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MATH PATHWAYS

Expanding Options for Success in College Math

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Algebra has traditionally been the default math requirement for most college degrees. However, algebra is designed to prepare students for calculus rather than for the type of math many students need in their majors, jobs and lives. Only 10 to 15 percent of algebra students intend to continue on to calculus or major in a math-intensive subject.[1]

This disconnect creates obstacles for students working toward a college credential. College algebra has been called "the single most failed course in community colleges," with various researchers and practitioners estimating failure rates for the course around 50 percent.[2] Instead of providing a foundation for upper-level courses in students' majors, algebra more often ends up functioning as a gatekeeper to higher education for students not majoring in a math-dependent field.

Students assigned to developmental math — pre-college, non-credit courses intended to prepare students for college-level math — face an even bigger hurdle. Overall, 59 percent of community college students and 33 percent of students at four-year public colleges test into developmental math, and students of color and low-income students are overrepresented in developmental courses.[3] But few of these students complete the math requirements for a degree — and the more developmental math courses students must take, the less likely they are to complete their math requirements. One research study found that in community colleges, only about 32 percent of students referred to developmental math completed a college-level math course within three years.[4]

In an effort to make math courses more relevant and improve success rates in college math, various organizations and colleges developed a new model of math education that has come to be called *math pathways*.[5] Math pathways enable students to take different paths through the math curriculum, depending on their course of study.

COMMON PRINCIPLES OF MATH PATHWAYS MODELS

Math pathways enable students to take different paths through the math curriculum so the math they learn is relevant to their course of study. Key elements of the models are:

- Developmental and college-level math courses that are aligned with different programs of study and career paths.
- Developmental requirements that take less time to complete than traditional developmental math.
- Active, collaborative learning.
- Challenging and engaging coursework with a focus on real-world problem-solving.

A communications, history or Spanish major might satisfy his or her college math requirement with a quantitative reasoning course, while a political science, journalism or nursing student might take statistics. Math, chemistry and economics majors stay on the algebra pathway. Some colleges offer math courses for specific majors, such as math for elementary education or math for business.

Developmental courses in math pathways also focus on statistics, quantitative reasoning or algebra. Some developmental math pathways can be completed in a single semester, enabling students to finish their college math requirement during their first year. Others allow students to complete all of their math requirements in one semester by enrolling in a college-level math course with additional supports.[6] Organizations promoting math pathways are now incorporating this one-semester model — called corequisite remediation — because evidence suggests that it may help more students pass college math.[7]

With math pathways, college students learn math relevant to their academic and career pursuits. While only a small fraction of workers use higher-level math, employees in many occupations need data-analysis skills and an understanding of math concepts.[8]

Implementing math pathways so that students experience their full benefits can be challenging work. Leaders must address concerns that mathematical rigor requires the study of algebra and change graduation and transfer requirements that favor algebra courses. Rethinking math in this way requires coordination between two-year colleges and their four-year transfer partners, along with changes to state and college system policies. But for many students, multiple math pathways can remove the obstacle that algebra requirements often pose.

Below, we describe three prominent examples of math pathways and review research evidence on their effectiveness:

- Dana Center Mathematics Pathways (DCMP), developed by the Charles A. Dana Center at the University of Texas at Austin.
- Carnegie Math Pathways, developed by the Carnegie Foundation for the Advancement of Teaching and now run by WestEd.
- Math pathways developed by the California Acceleration Project (CAP), a faculty-led professional development network supporting **California**'s community colleges.

The studies described below used different methods of analysis and do not enable a direct comparison of outcomes or impacts. However, they do provide multiple points of evidence that math pathways are a promising approach for enabling more students to complete their college math requirements and progress toward a degree.

Dana Center Mathematics Pathways

The DCMP model, first implemented in 2013–14 at nine colleges in **Texas**, consists of three pathways: statistics, quantitative reasoning and a path to calculus.[10] In its original design, DCMP enabled students who traditionally would have needed one or two semesters of developmental math to take one semester of Foundations of Mathematical Reasoning (or a similar locally developed course), which includes numeracy, statistics, algebra and quantitative reasoning skills. After passing this course, students enrolled in a college-level statistics, quantitative reasoning or algebra course, depending on their major. The Dana Center is now recommending that colleges use corequisite models.[11] The Dana Center is also working with states to help lay the organizational and policy groundwork to implement math pathways and support math faculty and administrators in implementing them.[12]

The strongest evidence for math pathways to date comes from a random assignment study by the Center for the Analysis of Postsecondary Readiness (CAPR), whose researchers are studying the impact of DCMP at four colleges

CLEARING ALGEBRA PREREQUISITES IN California

Until recently, both the California State University and the University of California systems had designated intermediate algebra as a prerequisite for any college-level math course, including statistics and liberal arts math. That meant that developmental math courses in community colleges — where about 80 percent of students started out — had to focus on algebra.

