Hartzler, R., & Blair, R. (Eds.) (2019). *Emerging issues in mathematics pathways: Case studies, scans of the field, and recommendations*. Austin, TX: Charles A. Dana Center at The University of Texas at Austin.
Available at **www.dcmathpathways.org/learn-about/emerging-issues-mathematics-pathways** 

## Chapter 10

# The Case for Mathematics Pathways from the Launch Years in High School through Postsecondary Education

Lindsay Perlmutter Fitzpatrick
The Charles A. Dana Center
The University of Texas at Austin

Douglas Sovde
The Charles A. Dana Center
The University of Texas at Austin

## Abstract

Students are often "misprepared" for the mathematics they will need to take in college. Mispreparedness is the misalignment of math course-taking requirements and student aspirations. This chapter examines the changing definitions of college readiness and practices in higher education mathematics that have a positive impact on student completion. It synthesizes this knowledge into four recommendations for K–12 districts, in partnership with higher education, that will improve student preparedness for college.

## Background

Success in mathematics courses is essential to college completion and career preparation. The definition of "college ready in mathematics" has been evolving to better reflect what mathematics students need to know and be able to do to be successful in their postsecondary aspirations. Too often, there remains a disconnect between course-taking requirements and content relevance in states' graduation requirements as compared to the preparation students need to be successful in their first college credit-bearing course. Students are often misprepared for the mathematics they will need to take in college.

This chapter explores the impact of mispreparedness on students, where we define "mispreparedness" as misalignment of mathematics course-taking requirements and student aspirations. The chapter also examines the changing definitions of college readiness and practices in higher education mathematics that have a positive impact on student completion. It synthesizes this knowledge into four recommendations for K–12 districts, in collaboration with higher education systems, to improve student preparedness for college.

**The Mathematics Launch Years Toolkit** consists of briefs intended to support districts and higher education systems in streamlining the transition for students from high school to college. The "Mathematics Launch Years" in high school refer to the content that follows the foundational algebraic and geometric thinking usually located in Algebra I, Geometry, and parts of Algebra II courses. In Launch Years courses, students can explore mathematics pathways aligned to their postsecondary programs of study and career aspirations.

### The definition of mathematics college readiness is evolving.

Historically, College Algebra was intended to prepare students for Calculus, but in many postsecondary institutions, the course was treated as preparation for the majority of degrees. It became the default mathematics requirement for 80 percent of academic majors. However, most students do not need an algebra-intensive curriculum or Calculus to excel in their degree programs (Burdman, 2015). In 2004, the Mathematics Association of America (MAA), citing this serious mismatch between the original rationale for College Algebra and the mathematical needs of students who take the course, called for the end of College Algebra as a terminal mathematics course for graduation (MAA, 2004).

The recognition that College Algebra is not an appropriate default gateway course has since gained traction, culminating in a recommendation in 2015 from the MAA, along with four other major mathematical professional associations: the American Mathematical Association of Two-Year Colleges, the American Mathematical Society, the American Statistical Association, and the Society for Industrial and Applied Mathematics. These esteemed organizations reinforced MAA's recommendation, calling for implementation of multiple mathematics pathways aligned to fields of study, some of which should include early exposure to statistics, modeling, and computation (Saxe & Braddy, 2015). Colleges and universities across the country have begun to respond to this call by implementing and encouraging enrollment in mathematics pathways, such as quantitative reasoning, statistics, and the pathway

to Calculus (or STEM pathway). Many of these initiatives include a redesign of traditional algebra-intensive programs.

**High school graduates who are misprepared for college mathematics have only a small chance of earning a postsecondary certificate or degree.**

The expectation of Calculus-only preparation is firmly rooted in K–12 districts, creating a problem similar to the one in higher education in which students are put on the path to Calculus regardless of its relevance to their programs of study. Students' lack of opportunity to engage with mathematics that matters to them is one of the factors resulting in a reality in which an estimated 60 percent of incoming two-year college students are placed into at least one developmental mathematics course each year (Bailey, Jeong, & Cho, 2010). Developmental mathematics is a course or sequence of courses students pay for at the college for which they do not receive college credit.

