Mathematics Pathways: Scaling and Sustaining

In 2010, the Charles A. Dana Center made a commitment to create mathematics pathways that support students' needs and success in college. Since that time, we have worked with other organizations, professional associations, state systems, institutions, and individual faculty and institutional leaders to increase equity and opportunity to higher education through mathematics pathways.

The results have been impressive. Mathematics pathways are not only understood and accepted more broadly, but the concept has also received the stamp of approval from the mathematics community.[1] The Dana Center has worked directly with more than a dozen states on pathways implementation. Hundreds of colleges and universities have begun implementation and tens of thousands of students are more engaged in learning meaningful mathematics and experiencing increased success.[2] While not yet universal, there is a feeling of inevitability in the movement to implement mathematics pathways, especially as they are increasingly understood to be an essential component of guided pathways.

The Charles A. Dana Center at The University of Texas at Austin is committed to promoting equity and access to quality mathematics 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.

In the spirit of continuous improvement, the Dana Center sees this as an appropriate time to reflect upon our collective accomplishments, assess what we have learned, and identify where to go from here. Clearly, we have come a long way in a short time, but there are still many students who do not have access to the benefits of mathematics pathways.

Our Collective Call to Action

Implementing systemic change is no easy feat. The greatest challenge is staying the course until we create a new reality for *all* students. This approach requires deeply embedding mathematics pathways into the culture and practice of institutions to ensure equitable access for all. Gaps in access and achievement will only be closed when the full population of students—including underrepresented minorities, first-generation students, and those who are low income—have the opportunity to benefit from improved structures and practices.

Three factors to assess progress towards normative practice at scale

- *Transfer and applicability across institutions*
- *Alignment of mathematics pathways within institutions*
- *Appropriate placement into gateway courses and support structures*

Therefore, we challenge the field to engage in a critical assessment of the depth and breadth of implementation of mathematics pathways. In our definition, full normative practice at scale is achieved at the institutional level when:

1) Every student is advised into a high-quality, rigorous mathematics pathway based on their academic goals;
2) Every student has an opportunity to complete the first college-level mathematics course in one year or less, with direct entry into a college-level course being the default; and
3) Equitable and accurate methods are used to determine every student's readiness for college level material.

At a state level, full implementation is achieved when all two- and four-year institutions have reached full implementation.

Based on the Dana Center's work, we have identified three critical factors that can be used to assess whether mathematics pathways have been fully implemented as normative practice at scale to support success for all students.

Factor 1: Consistent and Predictable Transfer and Applicability

Students need uniform transfer policies and the consistent applicability of mathematics courses and credits across institutions and between programs of study. An unpredictable system creates an atmosphere in which community colleges are reluctant to innovate for fear of creating misalignment with their transfer partners. It is also more difficult for students, advisors, and faculty to navigate a complex system of diverse requirements.

Community college students, or any students transferring between institutions, can face a number of problems with both *transfer* and *applicability* when transferring mathematics credits:[3]

1) Transfer: The course a student has taken at the two-year level is not accepted by the four-year institution.
2) Applicability: The course transfers for elective credit, but the credits are not applied to the student's chosen degree program because…
   a) the program has a different course requirement, or
   b) the institution or programs do not accept that particular course from the sending institution as equivalent.

