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 5

Key Considerations in Designing Co-requisite Supports

Connie Richardson
The Charles A. Dana Center
The University of Texas at Austin

Jennifer Dorsey
The Charles A. Dana Center
The University of Texas at Austin

Abstract

Postsecondary developmental mathematics sequences were designed to give underprepared students more time to master mathematical concepts and to improve success in the college-level course. However, research indicates that these sequences often become a barrier even for students who pass individual courses. Many institutions and their students are finding success with co-requisite courses, placing underprepared students directly into college-level courses with additional supports. Many systems and states implementing such strategies have been experiencing success, with some seeing five to six times the number of students passing their first college-level mathematics course in half the time or less. This chapter explores the structural, cultural, and content decisions made by institutions in implementing co-requisite courses, such as those related to student placement, curricular design, and whether just-in-time supports are separate or embedded. The chapter presents the results of interviews with faculty and administrators at two-year and four-year institutions. Key considerations for designing co-requisite courses are delineated and supported with institutional examples. Recommendations drawn from the learning sciences are also provided.

Introduction

The term *mathematics pathways* refers to a mathematics course or sequence of courses that college-ready or underprepared students take in order to meet the requirements of their program of study. The two critical principles in developing mathematics pathways are that students should engage immediately with mathematics content that supports their program of study and that systemic structures should enable them to complete a transferable course within their first year of college (Charles A. Dana Center, n.d.). Pathways courses and sequences have been most often available in Quantitative Reasoning, Statistics, and Algebra/STEM (Science, Technology, Engineering, Mathematics).

Traditional developmental content and course structure in mathematics often works at odds with these two principles. Long developmental mathematics sequences can mean two years or more of remediation, even for students who successfully complete each course in the sequence. Long sequences also offer multiple exit points for students who fail a class or fail to register for the next class in a sequence (Bailey, Jeong, & Cho, 2010; Xu & Dadgar, 2016). Also, much of the content in the traditional sequence is designed to be relevant primarily for students who are in a STEM degree program, while content that would support success in a wider range of fields is lacking.

Co-requisite course instruction is becoming a popular strategy to accelerate mathematics course completion and to ensure that students are entering directly into an appropriate mathematics pathway at the college level. While there are many versions of co-requisite instruction, the broad definition refers to the placement of students who have been designated as underprepared directly into college-level courses and providing additional supports.

The implementation of co-requisite strategies has been shown to act as a multiplier in the percentages of students passing their first college-level mathematics course in states and systems across the country. Some institutions and states that have implemented co-requisite structures are reporting five to six times the number of students completing a college-level course within one semester or one year. For example, the Tennessee Board of Regents Office of Institutional Research reported that, even in the first year of implementing corequisites, 60 percent of students completed their developmental requirements and college-level course in one semester when previously, 12 percent completed the same courses within a year (Denley & Knox, 2016). Other institutions and systems have reported similar success rates with co-requisite courses, with 70 percent of students or more completing their developmental requirement and college-level course in one semester. (For more information on the history of co-requisite models, see Adams, Gearhart, Miller, & Roberts, 2009; Asera, 2001.)

In response to these successful initiatives, the Charles A. Dana Center has received queries from the field about the best model for co-requisite mathematics. In order to learn more about the specifics of co-requisite implementation at two- and four-year institutions and systems that self-reported success to the field, Jennifer Dorsey, a member of the Dana Center evaluation team, conducted in-depth interviews with mathematics faculty and administrators to determine to what these institutions and systems attribute their success (see Appendix A for the interview protocol; see Appendix B for participants in the Dana Center's data gathering). Selected artifacts from these interviews and our other interactions with the field can be found by searching for "co-requisite" at dcmathpathways.org.

This chapter presents the learnings from these interviews. What is clear from those conversations is that there is no single way to successfully implement co-requisite courses on a campus, but there are specific areas where decisions will need to be made when designing a course sequence. Content considerations and strategies for building a strong learning culture within the corequisite classroom, along with a look at the broader context of comprehensive redesign that often leads to even stronger results, are included in this chapter. In addition, recommendations are provided for co-requisite implementation and continuous improvement based on the Dana Center's extensive experience in the field.

When designing and constructing the co-requisite model(s) that will best serve each institution (and each pathway), many decisions should be made in collaboration with faculty, advisors, administrators, and financial aid staff. These decisions revolve around three large categories of considerations: structures, content, and culture.