Historically, developmental courses on higher education campuses have had low success rates. National data show only 21 percent of students referred to remediation at a two-year college complete a "gateway" college mathematics course within two years. A gateway course is the first course that provides transferable, college-level credit allowing students to progress in their programs of study. When disaggregated by ethnicity and income, the disparity is troubling. Only 11 percent of African American students and 19 percent of Pell grant recipients referred to developmental courses in mathematics earn college credit in a mathematics course within two years (Complete College America, 2016). In addition to low success rates, these courses present an unnecessary hurdle for students whose programs of study do not actually require the specific content knowledge taught in those courses.

Increasing the number of high school graduates who are ready for college is a moral imperative with significant equity implications. The challenge is to increase the opportunity for students graduating high school to smoothly continue their growth as a learner and doer of mathematics in college. With increased and relevant course-taking choices in postsecondary institutions, course offerings in high schools need to adjust accordingly. Districts should re-examine how they can systemically and equitably provide relevant course offerings, additional supports for students, effective advising practices, and teaching practices that ensure students are developing capacity as learners and have a sense of purpose when they engage with mathematics. Solving the mathematics alignment challenge between K–12 and higher education is essential to preparing a more diverse student population for a successful college transition.

## Evidence of Mathematics Pathways Success

The movement for mathematics pathways has been gaining traction. In Fall 2015, 58 percent of two-year colleges in the U.S. had implemented a pathways course sequence (Blair, Kirkman, & Maxwell, 2018). Students enrolled in institutions embracing this movement are benefiting from the increased focus on program-specific mathematics preparation and are more likely to succeed (Rutschow & Diamond, 2015). Examples of program-aligned mathematics pathways include a statistics course for a social science major or a rigorous quantitative reasoning course with real-world mathematics applications for an English major. Emerging evidence shows the benefit of mathematics pathways reform. In 2014, The University of Texas at Arlington began shifting enrollment from College Algebra to the mathematics courses required for students' majors. Between 2012 to 2015, the success rates for UT Arlington's students increased in all

gateway mathematics courses, including College Algebra, between 5 and 16 percentage points (Banda, 2017).

Research by MDRC found that students enrolled in the Dana Center Mathematics Pathways (DCMP) statistics pathway experienced higher engagement and achieved higher pass rates compared to those enrolled in traditional algebra-intensive mathematics courses (Rutschow & Diamond, 2015). The MDRC report stated *three* times as many DCMP students completed a gateway mathematics course in one year as compared to traditional mathematics sequences. Further, five times as many DCMP students completed a gateway mathematics course in one year for those enrolled in back-to-back mathematics courses. Students reported being "surprised by how relevant math could be to their lives and how they could more critically evaluate everyday quantitative information . . . . Many had started in the DCMP classes feeling they could never grasp math, and many left . . . more confident in their ability to approach the quantitative issues they face in their everyday lives" (Rutschow & Diamond, 2015, p. 53). The combination of taking mathematics courses with examples set in relevant, real-world contexts and embedded social and emotional supports, such as learning about malleable intelligence and effective study habits, proved integral to students' success in those courses. These promising results underscore the need for studies to demonstrate these effects at larger scales.

## Recommendations for a Mathematics Transition from High School to Postsecondary Education

The Dana Center makes the following recommendations to support students' seamless transition from K–12 to postsecondary institutions. These recommendations are directed to K–12 leaders although this work requires collaboration with, and leadership from, higher education.

### 1. Collaborate with postsecondary partners to align expectations for the mathematics launch years courses in high school to the mathematics pathways movement in higher education systems in the region.

The articulation of higher education mathematics pathways with the mathematics launch years courses—when supported with quality instructional resources and well-prepared teachers—will improve students' postsecondary access and attainment. The brief *K–12 and Postsecondary Collaboration to Improve Mathematics Course Alignment: Recommended Process and Case Studies* (Charles A. Dana Center, 2018) outlines successful collaboration efforts across the education continuum to align mathematics expectations. As part of the Mathematics Launch Years Toolkit, the brief recommends involving policy stakeholders, identifying key K–12 and higher education leaders and structures, and using data to identify one galvanizing charge.

