Long-Term Effects of the Dana Center Math Pathways Model: Evidence from a Randomized Trial

A CAPR Working Paper

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October 2023

The Center for the Analysis of Postsecondary Readiness (CAPR) is a partnership of research scholars led by the Community College Research Center, Teachers College, Columbia University, and MDRC. The research reported here was supported by the Institute of Education Sciences, U.S. Department of Education, through Grant R305C140007 to Teachers College, Columbia University. The opinions expressed are those of the authors and do not represent views of the Institute or the U.S. Department of Education. For more information about CAPR, visit postsecondaryreadiness.org.

Abstract

Following up on an individual-level randomized controlled trial of a Dana Center Math Pathways (DCMP) model, this study assessed longer-term impacts on students' math completion, academic progress, and academic attainment. The version of the DCMP that was assessed in this study diversified the developmental and college-level math course content that students take, separating it into distinct pathways that better aligned with their career interests. It also streamlined developmental math sequences into a one-semester developmental course for all students, regardless of placement level, and implemented evidence-based curricula and pedagogy to engage students in active problem solving that was pertinent to real-life situations. The study, which followed 1,411 students from four Texas community colleges and ten campuses, found that, in the five years after random assignment, program group students were consistently more likely to successfully complete their first college-level math courses than control group students. The study did not find impacts after five years on the number of overall college credits that students accrued or on the likelihood that students attained a credential or transferred to a four-year college.

Keywords: community college, postsecondary education, developmental education, math pathways, college success, randomized controlled trial

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Acknowledgments

We would like to thank the staff at the Charles A. Dana Center at the University of Texas at Austin and the faculty, staff, administrators, and students at the four Texas community colleges that partnered with us for the original evaluation: Brookhaven College, Eastfield College, El Paso Community College, and Trinity Valley Community College. We would also like to thank Dorota Rizik, Sue Scrivener, and Dan Cullinan for their important contributions to this work, and Alex Mayer, Nikki Edgecombe, Tom Brock, Beth Kopko, Alexandra Logue, Trey Miller, and James Benson for their helpful feedback during review.

The Authors

1. Introduction

Community colleges have been struggling for decades to better support the large number of students entering college who are deemed academically underprepared for college-level work in math. Historically, incoming college students who were assessed as needing remedial support to bring their mathematics skills up to college-level standards have been required to take—and pay for—a sequence of one or more semester-length, non-credit-bearing courses, referred to as developmental math courses, before moving on to college-level math. A longitudinal study from the Institute of Education Sciences found that, in the early 2000s, 59 percent of students who entered two-year institutions took at least one developmental math course. Students of color and students from lower income backgrounds were more likely than their White and higher-income peers to take these courses (Chen, 2016).

Researchers and practitioners have come to view these developmental math requirements as a barrier to completing college math and obtaining a college degree. Research has found that a majority of students who were identified for developmental math education never completed their developmental sequence or any college-level math credits (Bailey et al., 2010). Since college-level math is a requirement for the vast majority of college credentials, a lack of successful math completion means a lack of credential attainment for most of these students. Most studies of traditional developmental math education have found that degree attainment and labor market outcomes for students who are referred to developmental courses tend to be no better—and are often worse—than those of similar students who are not referred to them (Dadgar, 2012; Hodara & Xu, 2016; Martorell & McFarlin Jr., 2011; Sanabria et al., 2020; Xu & Dadgar, 2018).

As the problems with traditional developmental math sequences became clear, practitioners and policymakers began working on ways to reform the developmental math system to help more students with developmental math needs successfully complete college-level math courses. The Charles A. Dana Center at the University of Texas at Austin was one of the organizations at the forefront of this reform movement, creating the Dana Center Mathematics Pathways (DCMP, formerly the New Mathways Project) with the support of the Texas Association of Community Colleges in 2011. The Dana Center worked with participating colleges to diversify developmental and college-level math course content, separating it into distinct pathways that better aligned with students' career interests, and shortening the developmental math sequence students were required to take, strengthening the curricula and pedagogy of the developmental math course, and providing additional support for students inside and outside of class. A rigorous random assignment study of the DCMP that was launched in 2014 at four Texas colleges found that the DCMP had a positive impact on students' completion of the developmental math sequence, increasing both their likelihood of taking and passing college-level math courses and the number of math credits they earned during the first three semesters (Zachry Rutschow et al., 2019).

The ultimate goal of programs like the DCMP is to ensure more students who enter college with developmental math needs can successfully progress through college and earn credentials that will support them in the labor market. To that end, this paper discusses the long-term outcomes of the DCMP, which show that the program continued to have a positive impact on students' completion of their first college-level math course for the five years after random assignment, but did not show significant impacts on students' overall academic progress (college credits earned), credential attainment, or transfer to a four-year college. The paper contributes to the literature by exploring the effects of a robust developmental math reform model—one that was effective in helping more students complete college-level math (which often acts as a gatekeeper to credential and degree attainment)—on longer-term outcomes of academic progress and attainment. Since the launch of this study, the Dana Center has continued to refine and update the program over time, but the findings discussed in this report reflect the effects of an early version of the DCMP that was implemented in four Texas colleges from 2015 through 2017. Thus, the version of the DCMP evaluated in this study is different from the version that currently is used in colleges in Texas and other states. Also, Texas has adopted new policies concerning developmental education that have affected the DCMP program. Key changes to the DCMP, and in the state more broadly, are discussed in more detail in Section 7.

2. The DCMP Model and Theory of Action

The DCMP model that was implemented for this study was based on the following four core components.

Multiple math pathways aligned to different fields of study. When the Dana Center began implementing the DCMP in 2011, the problems with developmental math were becoming clear but little was known about how best to reform the system. A key concern for the Dana Center, and other reformers, was that the math content of traditional developmental math courses did not align with many students' planned courses of study. Questions surfaced about whether students who were not going into science, technology, engineering, or mathematics (STEM) fields needed to master algebra content that was created to prepare students for college-level calculus (Gordon, 2008; Herriott & Dunbar, 2009). The DCMP diversified developmental and college-level math course content, separating it into three distinct pathways that were aligned with students' majors and career interests: (1) a statistics pathway, for students majoring in social sciences, social services, and health professions; (2) a quantitative reasoning pathway, for students majoring in liberal arts, fine arts, and the humanities; and (3) a path to calculus for students in STEM majors. (This study focuses on students who plan on entering the two non-STEM-focused pathways.) All three pathways began with a one-semester developmental course called Foundations of Mathematical Reasoning, which covered algebra (the content of standard developmental math courses) but also emphasized statistics and quantitative literacy. Upon successful completion of the Foundations course, students in the DCMP took a one-semester college-level statistics or quantitative reasoning course or began a two-semester path to calculus.

Accelerated developmental sequence. Traditional developmental math sequences often require students to take several semester-long, non-credit-bearing courses, creating a number of potential points where students may exit the sequence (Jaggars et al., 2014). These long course sequences, compounded by the financial and psychological burdens they create, can lead to high rates of attrition (Bailey, 2009; Edgecombe, 2011). By one account, only 20 percent of students who enrolled in developmental math passed their first college-level math course within three years, with that percentage dropping to 10 percent for students who were referred to sequences of three or more semester-long courses (or levels) of developmental math (Bailey et al., 2010). A majority of these students never failed or dropped out of a course; instead, they stopped enrolling in the developmental courses before they completed the sequence (Bailey et al., 2010). "Accelerating" the developmental sequence—by shortening instructional time to minimize the number of required developmental courses or the number of semesters spent in developmental education—became a focus area of early reform efforts, including those of the Dana Center (Bailey, 2009; Edgecombe, 2011). The DCMP streamlined the developmental math content so that students were prepared to advance to any math pathway after only one semester. Even students who tested two or more levels below "college-ready" in math only needed to take the one-semester developmental math course, Foundations. Once students passed Foundations, they were able to take college-level math the following semester. The intent of the DCMP program was that all students, regardless of incoming math level, could complete a college-level math course during their first year of college.

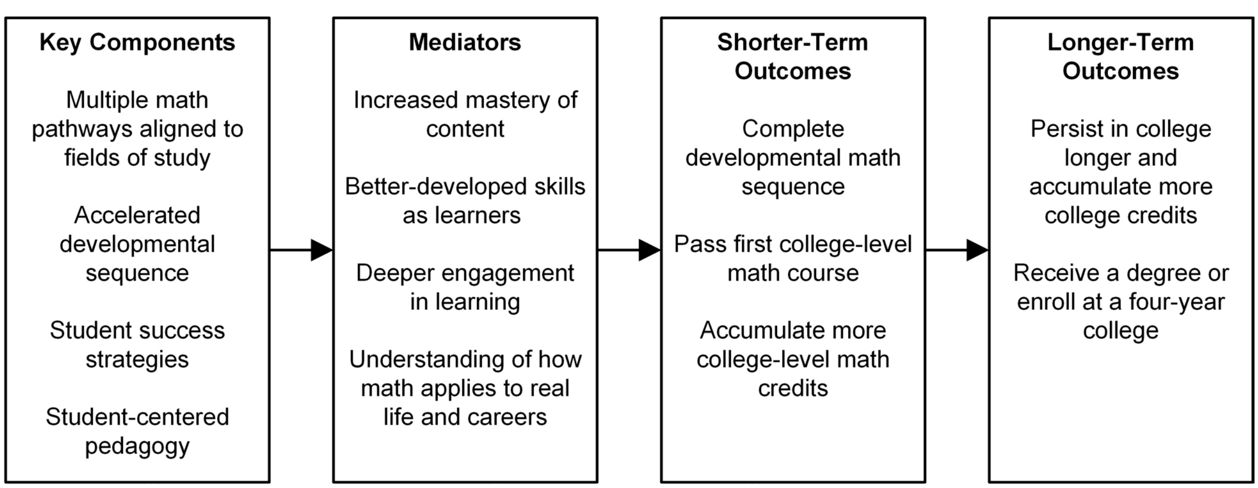
Evidence-based, student-centered curriculum and pedagogy. The Dana Center also saw room for improvement in the pedagogy and curriculum used in many traditional developmental math courses and worked with colleges to make the courses more student-centered, collaborative, and relatable to real life. The DCMP model included "contextualized curricula," which go beyond basic skill development and engage students in tasks that reflect real-life situations and focus on the higher-level competencies they need to be successful in college-level courses in relevant academic disciplines (Bickerstaff et al., 2022; Edgecombe, 2011; Perin, 2011). The model also emphasized a student-centered pedagogy, in which classroom activities are designed to encourage students to read, write, and speak about their math learning. This positions students as active learners so they are engaged more deeply, while teachers fill the role of facilitators of the learning process (Hern & Snell, 2014; Weiss et al., 2021). There is evidence indicating that these classroom reforms can have positive impacts on student outcomes (Martinson et al., 2018; Martinson et al., 2021; Weiss et al., 2021).

