DCMP Call To Action

October 2016

Dana Center Mathematics PATHWAYS

The Case for Mathematics Pathways

A working knowledge of basic mathematics empowers individuals to engage productively in today's society and economy, which is increasingly reliant on data and quantitative reasoning. Yet all too often, mathematics is an obstacle rather than an opportunity to students who want to achieve their career goals through higher education.

A growing body of evidence identifies traditional postsecondary mathematics as a primary barrier to degree completion and equitable outcomes for millions of students. Traditional entry-level college mathematics programs fail to serve students well because they are structured as disconnected courses whose content is misaligned to students' career and life needs. Underprepared students are especially impacted by multi-semester course sequences. These long sequences underestimate the capability of students to learn mathematics and delay students' engagement with college-level coursework that is required for their degree programs.

__The Charles A. Dana Center at The University of Texas at Austin__ is committed to promoting equity and access to quality math and science education for all students. Through the Dana Center Mathematics Pathways (DCMP), we promote course structures that support college students to learn mathematics content that is rigorous and meaningful to their lives and to progress towards students' timely completion of a certificate or degree. To learn more about the DCMP, visit our resource site at __www.dcmathpathways.org__.

This brief presents the case that a *mathematics pathways* solution can significantly increase student success by addressing two structural drivers of the problem: 1) the mismatch of content, and 2) long, multi-semester course sequences. Mathematics pathways refer to 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.

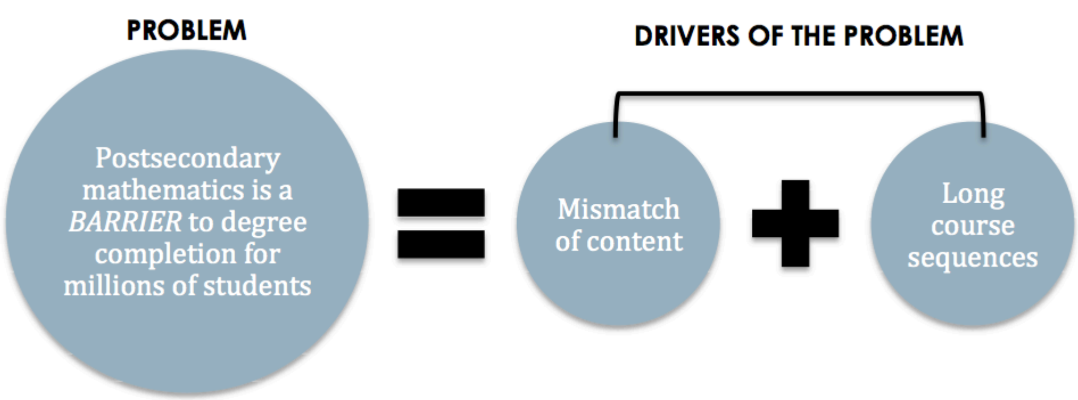

Figure 1. Drivers that create barriers for students.

Problem: Mathematics is a barrier to degree completion and equitable outcomes for millions of students.

Traditional mathematics courses have been found to be the most significant barrier to degree completion for all fields of study (Saxe & Braddy, 2015). Nationally, an estimated 60 percent of incoming two-year college students are placed into at least one developmental math course each year. Unfortunately, only 33 percent of those students complete the developmental math sequence and 20 percent complete a college-level math course (Bailey, Jeong, & Cho, 2009). To compound the situation, college-level mathematics courses also have high failure rates. Each year in the United States, only 50 percent of students pass the most commonly enrolled gateway math course, College Algebra, and fewer than 10 percent of students who pass this class enroll in Calculus, the gateway to STEM degrees (Gordon, 2008).

Outcomes are especially troubling for minority and underserved students. These populations are vastly overrepresented in remedial math courses and are consequently disproportionately impacted by the high rates of failure (EdSource, 2012). In 2012, only 55 percent of California's higher education students passed math courses that counted toward their degrees. Worse yet, a demographic breakdown found success rates of only 49 percent for Hispanic and 41 percent for African American students as compared to 60 percent for white students.

Placement practices also contribute to the problem by over-placing minority and underserved students in remedial education. There are multiple dimensions to this problem including reliance on a single assessment, the improper use of cut-off scores, the questionable validity of assessments, and assessment procedures that have negative impacts on student performance (Burdman, 2015).