In summer 2017, the Cal State Chancellor's Office issued an executive order broadening the courses that satisfy the general education quantitative reasoning requirement and removing intermediate algebra as a requirement for transfer students — clearing the way for math pathways in community colleges. The UC system, which is less centralized, also removed the intermediate algebra prerequisite for statistics, but not for quantitative reasoning or liberal arts math.[9]

in **Texas**.[13] Students in need of developmental math education were assigned to either DCMP courses or traditional developmental courses. After three semesters, students assigned to DCMP were nearly 50 percent more likely to have passed college-level math than those assigned to the traditional developmental sequence. Because random assignment ensures that the students in the two groups were similar at the start of the study, CAPR researchers are confident that the higher pass rates are due to DCMP and not to differences in students' prior education, motivation or other factors.[14]

Progression and Completion in Math, Fall 2015 and Spring 2016 Cohorts

	PASSED **Developmental Math**	ENROLLED **in College-Level Math**	PASSED **College-Level Math**
Dana Center Mathematics Pathways	56%	36%	25%
Traditional Developmental Math	48%	21%	17%

Arkansas' State-Level Planning for Math Pathways

In **Arkansas**, all 22 public two-year colleges and 11 four-year colleges have committed to implementing math pathways by fall 2018. Working with the Dana Center, the state convened a math task force made up of math faculty members from all of the state's public institutions, co-chaired by a two-year math faculty member and a four-year math faculty member and facilitated by representatives from the Arkansas Department of Higher Education and the state's Student Success Center. The task force developed recommendations for the implementation of math pathways, vetted those recommendations across the state, developed a plan for scaling, secured institutional commitments to implement math pathways, and formed working groups to define student learning outcomes for each pathways course and explore issues related to the transfer and applicability of math credits. To help determine the best pathway for each major, the task force surveyed faculty from various departments about which math skills their students need. Based on the results, the task force made recommendations about which course — statistics, quantitative reasoning or college algebra — would be most appropriate for each program, and the department of higher education is working with all public institutions in the state to adopt the recommendations.[15]

Carnegie Math Pathways

Launched in classrooms in 2011, Carnegie Math Pathways consists of two main pathways: Statway and Quantway. Statway was initially designed as a yearlong, college-level statistics course with support for developmental math students. Today, Statway is also offered as a single-term accelerated course and as a college-level statistics course with corequisite support. Quantway was initially designed as a two-semester, quantitative reasoning sequence — the first term at the developmental level and the second at the college level. It is now offered as a yearlong course with integrated support for developmental students; as a single-term, developmental course followed by a single-term, college-level course; and as a college-level course with corequisite support.

A WestEd study compared Statway students at 39 colleges who started between fall 2011 and fall 2016 with students in traditional developmental courses in 2008 at 18 of the colleges. The study is descriptive and did not control for

differences between the two groups. The results show that a much higher percentage of Statway students earned college-level math credit within one year than students in the traditional math sequence.[16]

College-Level Math Pass Rates, Fall 2011 to Fall 2016 Cohorts

	PASSED **College-Level Math**		
MATH OPTION TAKEN	Within **1 Year**	Within **2 Years**	Within **3 Years**
Yearlong Statway	54%		
Accelerated Statway	70%		
Traditional Developmental Math, 2008 Cohort	6%	15%	20%

The study also compared Quantway students at 27 colleges who started between fall 2011 and spring 2017 with traditional developmental math students at six of the same colleges. As shown in the table, a higher percentage of Quantway students passed developmental math.[17]

Developmental Math Pass Rates, Fall 2011 to Spring 2017 Cohorts

	PASSED **Developmental Math**	
DEVELOPMENTAL MATH OPTION TAKEN	Within **1 Semester**	Within **2 Semesters**
Quantway	63%	
Traditional Developmental Math	21%	29%

Among those who enrolled in the college-level Quantway course between 2012 and 2016, 71 percent passed and earned credit. The study did not report on the percentage of developmental students who continued in the college-level course.[18]

The Spread of Carnegie Math Pathways in the State University of New York

Faculty leadership and administrative support were essential to the spread of the Carnegie Math Pathways model in the State University of New York system, where community colleges are locally governed and faculty control curricula. Instead of mandating the adoption of math pathways, SUNY encouraged math faculty to learn about the Carnegie model and see if it would be valuable for their students. Two community colleges first adopted the model, and SUNY supported the scaling of math pathways by securing a grant from the Bill & Melinda Gates Foundation and providing matching funds — which allowed faculty and administrators to discuss strategies for innovative teaching and learning through a series of statewide and regional professional development opportunities. Now, 28 of SUNY's 64 colleges use Carnegie Math Pathways.[19]

California Acceleration Project

CAP developmental math, first implemented by eight colleges in the 2011 academic year, is based on a set of design principles that originally led colleges to replace multiple levels of coursework with one or two courses focused on the skills needed for college-level statistics.[20] CAP now advocates that colleges place developmental students in college-level math pathways courses paired with corequisite supports.