Student success strategies. Another concern of the Dana Center and other developmental math reformers was that traditional developmental math courses were often not paired with additional supports that may help to ensure student success. A recent synthesis of the evidence on developmental math reforms recommends the use of targeted supports, especially for students with weaker academic preparation, and points to effective, innovative programs that include both multifaceted supports and thoughtfully designed curricula (Bickerstaff et al., 2022; Martinson et al., 2021; Weiss et al., 2021). The DCMP model included academic and social supports for students that were both integrated into the developmental math courses and aligned with other college services. Instructors were encouraged to incorporate activities that support and engage students in their learning and that help students develop attitudes and help-seeking behaviors that will foster their success in college, such as attending tutoring sessions or regular check-ins with advisors.

Figure 1 illustrates the theory of action for the DCMP model assessed in this study. The hypothesis was that the four core components, implemented together, would lead to positive changes for students, including increased mastery of math content and deeper engagement in learning. Those mediators would affect some key shorter-term academic outcomes: completing the math developmental sequence, passing the first college-level math course, and accumulating more math credits. In the longer term, the hypothesis was that the DCMP would increase students' total number of college credits earned, and, ultimately, graduation rates from a community college or transfer rates to a four-year college.

Figure 1

The DCMP Model's Theory of Action as Evaluated in This Study



3. Research on Math Pathways

While programs like the DCMP have become more popular over the years, there is still limited rigorous evidence of their effectiveness. As noted earlier, the initial random assignment study of this early version of the DCMP found that after three semesters, the program had a positive impact of 23.5 percentage points on developmental math completion, 12.7 percentage points on college-level math course taking, and 6.8 percentage points on the completion of a first college-level math course, as well as a small positive effect (0.2 credits) on the number of college-level math credits earned (Zachry Rutschow et al., 2019).[1] It did not have an effect on total college credit accumulation in the first three semesters. Exploratory analyses of different subgroups of students suggested that the short-term impacts were larger for part-time students and students who were assessed as needing more than one developmental course (Zachry Rutschow et al., 2019).

The Carnegie Foundation for the Advancement of Teaching developed accelerated math pathway models: Quantway, which was initially designed as one semester of accelerated developmental math and one semester of college-level math that was focused on quantitative reasoning, and Statway, which is a year-long, combined developmental and college-level course—or a two-course sequence—that focuses on statistics. Each model included curricular and pedagogical enhancements to better support students. In a study of Quantway that used propensity score matching, students were more likely to attempt a college-level math course than their counterparts who were not in the program, with an odds ratio of 2.33, though the two groups demonstrated comparable performances in college-level math (Yamada et al., 2018). In a study of Statway that also utilized propensity score matching, students showed higher odds of success earning college-level math credits than their counterparts in the matched comparison group, with odds ratios of 5.31 and 7.40 for the Year 1 and Year 2 cohorts. The study also showed higher levels of two-year and four-year degree completion and higher transfer rates to a four-year college after five years (Norman et al., 2018; Yamada & Bryk, 2016).

A quasi-experimental study of the California Acceleration Project (CAP)—which featured a redesigned pathway through statistics for students pursuing non-math-intensive majors and included a curricular and pedagogical redesign—found promising results. Using a multivariate logistic regression, the study found that students in accelerated pathways were 4.5 times more likely to complete college-level math than their counterparts who were not in CAP (Hayward & Willett, 2014).

The most promising findings on a math pathways program to date come from a study of corequisite remediation at the City University of New York. In corequisite remediation, students who are assessed as not fully ready for college-level coursework are nevertheless placed directly in introductory college-level classes while receiving additional learning supports—such as concurrent developmental courses, workshops, or tutoring—that cover the remedial math topics they need to master (Ran & Lin, 2022). In this case, program group students who were identified as needing remedial algebra (but not remedial arithmetic) were placed in a college-level statistics course (that is, a statistics math pathway)

[1] The findings from the initial DCMP study differ slightly from the findings reported later in this paper. The current long-term follow-up study includes data from the Texas Education Research Center, which combines data from all public Texas colleges and thus captured information about students who may have transferred to other colleges in the state during the first three semesters. The report from the initial DCMP study could only track student course taking at the colleges participating in the study.

and received corequisite remediation in the form of a concurrent peer-led weekly workshop, while control group students were placed in a traditional developmental algebra course.[2] Thus, this intervention comprised both corequisite remediation and a math pathway. The randomized controlled trial found that students who were placed in the corequisite statistics course were 16 percentage points more likely to pass their college-level math course and accumulated almost five additional college credits in the first year of college (Logue et al., 2016). Three years after random assignment, students in the corequisite statistics course had also passed more advanced mathematics courses and were more likely to have completed their associate's degree (Logue et al., 2019). After five years, they were twice as likely to have earned a bachelor's degree than the control group students (Douglas et al., 2023).

[2] Workshop leaders were advanced undergraduates or recent graduates who had successfully completed the covered material.

4. Methods

This paper discusses results from a follow-up study of an individual-level randomized controlled trial of the DCMP. The study followed the participating students for a full five years after random assignment.[3]

Research Questions

The long-term follow-up study addresses the following research questions:

- What is the effect of the opportunity to participate in the DCMP on college-level math course completion, long-term academic progress, and long-term academic attainment?
- For a variety of subgroups of students, what are the long-term effects of the opportunity to participate in the DCMP?

Sample

Colleges: Four Texas community colleges, with a total of 10 campuses, participated in the study: Brookhaven College and Eastfield College (which were two separate one-campus colleges in Dallas),[4] Trinity Valley Community College (which has three campuses), and El Paso Community College (which has five campuses). Based on data from the Integrated Postsecondary Education Data System, at the time of implementation, these colleges are representative of both urban and rural communities, as well as small and large community colleges—they ranged in size from under 5,000 students to almost 30,000 students. The colleges also differed markedly in their racial and ethnic makeup; El Paso Community College served a primarily Hispanic population (85 percent), Trinity Valley Community College served a primarily White population (59 percent), and Brookhaven and Eastfield served mixed populations. Across the colleges, between 15 percent and 44 percent of students were enrolled full time, and 57 percent to 74 percent of incoming students were recent high school graduates (Zachry Rutschow et al., 2019).

At the start of the study, the DCMP was operating, to varying degrees, in many colleges across Texas. The colleges were chosen for the study based on multiple factors, including the fidelity of their DCMP implementation to the model, the strength of the contrast between their DCMP courses and other developmental math courses, their ability to expand the DCMP to enroll the targeted number of students, and their interest in participating in the study. Colleges were not chosen randomly, so generalizing findings more broadly than the four specific colleges in the study cannot be justified statistically. That said, the variety of colleges that participated in the study suggests that the findings may be applicable beyond the specific institutions involved.

Student Recruitment and Random Assignment: Students were enrolled in the study in four cohorts, from the fall 2015 semester to the spring 2017 semester. Advisors at each of the four participating

[3] The analysis was preregistered in the Registry of Efficacy and Effectiveness Studies (Registry ID #5060.2v1). The study's research activities were approved by the MDRC Institutional Review Board (#822366-26).

[4] Both campuses are now part of Dallas College.

colleges identified students who were eligible for the study. To be eligible for the DCMP and participate in the study, students had to have been assessed as needing one or more courses (levels) of math remediation. This assessment was based on students' scores on the Texas Success Initiative Assessment, a placement test given upon entry into college, or their scores on the ACT or SAT. Students whose scores were below the state-mandated cutoff were designated as being in need of developmental courses, and colleges generally used their own discretion to set score levels for different developmental courses within a range of scores set by the state. In addition to developmental need, students' intended majors needed to align with the statistics or quantitative reasoning course pathways (which are applicable to most non-STEM majors, such as journalism, psychology, sociology, anthropology, English, history, nursing, and criminal justice).

Given the rush of new students before a semester begins, advisors generally identified students at new student orientations in the summer and late fall, although some students were also identified by advisors during the regular school semesters. Each of the participating colleges had many students who tested as being in need of developmental math and who intended to pursue majors that were aligned with statistics and quantitative reasoning pathways. Nevertheless, advisors included a relatively small proportion of these students in the sample in the first two semesters. There were several reasons for this: the schools had not yet expanded the scale of the DCMP courses to reach large numbers of students; additional advising time was required to place students in the correct pathway; and there was a lack of clarity, in some cases, about the alignment of policies and math requirements with those of four-year colleges.

When students were identified as potential study participants, advisors explained the study and the DCMP to students. Students who were eligible and who provided informed written consent to participate in the study were randomly assigned, using the researchers' web-based random assignment platform, during the new student orientation or advising session. Students were assigned to either the program group, which had the opportunity to enroll in a DCMP sequence, or to the control group, which received the colleges' standard algebra-focused developmental and college-level math course sequences. Students were told their assignment immediately, and most students enrolled in courses for the semester directly after random assignment. Random assignment was blocked by cohort and identified by the semester students enrolled and their college campus.