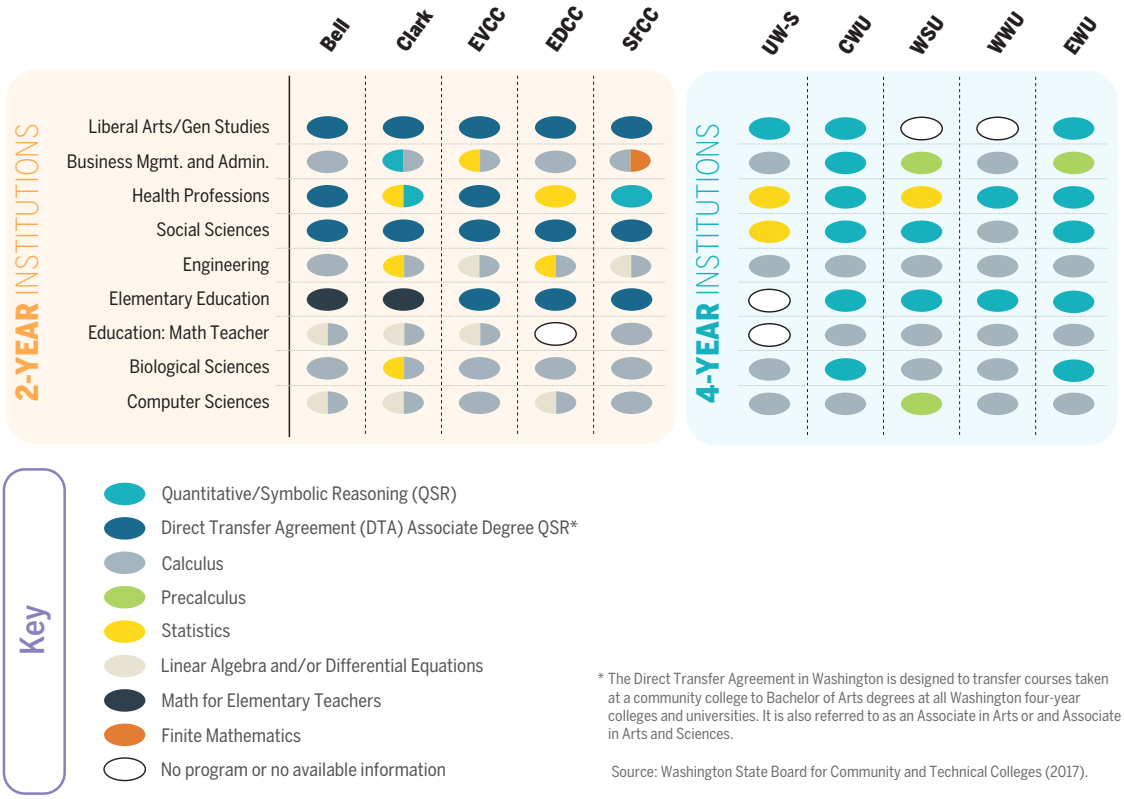
These obstacles can lead to credit loss or the accumulation of excess credits. Further, the sheer diversity of requirements across four-year institutions exacerbates the issue and often leads advisors to recommend that students take College Algebra, even if it is not appropriate for students' goals. Underserved populations are disproportionately affected by obstacles to transfer and applicability since they are more likely to attend community college.[4]

How to assess progress: Analyzing the math requirements for programs across institutions can help determine the extent to which transfer and/or applicability is an obstacle to students. States can begin by examining the math requirements of programs with the largest transfer populations across institutions, as shown in the example below, to help

identify inconsistent requirements that impact large numbers of students. It is also helpful to ask advisors about obstacles to transfer and applicability to surface both real problems and misconceptions that adversely impact students.

A student perspective: A community college student in Washington who plans to pursue a Bachelors' degree in the Social Sciences may have to choose from up to 15 mathematics course options. Looking at the requirements at four-year institutions (Figure 1) is of little help since some institutions require Statistics, some require Calculus, and others do not require any college-level math. This situation creates unnecessary complexity into the already complex process of a student's initial entry into higher education.

Figure 1. Math requirements for high-enrollment programs in Washington.



* The Direct Transfer Agreement in Washington is designed to transfer courses taken at a community college to Bachelor of Arts degrees at all Washington four-year colleges and universities. It is also referred to as an Associate in Arts or and Associate in Arts and Sciences.

Source: Washington State Board for Community and Technical Colleges (2017).