While these data are discouraging, new data from mathematics pathways implementation of the past five years provide clear insight into understanding that the main drivers of these high failure rates are not about the capabilities of the students themselves, nor are they a reflection of the commitment and skill of those working in remedial education. Rather, the reasons behind high failure rates lie in how these mathematics courses are structured.[1] Below we describe these two drivers in detail and offer key recommendations for dramatically improving student success.

Driver #1: Traditional entry-level math programs are not aligned with students' mathematical needs.

For decades, College Algebra has been the gateway mathematics course in higher education. In 2010, 54 percent of four-year college students and 80 percent of two-year college students were enrolled in entry-level (e.g., College Algebra) or precollege algebraic-intensive mathematics coursework (Blair, Kirkman, & Maxwell, 2013).

College Algebra was originally intended to prepare students for Calculus. Over time, however, College Algebra became the default mathematics experience for most students, 80 percent of whom do not need an algebra-intensive curriculum, let alone

[1] See *Core Principles for Transforming Remediation within a Comprehensive Student Success* (2015).

Calculus, to excel in their degree programs (Gordon, 2008). In 2004, the Mathematical Association of America (MAA) called for the end of using College Algebra as a terminal mathematics course, citing this serious mismatch between the original rationale for College Algebra and the mathematical needs of students who take the course (MAA, 2004).

In 2015, the MAA, along with four major mathematical professional associations—the American Mathematical Association of Two-Year Colleges (AMATYC), the American Mathematical Society (AMS), the American Statistical Association (ASA), and the Society for Industrial and Applied Mathematics (SIAM)—operationalized this recommendation, calling for multiple mathematics pathways that are aligned to fields of study, some of which should include early exposure to statistics, modeling, and computation (Saxe & Braddy, 2015). Colleges and universities have begun to respond positively by implementing and encouraging enrollment in a small number of math pathways, such as quantitative reasoning, statistics, technical mathematics (for certificate programs) and a redesigned algebraic-intensive/or Calculus pathway.

Unfortunately, due to the prevailing practice of advising the majority of students into College Algebra, the availability of math pathways to students has been limited. There is still a misconception that math pathways limit opportunities for students. Another misconception is that better prepared students should take College Algebra and underprepared students should take alternate pathways such as statistical or quantitative reasoning. However, as is shown below, all students benefit from and should have the opportunity to learn mathematics that is relevant to their academic interests and goals regardless of their preparation.

In order to succeed in converting math pathways to normative practice, it is critical to ensure that the transfer *and* applicability of the courses to degree plans is as consistent and predictable as College Algebra. Consequently, a key strategy for implementing mathematics pathways is for mathematics departments to work with partner disciplines across institutions to align math pathways to the appropriate programs of study.

In response to national and state leaders' call for increased mathematical skills by students in statistics, the Charles A. Dana Center released A Call to Action to Expand Access to Statistics to encourage mathematics departments to expand access so that students are allowed to enter directly into Introductory Statistics, and to eliminate or replace stand-alone prerequisite courses that do not adequately prepare students for statistics content.

Additional Resource:
Mathematics Prerequisites for Success in Introductory Statistics

Evidence of Math Pathways Success

When students engage with mathematics relevant to their programs of study—for example, a statistics course for a social science major or a rigorous quantitative reasoning course with real-world mathematics in finance or citizenship for an English major—they are more motivated and more likely to succeed (Rutschow & Diamond, 2015). While there have not been any large-scale studies to determine whether expanding options for gateway courses increases student success, there is emerging evidence that shows promise. In 2014, The University of Texas at Arlington began shifting enrollment out of College Algebra and into quantitative reasoning and statistic courses. The success rates increased in all three-gateway courses.

Students enrolled in the New Mathways Project (NMP) statistics pathway experienced higher engagement and achieved higher grades and pass rates as compared to those enrolled traditional algebraic intensive math courses. NMP 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 NMP classes feeling they could never grasp math, and many left . . . more confident in their ability to approach the quantitative issues that they face in their everyday lives" (Rutschow & Diamond, 2015, p. 53).