Student Sample: A total of 1,411 students were enrolled; 856 were assigned to the DCMP and 555 were assigned to the colleges' standard developmental math sequence.[5] The study was initially powered to detect small effects in the first few semesters after random assignment. The long-term follow-up study is powered to detect larger, policy-relevant effects in the five years after random assignment but cannot detect small effects on academic attainment.[6] Eighty-three percent of study participants were assessed as needing two or more developmental math courses. The mean age of participants was 23 years, over 60 percent were female, and 54 percent were Hispanic. According to students' survey responses at the time of random assignment, a majority of the students reported that they planned to enroll full time, and nearly a third reported having failed a high school or college math class (Zachry Rutschow et al., 2019).

[5]A total of 25 additional students (14 from the program group and 11 from the control group) who made up two blocks were randomly assigned and later dropped from the study when sections were cancelled at the colleges due to lack of enrollment. These were full random assignment blocks and so do not affect the study sample and are not included in these sample totals. One student assigned to the DCMP withdrew from the study after random assignment and is not included in these totals.

[6]For instance, power calculations suggest that the study can only detect effects on credential completion or transfer to a four-year college of about 6 percentage points or more in the last three years of the study.

Table 1 shows baseline equivalence measures between the students assigned to the DCMP (the program group) and those not assigned to the DCMP (the control group). The background characteristics of program and control group students were very similar at the outset of the study (an overall test of equivalency produced a p-value of 0.74). There were significant differences in the percentage of Black students and students with missing race data, and in the percentage of students who had received a high school diploma.

Implementation of the Intervention

As expected, most students in the program group took the DCMP Foundations courses while most students in the control group took developmental algebra courses. By the third semester, 85.6 percent of program group students and 80.2 percent of control group students had taken a developmental math course. Additionally, program group students who completed their developmental course requirements and enrolled in a college-level math class were more likely to take college-level statistics and quantitative reasoning, or some other non-college-algebra math class. Students in the control group took more college-level algebra courses than program group students; however, a substantial proportion of control group students also took statistics or quantitative reasoning (Zachry Rutschow et al., 2019).

Overall, using the four components of the DCMP shown in Figure 1, colleges in the study implemented the DCMP with relatively high fidelity to the model, and the contrast between DCMP and standard developmental courses was substantial (Zachry Rutschow et al., 2019). The colleges revised their math requirements for majors that would be better aligned with statistics and quantitative reasoning courses, changed advising practices so that they could more readily identify students' majors and place students in the appropriate math sequences, and ensured that faculty and staff members had the training and supports they needed to understand the DCMP model and implement the revised curricula and instructional approaches. Students participating in the DCMP were placed in an accelerated developmental sequence and colleges implemented the DCMP's developmental curriculum and pedagogy with relatively strong fidelity to the model. The student supports outside the classroom were the one area where implementation was weaker than intended. All the colleges had myriad supports available for students taking developmental education courses, including tutors and labs, but they had challenges adapting and expanding the services to help DCMP students.[7]

Data Sources

Most of the data used in the analysis came from the Texas Education Research Center (Texas ERC), a data repository for state K-12, higher education, and workforce data. The system contains enrollment, transfer, course completion, and degree attainment data for students who enrolled in public and private institutions in Texas. To capture degree attainment for students who may have transferred to a school outside of Texas, the researchers also collected and merged enrollment, transfer, and certificate and degree attainment data from the National Student Clearinghouse (NSC), which collects and distributes data from 97 percent of the nation's postsecondary students.[8]

[7]See Rutschow et al. (2019) for a full discussion of the implementation research.

[8]While the Texas ERC does collect and include NSC data, the files at the time of analysis were not as complete as what the study team had collected directly from the NSC. Earlier analyses done at three semesters and at three years after random assignment used only the data from college transcripts and the NSC. The addition of the Texas ERC data allows the team to better capture students' course taking and credit earning across all Texas colleges and universities and not just the colleges participating in the study, allowing the study to follow students who moved to another public or private institution in Texas. Using the Texas ERC data also provides an additional source of enrollment and degree information in case of missing or mismatched NSC data.

Table 1
Characteristics of Students in the Study

Characteristic	Program Group	Control Group	Difference	P-Value
Age (years)	22.4	22.6	-0.2	0.5617
Male (%)	31.2	29.7	1.5	0.5609
Missing	7.1	9.4	-2.2	0.1296
Race/ethnicity (%)				
White	13.8	13.5	0.3	0.8848
Black	14.0	10.5	3.6 **	0.0487
Hispanic	54.3	53.9	0.4	0.8689
Other	2.1	2.5	-0.4	0.6052
Missing	15.8	19.6	-3.9 *	0.0606
Credentials earned[a] (%)				
High school diploma	88.7	85.6	3.1 *	0.0878
GED	10.3	12.1	-1.8	0.2934
Occupational/technical certificate	6.0	6.3	-0.3	0.7895
Associate's degree	0.8	1.1	-0.3	0.6134
Bachelor's degree	0.2	0.0	0.2	0.2548
Master's degree or higher	0.1	0.0	0.1	0.4209
None of the above	0.5	1.3	-0.8 *	0.0978
Date of high school graduation/GED receipt (%)				
During the past year	53.1	51.3	1.8	0.5071
Between 1 and 5 years ago	22.4	24.3	-1.9	0.4182
Between 5 and 10 years ago	10.4	9.1	1.3	0.4318
More than 10 years ago	14.1	15.4	-1.2	0.5253
Planned enrollment this semester (%)				
Less than part time (fewer than 6 credits)	7.6	7.6	0.0	0.9965
Part time (6 to 11 credits)	30.3	32.6	-2.4	0.3606
Full time (12 credits or more)	62.1	59.7	2.4	0.3835
Has failed a high school or college math class in the past (%)	31.2	31.0	0.2	0.9367
Missing	7.2	6.7	0.6	0.6791
Math placement[b] (%)				
College-ready or exempt	2.8	2.3	0.5	0.5965
Placed 1 level below college-ready	12.6	14.1	-1.4	0.4360
Placed 2 levels below college-ready	83.6	82.5	1.1	0.5820
Placed 3 levels below college-ready	0.9	1.1	-0.1	0.7864
Sample size (total = 1,411)	856	555		

(continued)

Table 1 (continued)

SOURCES: MDRC calculations using data from a baseline survey of students participating in the study and administrative student data. The baseline survey was administered to students immediately prior to random assignment, during the study intake process.

NOTES: Rounding may cause slight discrepancies in sums and differences.
Statistical significance levels are indicated as: *** = 1 percent; ** = 5 percent; * = 10 percent.
Missing values are only shown for items with more than 5 percent missing values.
[a]Distributions may not add to 100 percent because categories are not mutually exclusive.
[b]While course names vary between colleges, math courses three levels below college readiness are frequently referred to as Pre-Algebra. Similarly, courses two levels down may be referred to as Beginning Algebra, and courses one level down may be referred to as Intermediate Algebra.

A baseline survey was given to students immediately before random assignment; it asked students for general academic information, such as the last grade of school they completed, their intended major, the number of credits they intended to take, and whether they had failed a math class previously. Some data from this survey were used to create subgroups and for baseline equivalence testing. Additional baseline data were collected from the colleges, including race and ethnicity information and students' math placement test scores.

Measures

Three outcome domains were examined: students' math completion, academic progress, and academic attainment.

Math Completion: The study team examined students' successful completion of their first college-level math course as a key confirmatory outcome of the study. While many nonquantitative certificates and degrees only require the completion of one math course, the DCMP could also support students' confidence, comfort, and interest in mathematics. To this end, the study also explored students' pursuit and success in math courses by looking at students' successful completion of a second college-level math course as well as students' total college-level math credits earned.

Academic Progress: The theory of action for the DCMP posits that by supporting students' more rapid completion of developmental math courses, entrance into college-level math courses, and successful completion of college-level math courses, the DCMP will help students to boost their overall college credits earned. This is considered a confirmatory outcome of the study. The study also explored whether a student was currently enrolled in any college (or had previously earned a credential). This measure was originally specified as "enrolled in any college in the analysis plan" and was meant to measure persistence in college. The measure was changed to "enrolled in any college or earned a credential" so that students who were no longer enrolled in college after successfully earning a credential would not be included in the group of students who dropped out of college and instead would be included in the group of students who persisted.[9] Another measure of persistence, "total number of semesters enrolled over the five-year period," is also included.

[9]Note that this variable is different than the key academic attainment variable ("ever earned a credential or is currently enrolled in a four-year college") because in this case, students can be enrolled in any college (two-year or four-year).

Academic Attainment: The ultimate objective of the DCMP is to ensure students are successful in college and earn credentials. Therefore, the study included the confirmatory outcome "ever earned a credential (including certificates or degrees) or is currently attending a four-year college." "Currently attending a four-year college" is included in this measure because the five-year follow-up period is not enough time to capture most transfer students' completion of a four-year degree, which can often take six or more years. The study also included separate measures of whether students ever earned a certificate, associate's degree, or bachelor's degree or were currently enrolled in a four-year college.

Subgroups

Using measures collected prior to random assignment, the study also investigated the effectiveness of the DCMP for students whom colleges have historically struggled to serve and support effectively. Specifically, the study compared the following student groups:

- students who tested at college level or one level below, and students who tested at two or three levels below[10]
- students who planned, at the time of random assignment, to enroll full time, and students who planned to enroll part time
- students who delayed college enrollment for six months or more after high school graduation, and students who entered college within six months of high school graduation
- Black, Hispanic, and White students
- female and male students

Analytic Approach

The study team's main impact analyses are intent-to-treat (ITT) analyses, which estimate the impact of being offered the opportunity to participate in the DCMP, regardless of whether the student actually enrolled in the DCMP course. The target of inference, or estimand, for this study is the average effect for the average student participating in the study. The findings in this study are generalizable only to the analytic sample and not to any broader population. To estimate the overall ITT effects on outcomes, the team constructed a generalized linear model that took into account the clustering of students within colleges and cohorts:

$$Y_i = \sum_{j=1} \alpha_j Block_{ji} + P_i + \sum_{k=1} \gamma_k X_{ki} + \varepsilon_i$$

Here, Y_i represents a target outcome. $Block_{ji}$ is a vector of J random assignment block indicators, equal to 1 if student i is in block j and 0 otherwise. Each block indicator represents a college campus*cohort. The study includes 10 college campuses and four cohorts; therefore, there are 40 unique

[10] While the study was meant to only include students who tested below college-ready, a small percentage of students (about 2.6 percent) were found to be college-ready according to the testing data collected. The discrepancy likely comes from the fact that the study team collected the test score data from the colleges after random assignment, and it may be that the test score data provided to the study team were different for some students than the information used by advisors at the time of enrollment.