Considerations When Designing Co-requisite Course Programs

At institutions with widespread co-requisite success, strong pathways implementation has been of fundamental importance. At those institutions, only calculus-intending students are in an algebraically-intensive sequence; students in programs that do not require calculus are placed in a course more appropriate to their goals, such as introductory statistics or quantitative reasoning. In Tennessee, for example, over 60 percent of students take statistics as their gateway mathematics course (Jenkins, Brown, Fink, Lahr, & Yanagiura, 2018). Indiana's statewide community college system, Ivy Tech, enrolls approximately half of its students in a quantitative reasoning course. In other states, it varies by institution whether students are predominantly in statistics, quantitative reasoning, or the algebraic pathway.

Designing the Structure of Co-requisite Courses

Co-requisite courses take many forms: boot camps, extended hours each week with embedded support content, separate but linked support courses that run throughout the semesters, mandatory tutoring, compressed courses, stretch courses, and other structures—all of which enable a student to complete a college-level course while receiving developmental mathematics support (see Appendix C). Structural considerations also include factors such as staffing, placement, and whether to have students co-mingle or be part of a cohort.

Co-requisite Designs

Many co-requisite designs can be used together successfully; in fact, a combination of designs may be called for. Many institutions have found that separate but linked support courses work well for quantitative reasoning or statistics courses, but they have struggled with that structure for the algebraic/STEM pathway. Instructors note the difficulty of starting College Algebra at the beginning of the semester when students have algebraic deficiencies. To compensate, the College Algebra course is often offered as a cohort model. This structure allows the developmental content to be frontloaded with many of the fundamental algebraic skills that will be needed as soon as the college-level content begins. A frontloading alternative to cohort classes for College Algebra is the boot-camp model in which a short course runs at the beginning of the semester and then a co-mingled structure begins after four or five weeks. Such frontloading is generally not necessary for other pathways.

Regardless of the design structure or the pathway, repeated information from the field found that more highly structured courses result in better success. Teresa Adams from the Community College of Denver reports that her institution's original model basically functioned as a homework hour, resulting in disengagement by students and frustration on the part of faculty. When faculty changed the model to include more targeted interventions to prepare students for the upcoming class, the climate of both the college-level and the support classes changed. The developmental students became more engaged and confident, often becoming the leaders of the college-level class.

If a co-requisite course is designed for students who are only slightly underprepared (e.g., placed at the Intermediate Algebra level under the old system), then one additional hour of support per week may be sufficient. If the co-requisite course is designed to replace multiple levels of developmental content, then several additional hours per week may be necessary. Dr. Christopher Herald at the University of Nevada–Reno reports that the general education mathematics course is supported by one additional co-requisite hour, while the Precalculus 1 course has two additional hours of support. Dr. Markus Pomper at Roane State Community College notes that his institution's three-credit-hour statistics course is paired with three hours of support. The Dana Center advises to "over-plan" supports initially, and then reduce the hours if the data indicate it may be feasible to do so.

Staffing

Co-requisite design teams sometimes do significant planning and design work before realizing they created a structure that they cannot staff. Developmental courses may be staffed with faculty who lack the credentials to teach college-level courses and/or are not trained to teach statistics or quantitative reasoning when pathways are designed. However, there is not a clear distinction between staffing a cohort and staffing a co-mingled class. It is possible to have one instructor with a co-mingled class and possible to have two instructors with a cohort class.

Cohort or Co-mingle

Some institutions have gravitated toward a cohort model so that the remediation takes place "in the moment." For example, San Jacinto College uses a cohort model for College Algebra that meets seven hours per week. The class moves seamlessly between college-level work and remediation as needed. This model requires a common instructor (some institutions use two co-instructors) and may be difficult or impossible to implement if college-level credentialed instructors are in short supply. Alternatively, choosing a co-mingled model

Table 1. Cohort and co-mingle with one and two instructors

	Cohort	Co-mingle
One instructor	Can be run as two distinct classes or as one seamless class with all of the same students	Must be two distinct classes (college-level and separate support class)
Two instructors	Two distinct classes with all of the same students	Must be two distinct classes (college-level and separate support class)

allows the institution to choose to continue utilizing developmental staff to teach the support course. There may still be staffing difficulties as the increase in college-level sections may strain the capacity of the department but the challenges would not seem as extreme if those sections were taught under a single-instructor cohort model. Additionally, in the co-mingled model, developmental students are able to attend college courses with their college-ready peers, which gives them access to classmates with more diverse ability levels.

