative, an effort under the Oregon Math Project, would encourage students to take the same two core math courses for their first two years of high school. Then, their third year would be tailored to the relevant math course.¹²⁵

The 2+1 Model reimagines math pedagogy and course content, as the three classes would ensure students were college- and career-ready in algebra, geometry, and statistics, as needed. Practitioners and stakeholders are still working on adjusting the framework prior to its implementation in 2020.¹²⁶

Tennessee Board of Regents:¹²⁷ Tennessee invested in significant changes across the state to improve college completion rates.¹²⁸ The Tennessee Board of Regents launched a pilot program in the 2014-15 school year in which it enrolled students

directly into a credit-bearing course with corequisite support. Within a year of implementing the corequisite model, passing rates in the remedial math course jumped from 12.3 percent to 63.3 percent.¹²⁹

Now, all 13 Tennessee community colleges have implemented their own math pathways, including corequisite supports, though they vary slightly by school. This way, students can choose among statistics, math for liberal arts, an algebra-to-calculus track, or another math course based on the most relevant pathway.¹³⁰ In the past, most first-time Tennessee students were enrolled in college algebra; however, as of fall 2016, 64 percent of first-time students elected into statistics.¹³¹

The Charles A. Dana Center at The University of Texas at Austin:¹³² The Charles A. Dana Center at The University of Texas at Austin launched the Dana Center Mathematics Pathways (DCMP), a center dedicated to ensuring equitable math access for all students in the K-16 system. The DCMP advocates for improving math quality and content, ensuring students take a college-level course in their first year, and utilizing evidence-based pedagogy.¹³³

Over the years, the DCMP has partnered with several states and dozens of institutions of higher education to create, develop, and implement math pathways. In Texas, the DCMP worked with the state's 50 community colleges and several four-year institutions to adopt multiple math pathways. The DCMP encouraged the implementation of statistics, quantitative reasoning, and STEM-prep pathways and explicitly ensured course and credit transferability between two-year and four-year institutions.¹³⁴ The work of the DCMP has transformed math education across the country and continues to advocate for math alignment and proficiency for all students.

University of Wisconsin System Math Initiative:¹³⁵ To remodel its current math system, the University of Wisconsin System Math Initiative is engaging faculty, advising staff, and reviewing national models. The Math Initiative aims to reevaluate gateway math courses and increase first-year credit-bearing math course enrollment rates. Additionally, it intends to reduce placement into developmental math courses and ensure transferability of math courses among University of Wisconsin schools.¹³⁶

The University of Wisconsin-Milwaukee implemented a new format of math pathways with quantitative reasoning and additional work group supports for students. As a result, developmental math course completion for freshmen increased from 55 percent to 70 percent. The University of Wisconsin System received a \$2 million grant from Great Lakes Higher Education Corporation & Affiliates and will use the funds to increase research, data collection, and analysis that will aid the Math Initiative until December 2020.¹³⁷

West Virginia Community and Technical College System:¹³⁸ The West Virginia Community and Technical College System (WVCTCS) adopted corequisite remediation to improve remediation rates in math and English. As a result, students enrolled in remedial math who also completed an associated, credit-bearing gateway course in one semester increased from 14 percent to 62 percent.¹³⁹ The WVCTCS model was so successful that the state's Higher Education Policy Commission removed all noncredit developmental courses and has seen an increase in student success.¹⁴⁰

Placing students into relevant math courses through pathways has trickled into West Virginia's K-12 districts as well. Currently, districts in the state choose between implementing traditional math pathways or integrated math pathways in their high schools. The content standards in the two pathways are the same, but the content is grouped differently based on the pathway per school year.¹⁴¹ Data are still being gathered, and though both pathways show promise of improving student math proficiency, integrated math pathways have been especially effective.¹⁴²

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