"blocks." P_i is a binary indicator, equal to 1 if student i is randomly assigned to the program group and 0 otherwise. X_{ki} is a vector of student baseline characteristics—race/ethnicity and having received a high school diploma prior to random assignment—that was included in the model to improve the precision of β_1 along with a binary variable for each baseline measure indicating whether the baseline measure is missing (to account for missing covariate data).

The parameter of interest is β_1, the effect of program assignment on Y_i. Notably, the ITT estimate is of the effect of assigning a student to the program group. It estimates the gains that a policymaker can realistically expect to achieve from implementing the program (because one cannot fully control whether students participate). While there is likely some difference between the ITT and the effect of the DCMP for those who receive it, a majority (74.1 percent) of program group members participated in at least one DCMP math course. The ε_i are the residual variances. Heteroskedastic robust standard errors were calculated.

As shown in Table 1, and as mentioned above, the background characteristics of students in the program and control groups were similar at the outset of the study. Baseline measures with significant differences between treatment and control groups (the percentage of Black students, students with missing race data, and students who had received a high school diploma) were included as covariates in the analysis for precision.

For the purposes of this study, students who were not found in the data sources used in the analysis are treated as if they had not completed a first college-level math course, accumulated credits, or earned a degree or transferred.[11] In this way, all 1,411 sample members were included in the impact analyses. As discussed in the data sources section, several data sources were used with overlapping information to produce the most complete data set possible for analysis.

To statistically test for differences in subgroup impacts, the team conducted split sample regression analyses and estimate differences using the HT statistic. This approach is similar to estimating the effects of the program for each group separately (that is, full-time and part-time enrollees) and then determining if the amount of variation in effects across groups is greater than what would be expected by chance alone. The subgroup analyses provide additional context for the impacts on the full sample, in order to generate new hypotheses for future testing. In some cases, the subgroups were small, making the subgroup analyses less reliable than the full sample analyses.

[11] It is not possible for the study team to know when data are missing because a student stopped participating in college and when data are missing for other reasons (such as mismatches between the data sets or lost information).

5. Findings

This section presents the findings for the two research questions. It first examines the impacts of the DCMP for each of the three outcome domains. For each outcome measure, the findings are presented for each of the five years after random assignment.[12] To capture five years of follow-up data for each of the four cohorts of students, the follow-up period ran from the fall 2015 semester through the fall 2021 semester. This section also presents the differential impacts for each of the subgroups that were investigated. For the subgroup analyses, it explores the findings at the end of the fifth year for each of the confirmatory measures.

Impacts on Math Completion

The early version of the DCMP that was evaluated in this study had a positive impact on students' math completion the first year they participated in the program, and the impacts persisted through the following years. As shown in Table 2, more students in the program group passed their first college-level math course by the end of the first year than students in the control group (amounting to an almost 10 percentage point impact). By the end of the five-year follow-up period, program group students were still 5.6 percentage points more likely to have successfully completed their first course.

Program group students were more likely to complete a second college-level math course in the second year after random assignment, which suggests the program helped students complete a second course more quickly. The effect dissipated after the second year, and the difference between program and control group students completing a second college-level math course is not statistically significant in Year 3 through Year 5. The overall number of students who completed a second college-level math course was small (11.0 percent of program group students and 10.4 percent of control group students at the end of the fifth year). This is in part because, by design, the students in the study were enrolling in non-STEM degrees at the time of random assignment and most of those degrees only require students to complete one college-level math course.

While the DCMP did help some students successfully complete their first college-level math course, it was not a large enough impact to result in program group students accumulating more math credits on average, since this variable is less sensitive to small differences. There was a small impact on math credits earned during the first year, but it dissipated by the end of the second year.

Impacts on Academic Progress

The DCMP had no effect on overall college credits earned. As seen in Table 2, by the end of the fifth year program group students earned an average of 30.71 college credits while control group students earned a mean average of 30.32 credits.

Program group students and control group students had similar college enrollment rates throughout much of the study, but in the fifth year, program group students were more likely either to have enrolled at any college or to have earned a credential. Program group students were 5.4 percentage points

[12] For cohorts where random assignment occurred in the fall, each analysis year starts with the fall semester, and for cohorts where random assignment occurred in the spring, each analysis year starts with the spring semester.

Table 2
Impacts on Math Completion, Academic Progress, and Academic Attainment

Outcome	Program Group Mean	Control Group Mean	Estimated Effect	Standard Error
Math completion				
Passed first college-level math course (%)				
First year	18.6	8.8	9.8 ***	1.9
Second year	29.0	24.2	4.8 **	2.4
Third year	34.3	28.8	5.5 **	2.5
Fourth year	37.7	31.8	5.9 **	2.5
Fifth year	39.3	33.8	5.6 **	2.6
Passed second college-level math course[a] (%)				
First year	1.0	0.4	0.6	0.5
Second year	5.7	3.7	2.0 *	1.2
Third year	8.4	7.5	0.9	1.5
Fourth year	9.9	9.3	0.6	1.6
Fifth year	11.0	10.4	0.6	1.7
Total college-level math credits earned				
First year	0.58	0.28	0.31 ***	0.06
Second year	1.09	0.93	0.16	0.11
Third year	1.45	1.28	0.18	0.14
Fourth year	1.64	1.51	0.12	0.16
Fifth year	1.75	1.62	0.13	0.16
Academic progress				
Total college-level credits earned				
First year	8.61	8.12	0.50	0.46
Second year	16.65	15.89	0.76	0.94
Third year	22.56	22.09	0.48	1.34
Fourth year	27.26	26.97	0.29	1.67
Fifth year	30.71	30.32	0.39	1.92
Currently enrolled in any college or previously earned a credential (%)				
First year	68.3	70.3	-2.0	2.5
Second year	49.9	51.0	-1.2	2.7
Third year	40.9	42.9	-1.9	2.7
Fourth year	39.7	38.1	1.6	2.6
Fifth year	39.1	33.7	5.4 **	2.6
Number of semesters enrolled	4.55	4.57	-0.02	0.17

(continued)

Table 2 (continued)

Outcome	Program Group Mean	Control Group Mean	Estimated Effect	Standard Error
Academic attainment				
Ever earned a credential or currently enrolled in a four-year college (%)				
First year	5.0	4.2	0.8	1.1
Second year	14.4	13.3	1.1	1.9
Third year	22.3	23.3	-1.1	2.3
Fourth year	27.5	27.0	0.5	2.4
Fifth year	32.7	30.2	2.5	2.5
Ever received a certificate (%)				
First year	0.4	0.3	0.0	0.3
Second year	2.0	0.7	1.3 *	0.7
Third year	3.4	2.1	1.4	0.9
Fourth year	4.5	3.3	1.2	1.1
Fifth year	5.3	4.0	1.3	1.2
Ever received an associate's degree (%)				
First year	1.5	1.1	0.4	0.6
Second year	6.8	6.4	0.4	1.3
Third year	14.1	14.0	0.1	1.9
Fourth year	17.6	18.4	-0.7	2.1
Fifth year	19.5	21.1	-1.6	2.2
Ever received a bachelor's degree (%)				
First year	0.0	0.0	0.0	0.0
Second year	0.1	0.2	-0.1	0.2
Third year	0.8	0.4	0.4	0.4
Fourth year	2.9	2.2	0.6	0.9
Fifth year	5.7	4.9	0.8	1.2
Currently enrolled in a four-year college (%)				
First year	3.6	2.7	0.9	1.0
Second year	8.3	8.9	-0.6	1.5
Third year	11.2	13.8	-2.6	1.8
Fourth year	15.3	15.7	-0.4	2.0
Fifth year	17.4	15.1	2.3	2.0
Sample size (total = 1,411)	856	555		

SOURCES: Data provided by the Texas Education Research Center and the National Student Clearinghouse.

NOTES: Rounding may cause slight discrepancies in sums and differences.
Statistical significance levels are indicated as: *** = 1 percent; ** = 5 percent; * = 10 percent.
[a]This measure is calculated as students who earned more than three college-level math credits.

more likely to still be enrolled in any college (or to have already earned a credential) at the end of five years. Since this impact is only observed in the fifth year, it does not provide clear proof that the DCMP leads to better persistence throughout college. On average, program and control group students were enrolled at a college for a similar number of semesters during the five years after random assignment. Still, the impact does suggest that this version of the DCMP may have better prepared some students for long-term persistence. Some of these students attended a two-year college for five years without attaining any type of certificate or degree, so while this shows persistence, it is not a clean measure of progress.

Impacts on Academic Attainment

The version of the DCMP in this study did not have an impact on students' academic attainment. As shown in Table 2, the program did not have a statistically significant impact on students' credential completion or current enrollment at a four-year college during any of the five years.[13] There were also no impacts on whether students earned a certificate, associate's degree, or bachelor's degree after five years, when measured separately. Five years after random assignment, just under one-third of program group students and control group students had earned some type of credential or were currently enrolled in a four-year institution.