Factor 2: Alignment of Mathematics Pathways

Students need clear and accurate guidance about which mathematics pathway to enroll in. An effective onboarding process helps students understand options and clarify goals to select an appropriate math pathway. This is often seen purely as an advising issue, but it is, in fact, an institutional issue of which advising is a key component.

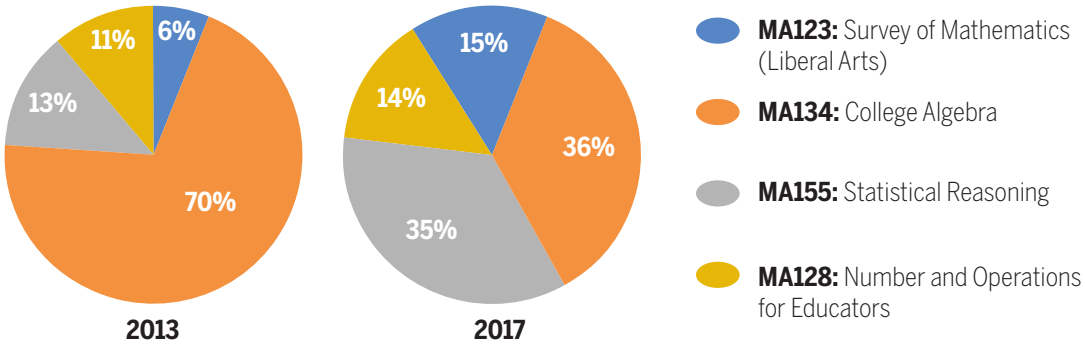
Advisors can only implement the recommendations made by departments. Therefore, it is essential that mathematics departments collaborate with partner disciplines to establish clear, evidence-based, default mathematics requirements that align to programs of study. Ideally, math requirements should be consistent across institutions to minimize excessive or lost credits accrued by students.

Once default math requirements are set, advisors need proper training and resources to enroll students into the appropriate math pathways. A well-designed set of guided pathways or meta-majors can greatly support this process. Institutions should also consider a default pathway for undecided students based on data about what programs students are most likely to enter.

How to assess: If an institution has fully implemented math pathways, the proportion of students in various gateway math courses should mirror the proportion of students in programs. For example, if 40% of students are enrolled in programs for which Statistics is the default gateway course, approximately 40% of the enrollment in gateway mathematics courses should be in Statistics. A rough assessment can be made by looking at the number of sections offered for each gateway course.

An institutional perspective: When Southeast Missouri State University (SMSU) implemented math pathways, enrollment in the four gateway mathematics courses changed dramatically. This shift was a leading indicator that SMSU was successful in early implementation. Further assessment of progress can be made by analyzing whether the new enrollments are in line with percentages of students in programs associated with each course.

Figure 2. Changing enrollment in Southeast Missouri State University math pathways.



Source: Used with permission from Dr. Tamela Randolph, Interim Provost, Southeast Missouri State University.

Factor 3: Appropriate Placement and Acceleration Options

Students need placement practices and course structures that allow them to complete gateway math courses successfully in the shortest time possible. It is increasingly clear that many students have been underplaced into developmental mathematics.[5] Traditional placement practices are often inaccurate in predicting student success and, in some cases, have actually been shown to have a negative impact.[6] This is especially true for mathematics pathways because the tests are largely algebra-based and have little or no relationship to the readiness requirements for non-algebraically intensive courses.[7] Therefore, evidence-based placement practices using multiple measures increase the opportunity for students to enroll directly into a college-level course.[8]

Students who truly do need support to be successful in the college-level course can be supported through accelerated structures. Mounting evidence indicates that one-semester co-requisite course models for students who are underprepared for college-level

mathematics greatly increase completion of a gateway mathematics course and decrease time to degree, thus saving time and money.[9] Because underrepresented minorities and first-generation students are disproportionately placed into developmental math,[10] access to accelerated structures increases equitable access to critical gateway courses.