Driver #2: Long developmental course sequences decrease students' chances of completing a credit-bearing math course.

Traditional entry-level math programs have been particularly harmful to the majority of underprepared students. Students who are not deemed college ready upon matriculation traditionally must enroll in a long sequence (often three semesters) of remedial coursework before they are allowed to enroll in a college-level math course.

Numerous studies show that these long course sequences have high attrition rates (Bailey, Jeong, & Cho, 2010; Hern, 2010). Students' progression is further complicated by several exit points, in which students leave the sequence by not enrolling, not passing, and/or not persisting to their college-level math course. Bailey et al. (2009) examined data on more than 141,000 students enrolled in Achieving the Dream colleges over a four-year period, who were referred to one to three developmental mathematics courses before taking college-level math. Only 10 percent of students who were referred to three courses of developmental mathematics and enrolled in a developmental course completed a college-level mathematics course in three years. The rate across all students enrolled in developmental mathematics was 20 percent; that is, over 113,000 students in this study did not proceed to college-level work.

These studies highlight a need to change how the success of our programs is evaluated. Rather than being satisfied with success in individual courses, we need to know whether students reach important milestones and complete meaningful requirements. Success rates in individual courses may be relatively high, but this metric obscures the effect of attrition between courses and the inevitable multiplicative attrition over a two- or three-course sequence.[2] By changing the metric to success in earning college-level credit, which is a critical milestone in overall completion of a degree, the devastating effect of long course sequences to students is revealed.

Evidence of Math Pathways Success

The research demonstrating the detrimental impact of long course sequences led to numerous efforts to accelerate the pathways to-and-through college-level gateway mathematics courses. While not the silver bullet for eliminating failure in postsecondary mathematics, there is now mounting evidence that a large majority of students, including those who are referred to developmental mathematics, can succeed in college-level math courses with appropriate support.

[2] ***Multiplicative attrition*** refers to the attrition over a sequence of courses. For example, individual courses may have a success rate of 70 percent; after two courses, only 49 percent (.7 x .7 = .49) of the original cohort succeed; and after three courses, only 34 percent succeed.

Several initiatives have developed models that combine acceleration and alignment to programs of study for students referred to developmental math. These initiatives fall into two categories: one-semester models and one-year models. Figure 2 illustrates the student success rates in these initiatives and in traditional sequences. These data clearly show that underprepared students can succeed in college-level math courses at higher rates and in less time as compared to students in traditional developmental sequences (Bailey et al., 2010; California Acceleration Project, 2015; Complete College America, 2016; Rutschow & Diamond, 2015; Sowers & Yamada, 2015).

Most stunning, the highest rates of success have come from one-semester *corequisite*[3] models, which have inherent in them a belief that underprepared students have capacity for learning mathematics at the college level. Furthermore, when one-year models are appropriate, their success is greatly increased when the first and second semesters are linked through *back-to-back math*.[4]

The common denominator of these initiatives is the structures that address the two drivers described above: placing students into meaningful and rigorous math pathways *and* creating courses that accelerate the progress of underprepared students.