Differential Impacts by Subgroup

Table 3 displays the impacts on math completion (measured as successfully completing the first college-level math course within five years after random assignment) for each of the subgroups, as well as the difference in impacts between subgroups. There was a significant difference between students who tested two or three levels behind in math, compared with students who were assessed as college-ready or one level behind. The DCMP had a significant positive effect on students who were two or more levels behind, and a substantial negative effect on students who tested as college-ready or one level behind. While the negative finding for students who tested near or at college level is concerning, it is consistent with other research that shows that developmental course taking can result in negative effects on college outcomes for students testing near or at college level (Boatman & Long, 2018). The DCMP was originally envisioned to support students who were assessed as being more than one level below college-ready, and these students represent 84 percent of the study sample. The program benefits these less-prepared students. The differential may have also been partly because only students who placed two or more levels below college-ready experienced the intervention's accelerated course sequence (both program and control group students who placed one level below college level were required to take a one-semester developmental course).

There was also a significant difference in the impacts between female and male students. The program had a large impact on female students' completion of the first college-level math course, while no impact was found for male students.

[13] In the fifth year, the difference between the program and control groups was 2.5 percentage points, but the study was not powered to detect an effect of this magnitude and the finding is not statistically significant. Therefore, it is unclear if the true effect is different from zero. The main driver of this difference seems to be that more program group students enrolled in four-year colleges, which was not the case for control group students. (The difference for students currently enrolled in a four-year college was 2.3 percent.)

Table 3
Impact on Completion of First College-Level Math Course, by Subgroup, Five Years After Random Assignment

Subgroup (%)	Sample	Program Group Mean	Control Group Mean	Mean Difference	Standard Error	P-Value	P-Value Difference in Effects	
Race/ethnicity								
Black	178	32.0	23.4	8.7	7.4	0.2400		
Hispanic	764	47.2	40.4	6.8	3.7	0.0630 *		
White	193	33.4	32.8	0.6	7.2	0.9340		
Gender							0.0640	†
Female	866	45.8	36.4	9.4	3.4	0.0060 ***		
Male	432	33.8	35.0	-1.2	4.6	0.7890		
Planned enrollment prior to random assignment							0.8210	
Full time	826	43.8	37.2	6.6	3.5	0.0550 *		
Part time	524	33.9	28.5	5.4	4.2	0.1960		
Time between high school and college							0.8930	
Six months or less	820	43.8	38.2	5.6	3.5	0.1100		
More than six months	568	32.6	27.7	4.9	3.8	0.1990		
Placement level							0.0010	†††
College-ready or one level below	223	44.9	59.0	-14.1	6.8	0.0410 **		
Two or more levels below college-ready	1,188	38.3	28.9	9.4	2.8	0.0010 ***		
Sample size (total = 1,411)		856	555					

SOURCES: Data provided by the Texas Education Research Center and the National Student Clearinghouse.

NOTES: Rounding may cause slight discrepancies in sums and differences.
Distributions may not add to 100 percent because categories are not mutually exclusive.
Statistical significance levels are indicated as: *** = 1 percent; ** = 5 percent; * = 10 percent.
The p-value indicates the likelihood that the estimated impact (or larger) would have been generated by an intervention with zero true effect.
Differential statistical significance levels are indicated as ††† = 1 percent, †† = 5 percent, † = 10 percent.

While other subgroups showed statistically significant impacts (Hispanic students and students who planned to attend college full time), these subgroup impacts were not significantly different than the impacts found for their counterpart subgroups, suggesting the impacts may not have been concentrated in these groups. For instance, Table 3 shows that the program had a significant impact on Hispanic students' completion of the first college-level math class. The mean difference for Black students was slightly larger in magnitude but is not significant, and there is not a significant difference in effects across the three groups (Black, Hispanic, and White students). Since there is not a significant difference across the three groups, the research team cannot assume the program was more effective for Hispanic students than the other groups. The issue here likely lies in part with the larger sample of Hispanic students, which allows for more precise estimates than the other groups.

No differential impacts on academic progress (measured as the overall college credits students earned five years after random assignment) or academic attainment (measured as whether students earned a credential or were currently attending a four-year college five years after random assignment) were found for any of the subgroup comparisons, nor were any statistically significant impacts found on these measures for any of the subgroups explored. Given the lack of differential impacts, tables of these findings are not included.

6. Study Limitations

As a randomized controlled trial, this study provides an internally valid estimate of the causal effect of this version of the DCMP. The length of the follow-up period allowed the team to capture not only the immediate and short-term effects of the program on outcomes such as math completion, but also the longer-term outcomes of college persistence and degree attainment. While internally valid, one limitation of the study is that the recruitment of schools was limited to Texas colleges that were already implementing the DCMP, and so the findings are not statistically generalizable outside the four colleges in the study. The colleges in the sample were also chosen in part because they were relatively strong implementers of the DCMP before the study, so it is possible that these findings represent the upper range of expected impacts that may only be found when the program is relatively well implemented.

There were also some differences between the teachers who taught the DCMP classes and those who taught the standard developmental course sequences. DCMP teachers tended to be full-time faculty members, while a range of faculty members, including both full-time and adjunct employees, taught other math classes. Given their full-time status and experience teaching, it is possible that the faculty members who taught the DCMP courses were stronger, on average, than instructors teaching other math courses.

Another limitation of the study is that, while the DCMP has several components (pathways, acceleration, changes to pedagogy, targeted student supports), it is not possible to identify which components were integral in eliciting the impact. This study represents the findings for a certain combination of these components, and it is not possible to either separate out the components that were most effective or supportive for students or understand whether the model would be more or less effective with slightly different combinations of the components. The Dana Center has been modifying the DCMP over the past decade and currently offers a math pathways program with corequisite remediation. It is not possible to know what the effects of this newer version of the program would be based on these study findings.

While the subgroup analysis offers some insight into potential differential effects of the DCMP, this study was not designed to do confirmatory subgroup analyses and so the subgroup findings are somewhat inconclusive. In particular, racial and ethnic groups were not equally distributed across the project (there were more Hispanic students than other groups) and were also not equally distributed across colleges, so any differential effect by race and ethnicity could have been influenced by differences in implementation at the colleges.[14]

[14] An analysis was done comparing impacts from the four colleges and no statistically significant differences were found.

7. Discussion

With this early version of the DCMP, the Dana Center was one of the first reformers of developmental math education to create a multidimensional reform model based on math pathways. To summarize the study findings, the DCMP model analyzed in this randomized controlled trial had an initial and sustained impact on students' successful completion of their first college-level math course of 5.6 percentage points at the end of the fifth year after random assignment. While it had an initial effect on college-level math credits earned in the first year and successful completion of a second college-level math course in the second year, those effects waned in the following years. While an impact on persistence in college emerged in the fifth year, no significant impacts were found on overall college credits earned or on credential completion or transfer to a four-year college in any of the five years after random assignment.

The study also looked at differential effects of the program on a variety of student groups and found that there was a significant positive effect on the completion of a first college-level math course for students who were two or more levels behind (of 9.4 percentage points) and a substantial negative effect for students who tested as college-ready or one level behind (14.1 percentage points). The program was originally envisioned for students who were two or more levels behind in math and this group made up 84 percent of the study sample. There was also a differential effect on female students completing a first college-level math course (of 9.4 percentage points) and no effect on male students' math completion. These findings suggest that the program effects were concentrated on female students and students with more developmental need. They also suggest that the program may be detrimental to students with limited developmental need, a finding that is consistent with other research (Boatman & Long, 2018). No other differential impacts were found across subgroups of students that were defined by their race and ethnicity, gender, time between high school graduation and college, or decision to attend college part time or full time.

The following discussion explores the components within this version of the DCMP that may have helped more students successfully complete college math courses and considers the DCMP program's potential to lessen disparities in math completion among different groups of students. It also puts the lack of the DCMP program's long-term effects on students' progress through college and on credential completion into perspective by discussing the findings in relation to the program costs and by comparing the findings with findings from other current research on community college reform models.

DCMP Components That May Have Impacted Students' Math Completion

Given the multidimensionality of the program, there are a few DCMP model components that may have led to a positive effect on college-level math completion. While the study cannot dissect the effectiveness of each of the individual components, it is worth considering the components that, when combined, led to positive effects on math completion. First, the acceleration of the developmental math sequence was meant to ensure students could complete a college-level math course in the first year of college. More program group students did complete college-level math in the first year, and the impact held for all five years. Second, the content of the developmental course was nontraditional—it did not focus solely on basic algebraic skills but also emphasized quantitative literacy, statistics, and algebraic reasoning to prepare students for college-level courses that were related to their course of study. Program group students followed a math pathway, and they were about twice as likely to take a college-level statistics or quantitative reasoning course compared with students in the control group, who were more likely to take college algebra (Zachry Rutschow et al., 2019). Finally, the DCMP developmental course had a curriculum that concentrated more on student engagement and active problem solving than the non-DCMP developmental math courses (Zachry Rutschow et al., 2019).

Subgroup Findings and Equity

The program appears to be particularly effective for female students, a group that is generally overrepresented in developmental math programs and underrepresented in STEM fields (Chen, 2016; Chen et al., 2020; National Center for Education Statistics, 2021; National Center for Education Statistics, 2022). The program was effective in helping more female students with developmental math needs successfully complete a first college-level math course.

Students of color are also overrepresented in developmental math programs (Chen, 2016; Chen et al., 2020; National Center for Education Statistics, 2021). While differential effects between racial and ethnic groups were not found, because the program has been shown to be effective in boosting math completion and students of color are overrepresented in developmental math, it can be assumed that the DCMP can help colleges raise math completion rates for students of color. Colleges that are interested in diminishing equity gaps even further might consider pairing a model like the DCMP with other targeted supports or culturally informed practices.

The effects of the program on math completion were concentrated on the students who tested two or more levels below college-ready (compared with those testing at college level or one level below), suggesting that this early version of the DCMP was most effective at supporting the students who would struggle to complete their math sequences the most. Since those are the students who benefit from the acceleration component (because the DCMP only required one semester-long developmental course, regardless of math level), it is possible that acceleration played an important role in the differential impact. In other research, decreasing the time it takes to get a degree has been shown to be an important factor in the effectiveness of developmental math reform (Douglas et al., 2023). As noted in Section 6, there is no way to untangle the different DCMP components (math pathways, acceleration, student-centered pedagogy, and student success strategies) in this study, and it is possible that any or all of these components supported math completion for this group of students.