Even in institutions with accelerated course options, there is often a reluctance to expand access to one-semester co-requisite courses beyond a narrow band of students close to placement cutoffs. Access can also be limited by small numbers of sections being offered or by advisors' reluctance to advise students into co-requisite courses if there is a traditional option. Growing evidence indicates that more students at all levels of preparation are more successful in co-requisite courses than in traditional sequences—it is time to expand access to these beneficial options.[11] The default should be to place the student in the most accelerated option possible. A student should only be placed into a year-long model if there is strong evidence indicating that option will increase the likelihood of success compared to a one-semester co-requisite model.

A student perspective: Andrés Salazar entered the College of the Canyons with the goal of earning a Bachelor's degree in Music Conducting. Based on his Accuplacer score, he would have been placed into Arithmetic and required to take four semesters of math before entering a college-level course. This placement gave Andrés a 12% chance of earning college credit in math in three years. But College of the Canyons used multiple measures, taking into account Andrés' 4.0 high school grade point average and his A in Algebra II, and allowed him to enroll directly into Elementary Statistics where he earned an A in one semester.* Unfortunately, the majority of students like Andrés continue to face unnecessary barriers to college completion even in institutions with co-requisite courses as illustrated in the following data from Texas.

A state perspective: A Texas Higher Education Coordinating Board survey demonstrates the disparity between offering co-requisite courses and creating full access to students. Eighty percent of 64 community colleges reported offering co-requisites for mathematics in Fall 2017. However, 62% of the colleges reported that less than 25% of developmental students were enrolled in co-requisite courses and 44% reported having less than 10% enrolled. Only 4% of the institutions enrolled 50% or more students in co-requisite courses.[12]

How to assess: Assessing whether placement practices have hurt or helped students is challenging because success or failure is measured against the unknown of what would have happened with a different placement. It is all too tempting for faculty to focus on the success or failure of individual students and to attribute failure to misplacement. Therefore, careful data collection and conversations with faculty and student services professionals about data are essential.

It is important to understand that the metric is student success over time, not just success in one particular course. The baseline data should track the progression of student cohorts as they move through course sequences and measure the likelihood that students achieve important milestones. Completion of the gateway mathematics course is one milestone, but it is also important to note that students in many STEM fields need to take multiple math courses. As institutions seek to increase equity and success in STEM, they should also track progress through the Calculus sequence at a minimum.

Institutions can and should compare their results with those from other institutions. If other institutions with similar populations have successfully expanded access to college-

*Andrés' story is shared with permission from the California Acceleration Project. Learn more about Andrés and other students in the publication *Up to the Challenge*, http://accelerationproject.org/Portals/0/Documents/Cap_Up%20to%20the%20challenge_web_v4.pdf.

level courses at scale and over time, it is reasonable to expect similar results. Institutions that do not accept that expanding access will be effective or do not experience similar success should have frank, open, and respectful discussions about the discrepancies in practice or outcomes.

Summary: Our Work Continues

The speed at which math pathways have gone from a novel idea to the accepted vision for modernizing entry-level college mathematics is truly remarkable. Many institutions and systems have made significant progress towards full implementation and continue to strive for the vision described in this brief.

Our challenge now is to continue to support institutions and systems to make math pathways normative practice at full scale. This means we must support the spread of math pathways to states and institutions not yet engaged *and* to assess and increase the depth and quality of existing implementations in order to provide the best possible opportunities for all students to be prepared, enabled and empowered by their mathematical learning experience.

Endnotes: A brief list of references is included here. See the full Notes and Resources at https://dcmathpathways.org/resources/call-action-mathematics-pathways-scaling-and-sustaining-notes-and-references-supplement.

[1] Saxe, K., & Braddy, L. (2015). *A common vision for undergraduate mathematical science programs in 2025*. Washington, DC: Mathematical Association of America.

[2] Data compiled from multiple sources. Please see https://dcmathpathways.org/resources/call-action-mathematics-pathways-scaling-and-sustaining-notes-and-references-supplement.