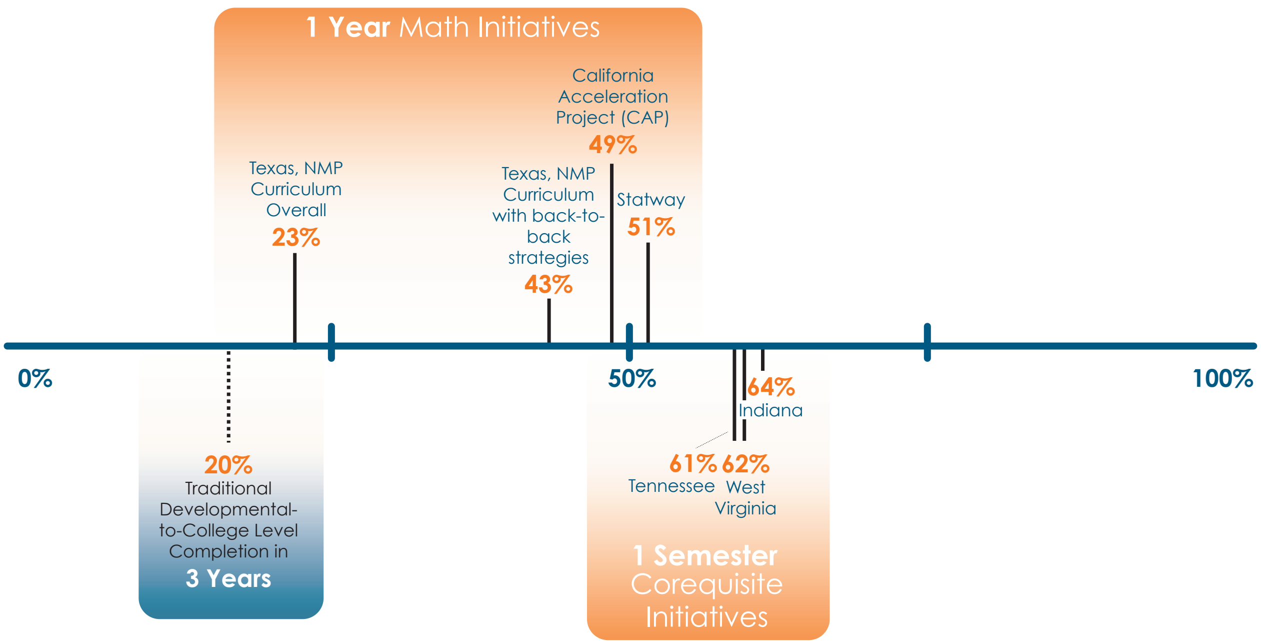

Figure 2. Percentage of developmental students who earn college-level math credit. (Time frame is indicated for the traditional sequence and the one-semester and one-year models.)

[3] ***Corequisite*** refers to the practice of placing students directly in college-level courses, regardless of preparation, and providing these students with supports for just-in-time instruction. For more information about corequisite models, see *Developmental Education Structures Designed for the Readiness Continuum: Aligning the Co-requisite Model and Student Needs* (2012).

[4] See *Back-to-Back Math: Strategies for Ensuring Successive Semester Enrollment* (2015).

This brief makes the case that many more students (up to three times more) will be successful in rigorous, challenging, and relevant courses that are part of well-designed mathematics pathways shaped by standards reflecting the policy and practice guidelines of the major professional associations. Implementing math pathways requires institution- and state-level changes that align students' mathematics courses to their programs of study and allow students to enter into college-level courses quickly.[5] Making these two major structural changes will have a significant positive impact on student success and will allow faculty and student support services to then focus their attention on continuous improvement efforts to the integration and alignment of student success strategies and evidence-based curriculum and pedagogy.

We affirm the following points:

1. A key success metric in evaluating math pathways is the percent and number of students who earn credit in a college-level math course that is appropriately aligned to their program of study.
2. Students should enroll in math pathways that reflect their intended programs of study.
3. The appropriate mathematics pathway for a particular student should be based on student's academic interests and goals and not on level of preparation.
4. Unless there are compelling reasons, underprepared students should enter into accelerated pathways with a one-semester co-requisite model as the default.
5. There should be accelerated structures for all pathways including the algebraic-intensive pathways leading to Calculus.

The evidence presented in this brief is only a summary of the information and research on this complex topic.

We hope this call to action will encourage mathematics educators and higher education administrators to seriously consider implementing the multiple pathways at the institutions they serve. More information can be found at the DCMP resource site, www.dcmathpathways.org.

[5] The Dana Center believes that most students should enter directly into a college-level math course with appropriate supports for underprepared students. Any other placement should be based on evidence that it will increase the student's chance of success. We recognize that some students may need more intensive instruction than can be provided in highly accelerated or intensified classes. Therefore, along with our partner organizations, we are calling for an initiative to address this issue in ways that allow us to responsibly serve *all* students seeking to improve their lives through higher education.

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About the Dana Center Mathematics Pathways

The Dana Center Mathematics Pathways (DCMP) is a systemic approach to dramatically increasing the number of students who complete math coursework aligned with their chosen program of study and who successfully achieve their postsecondary goals. The DCMP was initially launched as the New Mathways Project (NMP) in 2012 through a joint enterprise with the Texas Association of Community Colleges. For more information about the DCMP, see www.dcmathpathways.org.