Longer-Term Outcomes

As noted in Figure 1, the shorter-term effects of the DCMP on the successful completion of students' college math requirements were hypothesized to lead to longer-term effects on the broader college outcomes of persistence, overall credit accumulation, and degree attainment or transfer to a four-year institution. While this version of the DCMP positively impacted college math course completion, the only impact found on the longer-term outcomes of academic progress and attainment was on college persistence (that is, current enrollment in college or previous credential completion) and it was only found during the fifth year.

While the DCMP was not effective in helping more students earn degrees or transfer to four-year colleges on its own, a concurrent cost study of the version of the DCMP discussed in this paper suggests that the costs of the program were minimal (Cullinan, 2023). This version of the DCMP was found to have a social cost of $790 per student over the traditional developmental math sequence provided by the study colleges at the time of implementation. The social cost includes all the program costs of the DCMP plus the cost of developmental and college-level credits attempted by the students during the five-year follow-up period. Most of the additional costs for the DCMP were for start-up expenses, and there were few cost differences between the DCMP and traditional developmental math sequences after the DCMP was up and running. Program group students also attempted about one fewer developmental course credit on average than their control group counterparts, leading to some savings for program group students.

An analysis was conducted of the cost per outcome for key long-term outcome measures: "total college-level credits earned" and "earned a credential or is currently enrolled in a four-year college." The cost study did not look at costs per successful completion of a first college-level math course because this outcome is an early indicator of credential attainment, which is measured. The cost study found that the costs per outcome were similar for the program and control groups. Given that there were no statistically significant effects on these long-term academic outcomes and small differences in the costs between the DCMP and the traditional developmental math sequences at the participating schools, the costs per outcome were also similar for the program and control groups. Therefore, for these long-term outcomes there is no generalizable difference in the cost effectiveness between the DCMP as it was implemented in this study and the status quo. However, as an inexpensive program with short-term impacts, the DCMP may be appealing as a component of a wider set of reforms that could lead to an impact on credential attainment.

Perhaps the expectation that a single math intervention that targeted incoming students would affect college completion was overly optimistic. Other developmental math reforms have shown similar findings, with positive effects on math completion but little effect on longer-term outcomes like college completion (Douglas et al., 2020; Ran & Lin, 2022). A recent synthesis of rigorous research on postsecondary educational reforms found that most of an intervention's effects occur while they are provided to students, and that interventions that last longer tend to have larger effects on students' outcomes than shorter interventions (Scrivener & Weiss, 2022).

The early version of the DCMP may have been more effective if it had utilized a corequisite model. In more recent years, the Dana Center has integrated a corequisite remediation course structure into their model recommendations. This structure further accelerates students' entrance into credit-bearing courses. Instead of the one-semester developmental course that was used in the early version of the DCMP, students may enroll directly in a college-level course in their pathway. At the same time, students in need of developmental assistance may receive holistic services that include a companion support course, tutoring, or help from an advisor (Richardson, 2021).

Recent findings on the longer-term effects of corequisite remediation that is paired with a statistics math pathway suggest that the Dana Center's current effort to move to a corequisite remediation model may lead to stronger effects on academic attainment. An experimental study of corequisite remediation and math pathways in three CUNY colleges offers a comparison. As discussed in the literature review, the program led to impacts on completing associate's and bachelor's degrees (Douglas et al., 2023; Logue et al., 2019).

While it is impossible to disentangle the different components of the DCMP or the CUNY corequisite model, one difference between the two programs is that this version of the DCMP still required students to take a one-semester developmental math course while the corequisite remediation model in the CUNY study placed all students directly into a college-level math course—along with a weekly corequisite support workshop. One of the key hypotheses about what makes corequisite remediation effective is that it allows students to directly enter college-level math courses, removing the obstacles of developmental sequencing and making it possible for students to earn college credits in their first semester.

Still, not all studies of corequisite remediation have found impacts on longer-term outcomes. A regression discontinuity study of a statewide intervention in Tennessee that instituted corequisite remediation with math pathways found that students on the margin of the college-readiness threshold who were placed into corequisite remediation were 15 percentage points more likely to pass their first college-level math course. But, similar to this study of the DCMP, the study did not find significant impacts on enrollment persistence, transfer to a four-year college, or degree completion (Ran & Lin, 2022). An experimental study of an intervention that utilized corequisite remediation but not math pathways (that is, treatment students entered college-level algebra) also found a significant impact on college-level math course completion within three years, but did not show a measurable impact on student persistence at the college or on degree completion within three years (Douglas et al., 2020). While pairing math pathways with corequisite remediation may lead to stronger impacts, the impact of corequisite remediation on longer-term outcomes, even with math pathways, may be dependent on other important factors, such as the student sample, the setting, or the particular design of the intervention.

A movement toward corequisite remediation is afoot. In 2017, Texas House Bill 2223 was passed; it requires colleges to offer 100 percent of their developmental sections as corequisite courses, starting with the 2021-2022 academic year. Many other states are starting to promote or require corequisite remediation (Whinnery & Odekar, 2021). In 2017, California legislators passed Assembly Bill 705, which requires colleges to allow incoming students access to transfer-level classes (that is, college-credit-bearing courses) unless they are deemed highly unlikely to succeed in those courses. This law has led to a statewide movement toward corequisite remediation, at both the community college and university level.

While developmental math reforms work to remove barriers caused by remedial education, students often face other barriers to academic attainment and credential completion. Only one-third of the program and control group students completed a credential or transferred to a four-year institution in the five years after random assignment. Many students who enter community college underprepared for college math never complete any credential, and supporting their developmental math needs might not be enough on its own to address these dismal statistics.

One option to help boost graduation rates might be to pair accelerated or corequisite math pathways with multifaceted support programs that extend past the first year of college. These programs use several components—such as academic advising, tutoring, individual career and employment services, and tuition assistance—over multiple years to address barriers to students' college attainment. One notable example, the Accelerated Study in Associate Programs model, nearly doubled graduation rates in multiple colleges from two states with different student populations (Miller & Weiss, 2021). While programs such as the DCMP can make an important contribution, colleges may want to consider integrating math reforms with multifaceted services to meet the needs of a diverse set of students. The synthesis of experimental studies of community college reforms that was discussed earlier in this section found that comprehensive interventions (those that have more components) tended to have larger effects. The synthesis also found promising evidence that effects tended to be larger for interventions that increased students' advising use, increased students' tutoring use, and provided increased financial support to students—which could all be components of a comprehensive reform that includes math pathways (Scrivener & Weiss, 2022).

8. Conclusion

When this study began, the Dana Center was one of the organizations spearheading developmental math reform. The DCMP model examined in this study combined math pathways with several other components to build a comprehensive math reform that was scalable. While the Dana Center and others have built on this model since its implementation, this long-term follow-up study contributes to the field by providing evidence about the effects of the program on longer-term outcomes in the theory of change. The DCMP had an initial and sustained positive impact on students' college-level math course completion in the five years after random assignment. The impacts on math completion did not lead, as hypothesized, to broader impacts on college persistence and degree attainment. However, in light of other studies on community college reforms that have shown that short-term programs are unlikely, in most cases, to lead to longer-term outcomes on their own (Scrivener & Weiss, 2022), the initial goals may have been unrealistic. One exception is the recent long-term follow-up study of the CUNY corequisite remediation intervention that also implemented math pathways; the study found a strong impact on college completion. While not all research on the effect of corequisite remediation on college completion has been so positive, and the results of the CUNY study have not yet been replicated, the CUNY study suggests that the Dana Center's current approach—to pair math pathways with corequisite remediation—might lead to broader effects and presents a potential opportunity for a future replication study.

Appendix A

Supplementary Tables

The following tables represent the full set of analyses produced for the Dana Center Math Pathways long-term follow-up study. While the working paper includes the key analyses, these tables present the findings for all measures for each of the 10 semesters of the study's five-year follow-up period.

- Appendix Table A.1 displays the findings on math completion, including enrollment, the percentage of students who passed college-level math courses, and credits earned for math and nonmath courses.
- Appendix Table A.2 presents findings on academic progress, such as the total college-level credits that were attempted and earned, a breakdown of development credits that were attempted and earned, and the combined college-level and development credits that were attempted and earned.
- Appendix Table A.3 shows detailed enrollment findings for each semester (both "enrolled in any college" and "currently enrolled in any college or previously earned a credential").
- Appendix Table A.4 presents the full findings on academic attainment, including the key measure of "ever earned a credential or currently enrolled in a four-year college." It includes a breakdown of the percentage of students who were currently enrolled in a four-year college; who were ever enrolled in a four-year college; and who had ever received a certificate, associate's degree, or bachelor's degree. It also includes the highest degree earned.
- Appendix Tables A.5, A.6, and A.7 show the findings for all subgroups that were measured, including subgroups distinguished by race or ethnicity, gender, planned enrollment level (full or part time), time between high school and college (six months or less, or more than 6 months), and placement level in developmental mathematics ("college-ready or one level below" or "two or more levels below college-ready"). Table A.5 shows the percentage of students in these subgroups who completed a first college-level math course within the five-year period. Table A.6 shows total college-level credits earned by the end of the five-year period. Table A.7 shows the percentage of students who had attained a credential or were currently enrolled in a four-year college at the end of the five-year period.
- Appendix Figure A.1 displays the construction of the analysis sample from the initial random assignment.