[3] Bailey, T., Jenkins, D., Fink, J., Cullinane, J., & Schudde, L. (2017). *Policy levers to strengthen community college transfer in Texas*. New York, NY: Community College Research Center, Columbia University & Austin, TX: The University of Texas at Austin.

[4] Hodara, M., Martinez-Wenzel, M., Stevens, D., & Mazzeo, C. (2016). *Improving credit mobility for community college transfer students: Findings and recommendations from a 10-state study*. Portland, OR: Education Northwest.

[5] Scott-Clayton, J., Crosta, P. M., & Belfield, C. R. (2014). Improving the targeting of treatment evidence from college remediation. *Educational Evaluation and Policy Analysis*, *36*(3), 371-393.

[6] Smith-Jaggars, S., & Stacey, G. W. (2014). *What we know about developmental education outcomes*. New York, NY: Columbia University, Teachers College, Community College Research Center.

[7] Logue, A.W., Watanabe-Rose, M., & Douglas, D. (2016). Should students assessed as needing remedial mathematics take college-level quantitative reasoning courses instead? A randomized controlled trial. *Educational Evaluation and Policy Analysis, 38*(3), 578-598.

[8] Belfield, C., & Crosta, P. M. (2012). *Predicting success in college: The importance of placement tests and high school transcripts*. (Working Paper No. 42). New York, NY: Columbia University, Teachers College, Community College Research Center. Retrieved from https://ccrc.tc.columbia.edu/publications/predicting-success-placement-tests-transcripts.html.

[9] Complete College America. (2016). *Corequisite remediation: Spanning the completion divide*. Retrieved from http://completecollege.org/spanningthedivide/.

[10] Chen, X. (2016). *Remedial coursetaking at U.S. public 2- and 4-year institutions: Scope, experiences, and outcomes (NCES 2016-405)*. National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC. Retrieved from https://nces.ed.gov/pubs2016/2016405.pdf.

[11] Complete College America. (2016). *Corequisite remediation: Spanning the completion divide*. Retrieved from http://completecollege.org/spanningthedivide/.

[12] Texas Higher Education Coordinating Board. (2018). *Summary of 2017 Developmental Education Program survey responses – Community colleges*. Unpublished data; used with permission.

Mathematics Pathways: Scaling and Sustaining
Notes and References supplement

The brief *Mathematics Pathways: Scaling and Sustaining* presents information that is based on a large number of references. The printed version of the brief provides a short list of the most relevant citations. This document provides a more extensive list along with a few explanatory notes.

This list is organized by topic according to the sections of the brief.

Introduction

Mathematics Professional Associations on Mathematics Pathways

- American Mathematical Association of America. (2018). *IMPACT*. Retrieved from https://amatyc.site-ym.com/mpage/IMPACT.
- Committee on the Undergraduate Program in Mathematics. (2004). *Undergraduate programs and courses in the mathematical sciences: CUPM Curriculum Guide 2004*. Retrieved from the Mathematical Association of America website: http://www.maa.org/sites/default/files/pdf/CUPM/cupm2004.pdf.
- Conference Board of the Mathematical Sciences. (2016). *Collective effort to improve the first two years of college math statement by presidents of CBMS member professional societies.* Retrieved from http://www.cbmsweb.org/2016/10/collective-effort-to-improve-the-first-two-years-of-college-math-statement-by-presidents-of-cbms-member-professional-societies/.
- National Research Council. (2013). *The mathematical sciences in 2025*. Washington, DC: The National Academies Press.
- Saxe, K., & Braddy, L. (2015). *A common vision for undergraduate mathematical science programs in 2025.* Washington, DC: Mathematical Association of America.

Notes on the following statement, page 1: "*Hundreds of colleges and universities have begun work on their campuses and tens of thousands of students are more engaged in learning meaningful mathematics and experiencing increased success.*" This claim is based on the combined effects of the work across multiple projects and organizations.