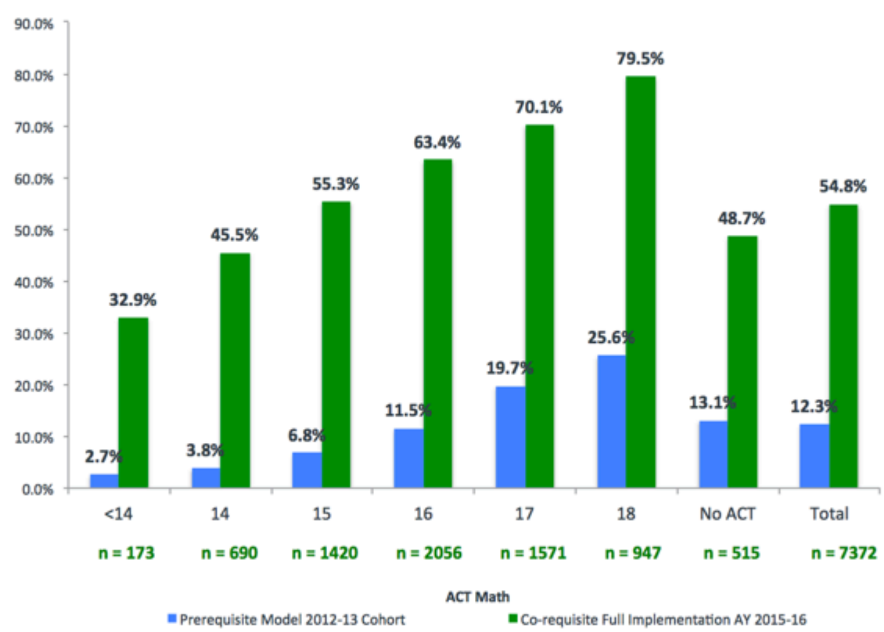
Placement

Placement into co-requisite courses is achieved in a variety of ways at college campuses, with some institutions placing only "bubble" students, or students who are missing the cutoff score for college placement by only a few points, into co-requisite courses. Other colleges and systems, including the Tennessee system (Denley & Knox, 2016) are placing all developmental students directly into college-level courses with co-requisite support with positive results.

Multiple measures placement has resulted in more students being placed directly into credit-bearing math courses, rather than remediation. Some institutions allow students with uneven academic records (e.g., sufficient high school GPA but low placement score or vice versa) to opt into supports, while students who are low in both GPA and placement score are required to take the support course. Cuyamaca College, a member of the California Acceleration Project, reports that multiple measures placement drastically reduced the number of students needing support courses, while simultaneously making great gains at closing achievement gaps.

Placement can also vary by pathway; if the existing placement instrument is algebraically-intensive, it may be given less consideration for placement into non-algebraically-intensive pathways courses. For those students still deemed as underprepared for college-level work, co-requisites are being employed as just-in-time remediation and extra time on task to directly support the appropriate pathways course.

Figure 1. Tennessee community colleges gateway math success in one year (adapted from Denley, 2016)



Designing the Content of Co-requisite Courses

Historically, all underprepared students received the same developmental mathematics instruction that focused on algebraic skills. Institutions that have redirected students to mathematics courses that are better aligned with programs of study are able to rethink and customize the skills content instruction provided. Rather than looking backward at a standardized marker of middle school and high school mathematics content, designers are able to look forward: What knowledge, skills, and strategies will meet the underprepared students where they are, and move them forward to success in their aligned gateway course? What other cultural considerations are needed?

For calculus-intending students, their needs are still heavily algebraic, and the only question is how much of the prerequisite content they are missing and when and how it will be provided. Offering a typical Intermediate Algebra course alongside a typical College Algebra course is unlikely to improve outcomes and may create further confusion, as the support content will usually be out of sync with the college course. Design teams will have greater success if they start from a departmentally standardized college algebra course and backmap to determine the essential foundational concepts to provide to students in the support course. Sometimes these programs also use the support course to build in additional time on the college-level content.

Students in liberal arts, health sciences, and social sciences are often served by a quantitative reasoning or introductory statistics course. Underprepared students in those pathways should receive support content that is appropriate for those courses. For example, underprepared students in introductory statistics are best supported with extra instruction in decoding statistics problems, determining which statistical test is appropriate, and analyzing results. Underprepared students in quantitative reasoning courses are provided extra instruction in numeracy, proportional reasoning, modeling, and statistical literacy. Dr. Becky Moening, from Ivy Tech Community College in Indiana, stresses the importance of the designers of the gateway course and the support course working closely together to ensure that the supporting content aligns and that the design teams engage in regular continuous improvement cycles. Roane State Community College created a co-requisite instructor manual with a common course calendar and student worksheets for its statistics co-requisite course.