Appendix Table A.1
Impacts on Math Completion

Outcome	Program Group		Control Group		Estimated Effects		
	Mean	Standard Deviation	Mean	Standard Deviation	Mean Difference	Standard Error	P-Value
Ever enrolled in first college-level math course (%)							
First semester	2.5	15.5	3.2	17.7	-0.7	0.9	0.4190
Second semester	27.7	44.8	11.5	31.8	16.2	2.2	0.0000 ***
Third semester	35.7	48.0	24.2	42.7	11.5	2.5	0.0000 ***
Fourth semester	40.6	49.2	30.4	45.9	10.2	2.6	0.0000 ***
Fifth semester	43.2	49.6	34.8	47.6	8.5	2.6	0.0010 ***
Sixth semester	45.4	49.8	36.4	48.1	9.0	2.6	0.0010 ***
Seventh semester	46.5	49.9	38.6	48.6	7.9	2.6	0.0030 ***
Eighth semester	48.1	50.0	39.8	48.9	8.3	2.6	0.0020 ***
Ninth semester	49.4	50.0	42.1	49.4	7.3	2.7	0.0060 ***
Tenth semester	49.9	50.0	42.3	49.4	7.6	2.7	0.0040 ***
Passed first college-level math course (%)							
First semester	2.0	14.0	2.5	15.7	-0.5	0.8	0.5600
Second semester	18.6	39.0	8.8	28.1	9.8	1.9	0.0000 ***
Third semester	24.8	43.3	19.1	39.2	5.7	2.2	0.0100 **
Fourth semester	29.0	45.5	24.2	42.7	4.8	2.4	0.0410 **
Fifth semester	31.9	46.7	26.7	44.2	5.1	2.4	0.0360 **
Sixth semester	34.3	47.6	28.8	45.2	5.5	2.5	0.0270 **
Seventh semester	35.3	47.9	30.6	46.0	4.8	2.5	0.0570 *
Eighth semester	37.7	48.5	31.8	46.5	5.9	2.5	0.0210 **
Ninth semester	38.9	48.8	33.2	47.1	5.7	2.6	0.0280 **
Tenth semester	39.3	48.9	33.8	47.2	5.6	2.6	0.0310 **

(continued)

Appendix Table A.1 (continued)

Outcome	Program Group Mean	Program Group Standard Deviation	Control Group Mean	Control Group Standard Deviation	Estimated Effects Mean Difference	Estimated Effects Standard Error	Estimated Effects P-Value
Ever enrolled in second college-level math course[a] (%)							
First semester	0.1	3.4	0.0	0.0	0.1	0.1	0.4150
Second semester	1.7	13.1	0.9	9.5	0.8	0.6	0.2190
Third semester	7.6	26.5	4.5	20.8	3.1	1.3	0.0220 **
Fourth semester	11.9	32.4	7.6	26.5	4.2	1.6	0.0100 ***
Fifth semester	14.6	35.3	11.1	31.3	3.5	1.8	0.0580 *
Sixth semester	16.6	37.3	14.7	35.3	1.9	2.0	0.3480
Seventh semester	18.3	38.7	15.8	36.4	2.4	2.1	0.2350
Eighth semester	19.9	40.0	17.5	37.9	2.4	2.1	0.2590
Ninth semester	21.0	40.9	18.2	38.5	2.8	2.2	0.1890
Tenth semester	21.8	41.4	18.7	38.9	3.1	2.2	0.1570
Passed second college-level math course[b] (%)							
First semester	0.1	3.4	0.0	0.0	0.1	0.1	0.4150
Second semester	1.0	10.2	0.4	6.0	0.6	0.5	0.1890
Third semester	3.6	18.7	2.2	14.6	1.4	0.9	0.1410
Fourth semester	5.7	23.2	3.7	18.7	2.0	1.2	0.0920 *
Fifth semester	7.3	26.1	5.1	21.9	2.2	1.3	0.0960 *
Sixth semester	8.4	27.8	7.5	26.2	0.9	1.5	0.5520
Seventh semester	9.1	28.8	8.4	27.6	0.7	1.5	0.6560
Eighth semester	9.9	29.9	9.3	28.9	0.6	1.6	0.7190
Ninth semester	10.9	31.3	10.2	30.1	0.7	1.7	0.6700
Tenth semester	11.0	31.4	10.4	30.4	0.6	1.7	0.7080

(continued)

Appendix Table A.1 (continued)

Outcome	Program Group Mean	Program Group Standard Deviation	Control Group Mean	Control Group Standard Deviation	Estimated Effects Mean Difference	Estimated Effects Standard Error	Estimated Effects P-Value
Total college-level math credits attempted							
First semester	0.08	0.55	0.10	0.53	-0.01	0.03	0.6230
Second semester	0.87	1.47	0.37	1.07	0.50	0.07	0.0000 ***
Third semester	1.32	1.97	0.89	1.73	0.43	0.10	0.0000 ***
Fourth semester	1.65	2.32	1.28	2.41	0.36	0.13	0.0040 ***
Fifth semester	1.91	2.67	1.58	2.80	0.32	0.15	0.0270 **
Sixth semester	2.14	2.99	1.88	3.33	0.26	0.17	0.1190
Seventh semester	2.29	3.17	2.08	3.73	0.21	0.18	0.2570
Eighth semester	2.43	3.28	2.26	4.07	0.17	0.19	0.3860
Ninth semester	2.55	3.39	2.41	4.20	0.14	0.20	0.4740
Tenth semester	2.61	3.49	2.46	4.29	0.16	0.21	0.4420
Total college-level math credits earned							
First semester	0.07	0.51	0.07	0.47	-0.01	0.03	0.8010
Second semester	0.58	1.28	0.28	0.91	0.31	0.06	0.0000 ***
Third semester	0.87	1.66	0.66	1.48	0.21	0.08	0.0130 **
Fourth semester	1.09	1.95	0.93	2.05	0.16	0.11	0.1300
Fifth semester	1.28	2.23	1.08	2.34	0.20	0.12	0.1030
Sixth semester	1.45	2.50	1.28	2.77	0.18	0.14	0.2010
Seventh semester	1.53	2.59	1.40	3.11	0.13	0.15	0.3710
Eighth semester	1.64	2.66	1.51	3.39	0.12	0.16	0.4310
Ninth semester	1.72	2.72	1.59	3.43	0.13	0.16	0.4210
Tenth semester	1.75	2.77	1.62	3.46	0.13	0.16	0.4360

(continued)

Appendix Table A.1 (continued)

Outcome	Program Group		Control Group		Estimated Effects		
	Mean	Standard Deviation	Mean	Standard Deviation	Mean Difference	Standard Error	P-Value
Total college-level nonmath credits attempted							
First semester	5.49	4.61	5.66	4.47	-0.17	0.23	0.4660
Second semester	11.22	8.94	11.11	8.57	0.12	0.46	0.7960
Third semester	15.95	13.21	15.54	12.56	0.41	0.69	0.5510
Fourth semester	20.71	17.96	20.29	17.22	0.42	0.94	0.6590
Fifth semester	24.26	21.46	24.15	20.89	0.11	1.14	0.9250
Sixth semester	27.58	25.08	27.62	24.84	-0.04	1.34	0.9730
Seventh semester	30.50	28.32	30.37	28.02	0.13	1.52	0.9330
Eighth semester	33.22	31.79	33.19	31.54	0.03	1.71	0.9850
Ninth semester	35.25	34.20	35.19	34.14	0.06	1.84	0.9750
Tenth semester	37.32	36.62	37.06	36.86	0.26	1.98	0.8940
Total college-level nonmath credits earned							
First semester	3.83	4.25	3.89	4.19	-0.06	0.22	0.7800
Second semester	8.03	8.36	7.84	8.07	0.19	0.44	0.6690
Third semester	11.68	12.36	11.21	11.72	0.47	0.65	0.4660
Fourth semester	15.56	16.92	14.96	15.85	0.60	0.89	0.4970
Fifth semester	18.34	20.16	17.96	19.16	0.38	1.06	0.7230
Sixth semester	21.11	23.61	20.81	22.81	0.30	1.26	0.8130
Seventh semester	23.42	26.42	23.14	25.71	0.28	1.41	0.8420
Eighth semester	25.62	29.54	25.46	28.86	0.16	1.58	0.9180
Ninth semester	27.23	31.56	27.13	31.30	0.10	1.70	0.9540
Tenth semester	28.96	33.72	28.70	33.91	0.26	1.82	0.8860
Sample size (total = 1,411)	856		555				

SOURCES: Data provided by the Texas Education Research Center and the National Student Clearinghouse.

NOTES: Rounding may cause slight discrepancies in sums and differences.
Statistical significance levels are indicated as: *** = 1 percent; ** = 5 percent; * = 10 percent.
The p-value indicates the likelihood that the estimated impact (or larger) would have been generated by an intervention with zero true effect.
[a]This measure is calculated as students who enrolled in more than three credits of college-level math.
[b]This measure is calculated as students who earned more than three credits of college-level math.