- 88 institutions in Arkansas, Michigan, Missouri, Oklahoma, and Washington committed to implementing mathematics pathways through the Dana Center Mathematics Pathways (DCMP). Charles A. Dana Center at The University of Texas at Austin. (2018). *Implementation Connect - January 2018.* Austin, TX: Author. Retrieved from https://dcmathpathways.org/sites/default/files/resources/2018-02/MPC-implementation-connect-january2018-v2.pdf.

- 50 community college districts formed a collaboration with the Dana Center to implement mathematics pathways. In addition, 38 Texas universities have engaged in this effort. See lists of institutions by region at http://dcmathpathways.org/where-we-work/texas.
- 12 community colleges and universities participated in the University of Maryland's First in the World grant to implement a statistics pathway.
- 19 community colleges and universities in Tennessee implemented mathematics pathways as a part of a statewide initiative. This work went full scale in Fall 2015. See https://www.tbr.edu/sites/tbr.edu/files/media/2016/12/TBR%20CoRequisite%20Study%20-%20Full%20Implementation%202015-2016.pdf.
- 48 community colleges and universities in Montana and Ohio developed implementation plans for mathematics pathways through the joint Dana Center/Complete College America project "Building Math Pathways to Programs of Study. See http://dcmathpathways.org/where-we-work/building-math-pathways-programs-study, https://www.ohiohighered.org/math.
- 26 institutions in the University of Georgia system are implementing mathematics pathways as part of a statewide student success agenda. See https://www.completegeorgia.org/math-pathways.
- Over 90 institutions have implemented Statway and/or Quantway as part of the Carnegie Math Pathways network. See https://www.carnegiemathpathways.org/#.
- 45 California community colleges were offering accelerated statistics pathways in 2016. Rodriguez, O., Johnson, H., Cuellar Mejia, M., & Brooks, B. (2017). *Reforming math pathways at California's community colleges.* San Francisco, CA: Public Policy Institute of California.

Factor 1: Consistent and Predictable Transfer and Applicability

Obstacles to Transfer

- Bailey, T., Jenkins, D., Fink, J., Cullinane, J., & Schudde, L. (2017). *Policy levers to strengthen community college transfer in Texas*. New York, NY: Community College Research Center, Columbia University & Austin, TX: The University of Texas at Austin.
- Berkner, L., & Choy, S.(2008). *Descriptive summary of 2003-04 beginning postsecondary students: Three years later (NCES 2008-174)*. Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Retrieved from https://nces.ed.gov/pubs2008/2008174.pdf.
- Crisp, G., & Nuñez, A.-M. (2014). Understanding the racial transfer gap: Modeling underrepresented minority and non-minority students' pathways from 2-year to 4-year institutions. *Review of Higher Education*, *37*(3), 291-320.

- Horn, L., & Skomsvold, P. (2011). *Community college student outcomes: 1994–2009 (NCES 2012-253)*. Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Retrieved from https://nces.ed.gov/pubs2012/2012253.pdf.
- Martinez-Wenzl, M., & Marquez, R. (2012). *Unrealized promises: Unequal access, affordability, and excellence at community colleges in Southern California*. Los Angeles, CA: The Civil Rights Project.
- Shapiro, D., Dundar, A., Huie, F., Wakhungu, P., Yuan, X., Nathan, A., & Hwang, Y., A. (2017, April). *Completing college: A national view of student attainment rates by race and ethnicity – Fall 2010 cohort* (Signature Report No. 12b). Herndon, VA: National Student Clearinghouse Research Center.
- Taylor, J. L., & Jain, D. (2017). The multiple dimensions of transfer: Examining the transfer function in American higher education. *Community College Review, 45*(4), 273-293.