An evaluation by the RP Group compared the completion of college-level math courses by students in the accelerated courses and students in traditional developmental courses in the 2011 academic year. This study used statistical methods to control for differences between students in the two groups. It found that the odds of completing college-level math were 4.5 times greater for students who took CAP math pathways than for those who took traditional developmental math.[21] After controlling for demographic and academic factors, the accelerated courses were estimated to allow 38 percent of students to complete a college-level course within two academic years, compared with 12 percent in traditional developmental courses.[22]

Math Pathways at Cuyamaca College in California

In 2011, working with CAP, Cuyamaca College began offering an accelerated statistics pathway as an alternative to developmental algebra. In fall 2016, Cuyamaca created five different math pathways — general education, education, career and technical education, business and STEM — and began offering corequisite remediation.

Now, all liberal arts and career and technical students can start in college-level statistics with corequisite support. Most students in STEM and business pathways are eligible for college STEM or business math if they enroll concurrently in a support course. The changes allowed 67 percent of underprepared students who began in corequisite math courses in 2016–17 to complete college-level math within a year, up from 10 percent of underprepared students who began in developmental math courses under the traditional model in 2015–16.[23]

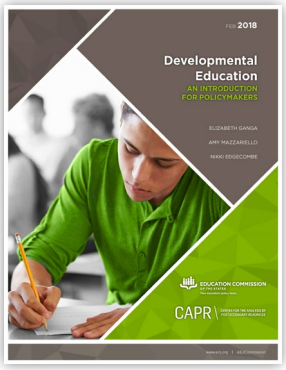
Supporting the Adoption of Math Pathways

Math pathways require major changes to developmental and college-level math courses. Because of that, policies and practices — and sometimes laws — need to change at the level of the institution, college system and state to allow for the full adoption of math pathways. There are several common barriers to adoption, including policies and practices that make it difficult for students to transfer credits between colleges and apply them to a major; misaligned prerequisites that, for instance, require a student to take algebra before statistics; biases in favor of algebra as a prerequisite even if algebra skills are not needed in a major; and disagreements between departments and colleges about the most appropriate math requirements.[24]

State and system policymakers can take several steps to ensure that colleges, faculty members, advisors and transfer partners have the support they need to successfully implement math pathways.

- ✓ **Facilitate the revision of math requirements** based on the skills needed for particular majors. With faculty input and buy-in across two- and four-year colleges, revise math requirements and prerequisites so that they can be fulfilled by statistics, quantitative reasoning and other math courses relevant to each major.

- ✓ **Ensure that credits earned in math pathways courses transfer** between colleges and that they can be used to satisfy major requirements. Solicit binding commitments from four-year colleges to accept math pathways courses for major credit and establish consistent requirements that are clear to students, advisors and faculty.
- ✓ **Facilitate cooperation** between two- and four-year colleges and different departments within colleges. Include advisors and non-math department faculty and administrators in discussions about requirements and credit transfer policies.
- ✓ **Support new approaches to advising** to prioritize helping students choose programs and the appropriate math courses for their programs.
- ✓ **Add supports for faculty members** to create high-quality college-level, developmental and support courses; to teach new math subjects; and to teach in new ways.
- ✓ **Set up a system to collect and analyze data** to measure students' progress, identify areas for programmatic improvements and examine the implications of math pathways for equity gaps.
- ✓ **Coordinate math pathways with other reforms** to developmental education or the college more broadly, such as reforms to developmental course placement, efforts to improve transfer and initiatives to create more structured programs through guided pathways.
- ✓ **Partner with K-12 systems** to ensure more students graduate college-ready in math and begin exploring majors and careers.
- ✓ **Allocate funding** to colleges for implementing math pathways.
- ✓ **Keep abreast of research**, because while the early evidence on math pathways is promising, rigorous research about the effects on student outcomes is still in the early stages. Additionally, new research often includes practical lessons that can help policymakers learn from others' experiences.



This resource is the second in a series about developmental education. The first installment is *Developmental Education: An Introduction for Policymakers*.

ENDNOTES

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