Mathematics requirements for Business and Education programs vary broadly. There are examples in which these programs are aligned to College Algebra, quantitative reasoning, and statistics as well as to specialized business math and education math courses. Regardless of the required college-level course, the most successful institutions align the support content to the gateway content.

Other Content Considerations

Some institutions report student disengagement in support courses. In order to build urgency for students, most programs provide separate assessments to students in the support course. The determination of final grades varies, but one common structure is shown on the next page.

In addition to consideration of time on support content and college-level content, many programs devote some amount of time in the support course to learner success strategies. These strategies include explicit instruction in goal-setting, self-regulation, and the value of struggle, all of which can increase persistence.

Table 2. Pass/fail support courses at Roane State Community College in Tennessee

	Pass college-level course	Fail college-level course
Pass support course	Gen Ed is requirement satisfied. Unless other math courses are needed, remediation requirements are satisfied.	Student repeats college course. Repetition of remedial class is optional.
Fail support course	Gen Ed is requirement satisfied. Unless other math courses are needed, remediation requirements are waived.	Student repeats both classes.

The Comprehensive Approach and Recommendations

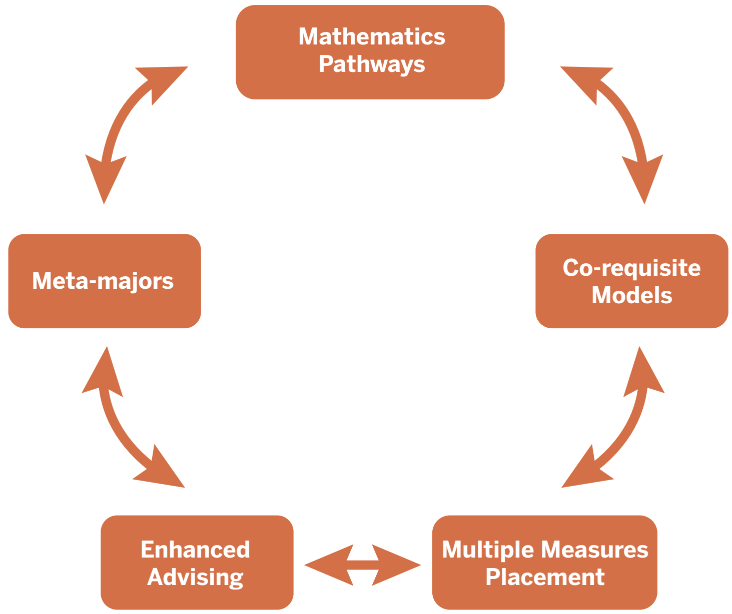
Culture Considerations

Although not exclusive to co-requisites, culture shifts are taking place across the country due to changes in funding models and, in some areas, declining enrollments.

- Shifting the culture of the department from “sink-or-swim” to “we’re all in this together” is a component of many successful programs. Departments that have focused on early referral have seen increased success and decreased withdrawals.
- Emphasizing this collaborative culture with students has often resulted in the organic formation of peer support groups.
- Explicit instruction about the purpose and benefits of the co-requisite model can help to mitigate student concerns about taking additional or extended mathematics in one semester.
- Ongoing formative assessment, rather than solely relying on a few major exams, has resulted in earlier interventions and increased success. Implementing such shifts can pay off in an increased sense of belonging to both the class and the campus, as well as increased feelings of capability and purpose.

The canvassing of successful pathways programs revealed that co-requisites were not implemented in isolation. Just as co-requisite supports are implemented in diverse ways, institutions are implementing pathways, meta-majors, and multiple measures placement in a variety of ways in order to best serve their student population and local context. Several of the major interventions are illustrated in the following graphic and are described more fully in other chapters of this monograph.

Figure 2. Co-requisite models are most effective when embedded within comprehensive redesign efforts



The use of meta-majors with common, relevant, default math courses has been credited with reducing the problem of large numbers of students with undeclared programs, thereby allowing students to be placed into an appropriate mathematics course in their first semester.