### 2. Require four years of mathematics for high school graduation and encourage students to enroll in courses during all years of high school.

All high school students should take college-aligned, demanding mathematics each year to increase their chances of entering college prepared for college-level courses. In a study across three states of students who took the American College Test (ACT), 74 percent of those who had completed at least Algebra I, Geometry, and Algebra II moved directly into college-level, credit-bearing courses. The percentage increased to 83

percent for students who took an additional fourth year of advanced mathematics in high school (ACT, 2007). Students' mathematics launch years courses in the latter part of high school should finalize their preparation so they can progress directly into college-level mathematics courses.

### 3. Support all students in choosing which mathematics launch years courses to take based on their areas of academic, personal, and career interests.

High schools have the opportunity to expand mathematics preparation beyond the well-trodden, narrow path of Algebra I–to–Calculus sequence to include the diverse domains of mathematics students may need for their postsecondary degrees. All students need a foundation of essential algebraic, function, geometric, probabilistic, and statistical concepts, which are usually found in high school Algebra I, Geometry, and parts of Algebra II courses. The launch years of high school mathematics should offer a range of advanced high school and entry-level college mathematics courses that prepare students for the variety of mathematics pathways and career programs they will encounter in college. Courses that include applied algebra and statistics content cover a broader range of skills and critical thought processes appropriate for many fields of study. For example, when students encounter data and statistics, these courses teach students how to evaluate the validity of the information, draw conclusions, and strategically problem-solve.

By the fourth year of high school, many students are prepared to take foundational college-level mathematics courses through Advanced Placement (AP), International Baccalaureate, and other dual credit options. Some students may not yet be deemed college ready and can instead complete a college mathematics transition course. K–12 school districts and local institutions of higher education should begin or continue working together when choosing or developing fourth-year mathematics course options to confirm alignment to mathematics pathways in higher education.

The following options provide the opportunity for all twelfth graders either to finish preparing for college-level mathematics or to take the mathematics courses aligned with their programs of study. All courses should be demanding enough so students can move between the different mathematics pathways if they change to a new program of study that requires a different course sequence.

**Programs of Study Requiring Algebra-Intensive Mathematics:** The traditional Pre-Calculus and AP Calculus pathway is intended for individuals who are considering pursuing algebra-intensive majors in fields such as physical science, mathematics, biological science, computer science, engineering, business, or agriculture (Chen & Soldner, 2014). These majors typically require mathematics content that includes conceptual understanding, along with high levels of computational facility with algebraic and trigonometric expressions and functions. This content is covered in high school and college-level algebra and pre-calculus courses.

**Programs of Study Requiring Non-Algebra-Intensive Mathematics:** For students potentially interested in fields that do not require extensive knowledge of algebraic computation, other fourth-year mathematics course options—many of which are offered for dual credit—provide quantitative preparation more relevant to students' career aspirations. Statistics or quantitative reasoning courses taken after successful completion of Algebra II or an

equivalent course are intended for the large population of students pursuing degrees in fields such as the allied health sciences, public safety, or the liberal arts and social sciences (Cullinane & Treisman, 2012).

### 4. Identify students who are not ready for credit-bearing college mathematics by the end of their junior year and offer a twelfth-grade mathematics transition course.

High school students who need additional algebraic reasoning, statistics, and quantitative skills can benefit from enrolling in a transition mathematics course in their senior year. Twelfth-grade transition courses in mathematics are available in a growing number of states across the country including Florida, Illinois, New Jersey, New York, Tennessee, Texas, Ohio, and West Virginia (Community College Research Center, 2016). These intervention structures identify students who are not college ready in mathematics by the end of eleventh grade, and require or encourage these students to take transition mathematics courses to build quantitative reasoning skills before they graduate from high school. Another brief from the Mathematics Launch Years Toolkit discusses transition courses more deeply. The Dana Center's *Defining Content in a Transition to College Mathematics Course at the Regional or State Level* (2018) presents strategies for working across stakeholder groups to define mathematics content and includes a case study of this process in Texas.