Factor 3: Appropriate Placement and Acceleration Options

Placement

- Belfield, C., & Crosta, P. M. (2012). *Predicting success in college: The importance of placement tests and high school transcripts.* (Working Paper No. 42). New York, NY: Columbia University, Teachers College, Community College Research Center. Retrieved from https://ccrc.tc.columbia.edu/publications/predicting-success-placement-tests-transcripts.html.
- Bracco, K. R., Dadgar, M., Austin, K., Klarin, B., Broek, M., Finkelstein, N., Mundry, S., & Bugler, D. (2014). *Exploring the use of multiple measures for placement into college-level courses: Seeking alternatives or improvements to the use of a single standardized test*. San Francisco, CA: WestEd.
- Logue, A.W., Watanabe-Rose, M., & Douglas, D. (2016). Should students assessed as needing remedial mathematics take college-level quantitative reasoning courses instead? A randomized controlled trial. *Educational Evaluation and Policy Analysis, 38*(3), 578-598.
- Melguizo, T., Kosiewicz, H., Prather, G., & Bos, J. (2014). How are community college students assessed and placed in developmental math? Grounding our understanding in reality. *Journal of Higher Education, 85*(5), 691-722.
- Ngo, F., Chi, W. E., & Park, E. Y. (2018). Mathematics course placement using holistic measures: Possibilities for community college students. *Teachers College Record, 120*(2), 1-42.
- Ngo, F., & Melguizo, T. (2016). How can placement policy improve math remediation outcomes? Evidence from community college experimentation. *Educational Evaluation and Policy Analysis*, *38*(1), 171–196.
- Scott-Clayton, J., Crosta, P. M., & Belfield, C. R. (2014). Improving the targeting of treatment evidence from college remediation. *Educational Evaluation and Policy Analysis, 36*(3), 371-393.

- Smith-Jaggars, S., & Stacey, G. W. (2014). *What we know about developmental education outcomes.* New York, NY: Columbia University, Teachers College, Community College Research Center.

Co-Requisite and Accelerated Structures

- California Acceleration Project. (2017). *Up to the challenge: Community colleges expand access to college-level courses*. Retrieved from http://accelerationproject.org/Publications/ctl/ArticleView/mid/654/articleId/56/Up-to-the-Challenge-Community-Colleges-Expand-Access-to-College-Level-Courses.
- Charles A. Dana Center, Complete College America, Education Commission of the States, & Jobs for the Future. (2012). *Core principles for transforming remedial education: A joint statement.* Retrieved from https://www.jff.org/resources/core-principles-transforming-remedial-education-joint-statement/.
- Chen, X. (2016). *Remedial coursetaking at U.S. public 2- and 4-year institutions: Scope, experiences, and outcomes (NCES 2016-405)*. Washington, DC.: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Retrieved from https://nces.ed.gov/pubs2016/2016405.pdf
- Complete College America. (2016). *Corequisite remediation: Spanning the completion divide.* Retrieved from http://completecollege.org/spanningthedivide/.
- Denley, T. (2017). *Co-requisite remediation full implementation 2015-16*. Nashville, TN: Tennessee Board of Regents.
- Ganga, E., Mazzariello, A., & Edgecombe, N. (2018). *Developmental education: An introduction for policymakers.* Denver, CO: Education Commission of the States.
- Henson, L., Huntsman, H., Hern, K., & Snell, M. (2017). *Leading the way: Cuyamaca College transforms math remediation.* Sacramento, CA: The California Acceleration Project.
- Hoang, H., Huang, M., Sulcer, B., & Suleyman, Y. (2017). *Carnegie Math Pathways 2015 - 2016 Impact report: A 5-year review.* Stanford, CA: Carnegie Foundation for the Advancement of Teaching.
- Logue, A.W., Watanabe-Rose, M., & Douglas, D. (2016). Should students assessed as needing remedial mathematics take college-level quantitative reasoning courses instead? A randomized controlled trial. *Educational Evaluation and Policy Analysis, 38*(3), 578-598.