Early in the evolution of co-requisite courses, most programs started with pilot courses and sometimes only involved students near the cut score of placement exams. However, attempting to scale up a pilot co-requisite course can sometimes reveal what Uri Treisman calls "inconvenient truths" that may have been ignored in the pilot development. Sufficient evidence of the success of co-requisites (when compared to traditional developmental sequences) exists; therefore, we recommend a comprehensive approach including:

- Planning with a vision for scale. Planning teams should aim for full implementation, face and honor the inconvenient truths, implement, and then engage in continuous improvement.
- Implementing multiple measure placement. Provide additional avenues by which students can demonstrate readiness for college-level coursework. Placement tests that are heavily algebraic should be used with caution for non-STEM-intending students.
- Choosing pathways based on the student's stated academic and life goals. Planning and implementation teams should guard against the danger of placing students into those pathways based on a low placement score.
- Cohorting and co-mingling both have passionate advocates.

  Some institutions report that the cohort model has increased students' sense of belonging by giving them an instant community.

  Other institutions report that co-mingling increases the sense of belonging to the institution. While we see the value *in each, we are concerned that a cohort class could be viewed as "lesser."*

The Dana Center recommends co-mingling as a model that more clearly maintains the integrity of the college course while welcoming students into the college community.

Combining the integrity and inclusiveness of the college course with the staffing benefits of co-mingling tips the scales for us into the co-mingling camp.

- Similarly, there is a lack of agreement about the need for structured content versus using the support course as a tutorial or homework time. There are successful programs in both camps. However, we believe that students benefit when departments agree on the content and calendar of both courses so that all faculty have faith in the integrity of the courses.

- Understanding your data. Inspecting pass rates of individual courses is insufficient. Ask the institutional research department to provide longitudinal data on developmental students. What is the current true percentage of students who complete a gateway mathematics course within two years, if they initially placed two levels down? What portion of the non-completers were actually successful in their courses but stopped out somewhere along the way?

- Engaging in continuous improvement.

  Compare gateway course completion data to the baseline data described above.

  Survey stakeholders, including students, to gather information on how the structures are working and where modifications may be needed.

  Analyze course assessments to see where continued content refinement may be needed.

Given the information and recommendations presented in this chapter, think about your own college and policy context and decide what may work best for your students. Key considerations are how you will structure the course, how you will staff the courses, how you will organize the content for the two courses, and how you will place students into courses. Plan **now** for continuous improvement!

Appendix A
Co-requisite Instruction Interview Protocol

Background Information

1. School/campus name:
2. Two-year or four-year institution?
3. System/state: (Is your college a part of any system?)
4. Contact person/information:
5. How big is this program at the college (as proportion of similar students)?
6. What structures are in place such as guided pathways, pedagogy alignment?

Course Implementation Methods

7. Student grouping: Cohort or Co-mingle?
8. Course structure: Boot camp, Compressed courses (e.g., 8x8, 4x12), Mandatory tutoring, Stretch courses (across two semesters), Support courses that run alongside college-level?
9. Class size
10. Grades: One grade or separate, does one affect the other?

Course Placement Criteria

11. Student choice, advisor recommendation, faculty recommendation, test score?
12. Advising mandatory? For which students?
13. Which test do they use: Single test, combination of various tests?
14. Score range for eligibility
15. Bubble students only? Yes/No

Credit Hours/Financing

16. Students:
    a. Total credit hours awarded, how many are college-level, how many count towards degree?
    b. How many hours do they pay for?
17. Faculty:
    a. Total credit hours that count towards load, how many hours are they paid for?
    b. How many hours are they paid for?

Staffing

18. Type: College level faculty, adjunct, lab attendant?
19. Same or different staff for co-requisite and main course?
20. Number of staff present during class hours (one, two?)

Co-Requisite Course Content

21. Syllabus: Same across the campus or not?
22. Types of courses offered (stats, college alg., QR or contemporary math, etc.)
23. Non-cognitive content embedded? (study skills, self-efficacy, brain malleability, etc.)
24. Does co-requisite content align to college-level course content? How?

Evaluation of the Program

25. Completion of the program of study/graduation rates
26. Student completion of college-level course (include time frame)
27. Would you be willing to share any of this data with us? Aggregate data?

Program History

28. When did you start the program?
29. Did you start with a pilot or at scale? (or somewhere in between?)
30. Have you made significant changes since then?

Additional Information

31. Is there anyone else we should talk to?
32. If we decide to do some case studies or other publications in this area, would you be interested in participating further?