## Conclusion

Students' success in college is greatly influenced by the mathematics they learn, how they learn it, and how they see themselves as a learner and doer of mathematics. It is time to better align the mathematics courses and expectations from high school to postsecondary education. The four recommendations in this chapter offer K–12 districts and higher education systems a place to start thinking about how they can tackle this work and alerts postsecondary education institutions and other stakeholders of the importance of aligning courses, programs, and systems to maximize student success.

## References

American College Test (ACT). (2007). *Rigor at risk: Reaffirming quality in the high school core curriculum*. Retrieved from http://files.eric.ed.gov/fulltext/ED496670.pdf

Bailey, T., Jeong, D. W., & Cho, S. W. (2010). Referral, enrollment, and completion in developmental education sequences in community colleges. *Economics of Education Review, 29*, 255–270.

Banda, S. (2017, March 24). South Texas Regional Convening. Edinburg, TX.

Blair, R., Kirkman, E. E., & Maxwell, J. W. (2018). *Statistical abstract of undergraduate programs in the mathematical sciences in the United States: Fall 2015 CBMS survey*. Providence, RI: American Mathematical Society.

Burdman, P. (2015). *Degrees of freedom: Varying routes to math readiness and the challenge of intersegmental alignment*. Retrieved from http://edpolicyinca.org/sites/default/files/PACE%202.pdf

Charles A. Dana Center. (2018). *Defining content in a transition to college mathematics course at the regional or state level*. Austin, TX: Author.

Charles A. Dana Center. (2018). *K–12 and postsecondary collaboration to improve mathematics course alignment: Recommended process and case studies*. Austin, TX: Author.

Chen, X., & Soldner, M. (2014). *STEM attrition: College students' paths into and out of STEM fields* (NCES 2014-001). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Retrieved from http://nces.ed.gov/pubs2014/2014001rev.pdf

Community College Research Center. (2016). *What we know about transition courses*. New York: Community College Research Center, Teachers College, Columbia University. Retrieved from http://ccrc.tc.columbia.edu/publications/what-we-know-about-transition-courses.html

Complete College America. (2016). *Data collection*. Retrieved from https://ccacollection.sheeo.org/cca/

Cullinane J., & Treisman, P. U. (2012). *Improving developmental mathematics education in community colleges: A prospectus and early progress report on the Statway initiative*. (A National Center for Postsecondary Research Working Paper). Austin, TX: The Charles A. Dana Center at the University of Texas. Retrieved from http://files.eric.ed.gov/fulltext/ED533871.pdf

Mathematical Association of America. (2004). *Undergraduate programs and courses in the mathematical sciences: CUPM curriculum guide 2004*. Retrieved from http://www.maa.org/sites/default/files/pdf/CUPM/cupm2004.pdf

Rutschow, E. Z., & Diamond, J. (2015, April). *Laying the foundations: Early findings from the New Mathways Project*. Retrieved from http://www.mdrc.org/publication/laying-foundations

Saxe, K. & Braddy, L. (2015). *A common vision for undergraduate mathematical sciences programs in 2025*. Retrieved from http://www.maa.org/sites/default/files/pdf/CommonVisionFinal.pdf

## About the authors

**Lindsay Perlmutter Fitzpatrick** is a senior policy analyst at the Charles A. Dana Center at The University of Texas at Austin, where she analyzes current trends in mathematics education and develops resources for policymakers and education leaders that leverage the trends to help expand equity and access to a high-quality education for all students. She develops tools to support K–12 districts and higher education systems in aligning mathematics pathways and addressing any related policy issues. Lindsay had taught social studies in high schools and middle schools in New York City through Teach For America and to majority low-income student populations in Austin.

**Doug Sovde** is director of K–12 education strategy, policy, and services at the Charles A. Dana Center at The University of Texas at Austin, where he leads both the strategic direction and partnerships necessary to create equity-driven, high-quality professional learning, instructional materials, and policy and advocacy at scale. He collaborates with coalitions of school district and equity leaders to support sustainable systemic change. In addition, Doug provides thought leadership at local, state, and national levels to help steward the K–12 mathematics and science education fields toward approaches and policies that benefit all students.