Appendix B
Participants in Dana Center Data Gathering

Individuals from the following institutions and organizations took part in data gathering, including surveys and interviews, conducted by representatives of the Charles A. Dana Center:

Arapahoe Community College, Colorado Community College System, Colorado
Central Texas College, Texas
Chancellor of Community Colleges, West Virginia
College of Coastal Georgia, Georgia
College System of Tennessee
Community College of Denver, Colorado
Elkhart North Central Region, Ivy Tech Community College System, Indiana
Georgia State Perimeter College, Georgia
Georgia State University, Georgia
Kilgore College, Texas
Roane State Community College, Tennessee
South Texas College, Texas
Tennessee Board of Regents, Tennessee
Texas State Technical College, Texas
Warsaw College, Ivy Tech Community College System, Indiana

Appendix C
Definition of Terms

- **Cohort:** Courses that separate college-ready students and underprepared students who are taking co-requisite courses into separate college-level courses. A cohort of underprepared students may take one class with extended hours,in which the support is embedded as needed, or there may be two distinct, linked courses, one in which college content is addressed with the other providing the support.
- **Co-mingle:** Courses that mix college-ready and underprepared students who are taking co-requisite support courses into the same college-level class. Underprepared students are provided additional support, which may take the form of advance work, such as a boot camp. Most commonly, the support is ongoing throughout the semester, as an additional class that meets on a regular schedule or required tutoring or lab time.
- **Structures:** How courses are offered "on the books."
    - **Boot camp:** First 3–5 weeks of the semester are remediation, followed by the college-level content (classes meet extra hours each week throughout the semester in order to equal the two classes or class plus lab).
    - **Compressed courses:** Developmental prerequisite class is compressed into 8 weeks, and then the college-level class is compressed into 8 weeks, so that both classes are completed in one semester (classes meet extra hours each week throughout the semester in order to equal the two classes). Note that this model contains a transition point, providing a risk that students will stop out.
    - **Mandatory tutoring:** Required attendance in a tutoring lab for a specified number of hours per week.
    - **Stretch courses:** College-level classes with the developmental content embedded and stretched over two semesters (e.g., Statway™ model). This model also risks student stop-out at the semester break.
    - **Support courses:** Structured support courses that run before, after, or on opposite days to the college-level courses; completed within one semester.

References

Adams, P., Gearhart, S., Miller, R., & Roberts, A. (2009). The accelerated learning program: Throwing open the gates. *Journal of Basic Writing*, *28*(2), 50–69.

Asera, R. (2001). *Calculus and community: A history of the Emerging Scholars Program.* New York: The College Board.

Bailey, T., Jeong, D., & Cho, S. (2010, April). Referral, enrollment, and completion in developmental education sequences in community colleges. *Economics of Education Review, 29*(2), 255–270.

Charles A. Dana Center. (n.d.). Dana Center Mathematics Pathways. Retrieved from http://www.utdanacenter.org

Denley, T. (2016). *Co-requisite remediation full implementation analysis* (Technical Brief Number 3). Nashville, TN: Tennessee Board of Regents.

Denley, T., & Knox, P. (2016). *Building student success with a co-requisite remediation model and mindset know-how* (Technical Brief Number 5). Nashville, TN: Tennessee Board of Regents.

Jenkins, D., Brown, A. E., Fink, J., Lahr, H., & Yanagiura, T. (2018). *Building guided pathways to community college student success: Promising practices and early evidence from Tennessee*. New York, NY: Community College Research Center (CCRC), Teachers College, Columbia University.

Xu, D., & Dadgar, M. (2018). How effective are community college remedial math courses for students with the lowest math skills? *Community College Review*. *46*(1), 62–81.

About the authors

Connie Richardson leads the curriculum development team for the mathematics courses for the Dana Center Mathematics Pathways (DCMP). She also supports the development of DCMP's professional learning offerings related to curricular redesign, co-requisite supports, and pedagogy. In this work, Connie collaborates with faculty to identify best practices and disseminate to the field. Connie has 14 years of experience at the high school level, teaching a wide variety of courses, including Advanced Placement Calculus and Statistics. She also has more than nine years of experience at the university level, teaching developmental and college-level mathematics and teacher preparation courses.

Jennifer Dorsey serves as a research and evaluation analyst at the Charles A. Dana Center, specializing in qualitative research, and leads the evaluation of the Dana Center Mathematics Pathways (DCMP). She works with Center staff to design and conduct research and evaluation of the DCMP and analyze, interpret, and report results. Jennifer also works with external evaluators of the DCMP, including MDRC, the Community College Research Center, and Shore Research Group. Additionally, she serves as a qualitative research consultant for other projects at the Dana Center, including work with the Academic Youth Development program and the Urban District Leadership Network.