Appendix Table A.2
Impacts on Academic Progress: Total Credits Attempted and Earned

Outcome	Program Group		Control Group		Estimated Effects		
	Mean	Standard Deviation	Mean	Standard Deviation	Mean Difference	Standard Error	P-Value
Total college-level credits earned							
First semester	3.90	4.37	3.97	4.28	-0.07	0.23	0.7620
Second semester	8.61	8.91	8.12	8.38	0.50	0.46	0.2840
Third semester	12.55	13.17	11.86	12.49	0.68	0.69	0.3220
Fourth semester	16.65	18.00	15.89	16.98	0.76	0.94	0.4190
Fifth semester	19.62	21.43	19.04	20.54	0.57	1.13	0.6120
Sixth semester	22.56	25.09	22.09	24.44	0.48	1.34	0.7220
Seventh semester	24.95	27.99	24.54	27.50	0.42	1.50	0.7820
Eighth semester	27.26	31.21	26.97	30.80	0.29	1.67	0.8640
Ninth semester	28.95	33.32	28.72	33.33	0.23	1.80	0.8990
Tenth semester	30.71	35.52	30.32	36.00	0.39	1.92	0.8400
Total college-level credits attempted							
First semester	5.57	4.71	5.75	4.55	-0.18	0.24	0.4380
Second semester	12.10	9.50	11.48	8.87	0.62	0.49	0.2030
Third semester	17.27	14.10	16.43	13.37	0.84	0.73	0.2510
Fourth semester	22.35	19.14	21.57	18.50	0.78	1.01	0.4390
Fifth semester	26.17	22.86	25.74	22.53	0.43	1.22	0.7250
Sixth semester	29.72	26.76	29.50	26.83	0.22	1.44	0.8800
Seventh semester	32.78	30.15	32.45	30.22	0.34	1.62	0.8360
Eighth semester	35.65	33.76	35.45	33.93	0.20	1.82	0.9120
Ninth semester	37.80	36.28	37.60	36.67	0.20	1.96	0.9180
Tenth semester	39.94	38.78	39.51	39.49	0.42	2.11	0.8410

(continued)

Appendix Table A.2 (continued)

Outcome	Program Group Mean	Program Group Standard Deviation	Control Group Mean	Control Group Standard Deviation	Estimated Effects Mean Difference	Estimated Effects Standard Error	Estimated Effects P-Value
Total developmental credits earned							
First semester	2.68	2.93	2.35	2.95	0.34	0.16	0.0300 **
Second semester	3.23	3.35	3.29	3.79	-0.06	0.19	0.7550
Third semester	3.53	3.59	3.59	3.99	-0.06	0.20	0.7790
Fourth semester	3.62	3.63	3.78	4.07	-0.16	0.20	0.4270
Fifth semester	3.72	3.67	3.89	4.10	-0.17	0.20	0.4100
Sixth semester	3.78	3.70	3.97	4.13	-0.19	0.21	0.3620
Seventh semester	3.82	3.71	4.01	4.12	-0.19	0.21	0.3470
Eighth semester	3.86	3.75	4.05	4.13	-0.19	0.21	0.3560
Ninth semester	3.89	3.75	4.08	4.13	-0.20	0.21	0.3460
Tenth semester	3.90	3.76	4.09	4.14	-0.19	0.21	0.3590
Total developmental credits attempted							
First semester	4.29	3.12	4.06	3.25	0.22	0.16	0.1670
Second semester	5.40	4.12	5.96	4.61	-0.56	0.22	0.0120 **
Third semester	5.87	4.62	6.61	5.19	-0.74	0.25	0.0040 ***
Fourth semester	6.06	4.80	6.96	5.42	-0.90	0.26	0.0010 ***
Fifth semester	6.20	4.95	7.23	5.63	-1.03	0.27	0.0000 ***
Sixth semester	6.31	5.11	7.37	5.76	-1.06	0.28	0.0000 ***
Seventh semester	6.36	5.14	7.45	5.86	-1.10	0.28	0.0000 ***
Eighth semester	6.42	5.20	7.51	5.88	-1.09	0.29	0.0000 ***
Ninth semester	6.46	5.21	7.56	5.89	-1.10	0.29	0.0000 ***
Tenth semester	6.48	5.22	7.56	5.89	-1.09	0.29	0.0000 ***

(continued)

Appendix Table A.2 (continued)

Outcome	Program Group		Control Group		Estimated Effects		
	Mean	Standard Deviation	Mean	Standard Deviation	Mean Difference	Standard Error	P-Value
Total college-level and developmental credits earned							
First semester	6.58	5.49	6.32	5.41	0.27	0.29	0.3530
Second semester	11.85	10.19	11.41	9.94	0.44	0.54	0.4140
Third semester	16.08	14.46	15.45	14.16	0.63	0.77	0.4140
Fourth semester	20.27	19.29	19.67	18.72	0.60	1.02	0.5560
Fifth semester	23.34	22.75	22.93	22.38	0.41	1.21	0.7380
Sixth semester	26.35	26.43	26.06	26.27	0.29	1.42	0.8400
Seventh semester	28.77	29.31	28.55	29.27	0.22	1.58	0.8890
Eighth semester	31.12	32.51	31.02	32.51	0.10	1.75	0.9560
Ninth semester	32.83	34.60	32.80	35.02	0.03	1.87	0.9860
Tenth semester	34.61	36.80	34.41	37.66	0.20	2.00	0.9210
Total college-level and developmental credits attempted							
First semester	9.86	5.39	9.82	5.30	0.04	0.27	0.8830
Second semester	17.50	10.34	17.44	10.16	0.06	0.53	0.9140
Third semester	23.14	14.88	23.04	14.70	0.10	0.78	0.8950
Fourth semester	28.41	19.96	28.53	19.82	-0.12	1.06	0.9060
Fifth semester	32.37	23.66	32.97	23.95	-0.60	1.27	0.6360
Sixth semester	36.03	27.56	36.87	28.20	-0.85	1.49	0.5700
Seventh semester	39.14	30.94	39.90	31.47	-0.76	1.67	0.6490
Eighth semester	42.07	34.51	42.96	35.07	-0.89	1.87	0.6330
Ninth semester	44.26	37.01	45.16	37.78	-0.90	2.01	0.6540
Tenth semester	46.41	39.49	47.08	40.55	-0.67	2.15	0.7570
Sample size (total = 1,411)	856		555				

SOURCES: Data provided by the Texas Education Research Center and the National Student Clearinghouse.

NOTES: Rounding may cause slight discrepancies in sums and differences.
Statistical significance levels are indicated as: *** = 1 percent; ** = 5 percent; * = 10 percent.
The p-value indicates the likelihood that the estimated impact (or larger) would have been generated by an intervention with zero true effect.

Appendix Table A.3
Impacts on Academic Progress: Enrollment

Outcome	Program Group		Control Group		Estimated Effects		
	Mean	Standard Deviation	Mean	Standard Deviation	Mean Difference	Standard Error	P-Value
Enrolled in any college (%)							
First semester	89.2	30.2	90.0	31.3	-0.8	1.5	0.5900
Second semester	68.2	46.4	70.0	46.1	-1.8	2.5	0.4730
Third semester	55.2	49.7	54.7	49.8	0.5	2.7	0.8520
Fourth semester	48.2	50.0	49.9	50.0	-1.7	2.7	0.5370
Fifth semester	41.2	49.3	44.7	49.7	-3.5	2.7	0.1950
Sixth semester	35.9	48.1	38.9	48.7	-3.1	2.6	0.2400
Seventh semester	33.4	47.2	34.1	47.4	-0.7	2.6	0.7870
Eighth semester	31.5	46.5	30.6	46.1	0.9	2.5	0.7190
Ninth semester	26.7	44.3	24.4	42.9	2.3	2.4	0.3300
Tenth semester	25.5	43.7	19.8	39.8	5.8	2.3	0.0120 **
Enrolled in any college or previously earned a credential (%)							
First semester	89.2	30.2	90.0	31.3	-0.8	1.5	0.5900
Second semester	68.3	46.4	70.3	46.0	-2.0	2.5	0.4210
Third semester	56.1	49.6	55.5	49.8	0.7	2.7	0.8060
Fourth semester	49.9	50.0	51.0	50.0	-1.2	2.7	0.6650
Fifth semester	44.4	49.7	47.3	50.0	-2.9	2.7	0.2860
Sixth semester	40.9	49.2	42.9	49.5	-1.9	2.7	0.4670
Seventh semester	40.5	49.1	40.3	49.1	0.1	2.7	0.9590
Eighth semester	39.7	49.0	38.1	48.6	1.6	2.6	0.5530
Ninth semester	38.5	48.7	36.1	48.1	2.4	2.6	0.3570
Tenth semester	39.1	48.9	33.7	47.2	5.4	2.6	0.0380 **

(continued)

Appendix Table A.3 (continued)

Outcome	Program Group		Control Group		Estimated Effects		
	Mean	Standard Deviation	Mean	Standard Deviation	Mean Difference	Standard Error	P-Value
Number of semesters enrolled	4.55	3.14	4.57	3.09	-0.02	0.17	0.9020
Sample size (total = 1,411)	856		555				

SOURCES: Data provided by the Texas Education Research Center and the National Student Clearinghouse.

NOTES: Rounding may cause slight discrepancies in sums and differences.
Statistical significance levels are indicated as: *** = 1 percent; ** = 5 percent; * = 10 percent.
The p-value indicates the likelihood that the estimated impact (or larger) would have been generated by an intervention with zero true effect.

Appendix Table A.4
Impacts on Academic Attainment

Outcome (%)	Program Group		Control Group		Estimated Effects		
	Mean	Standard Deviation	Mean	Standard Deviation	Mean Difference	Standard Error	P-Value
Ever earned a credential or currently enrolled in a four-year college							
First semester	1.8	13.1	1.4	11.9	0.4	0.7	0.5650
Second semester	5.0	21.9	4.2	19.9	0.8	1.1	0.4820
Third semester	8.4	27.8	7.8	26.8	0.5	1.5	0.7270
Fourth semester	14.4	35.2	13.3	33.8	1.1	1.9	0.5510
Fifth semester	17.9	38.4	16.8	37.4	1.1	2.1	0.5960
Sixth semester	22.3	41.7	23.3	42.2	-1.1	2.3	0.6420
Seventh semester	25.7	43.8	25.2	43.4	0.5	2.4	0.8200
Eighth semester	27.5	44.7	27.0	44.4	0.5	2.4	0.8450
Ninth semester	30.6	46.2	29.5	45.6	1.1	2.5	0.6500
Tenth semester	32.7	47.0	30.2	45.9	2.5	2.5	0.3180
Currently enrolled in a four-year college							
First semester	1.5	12.2	1.0	10.4	0.5	0.6	0.4360
Second semester	3.6	18.7	2.7	16.2	0.9	1.0	0.3450
Third semester	5.6	23.0	5.3	22.3	0.3	1.2	0.7840
Fourth semester	8.3	27.6	8.9	28.4	-0.6	1.5	0.6750
Fifth semester	10.8	31.1	10.5	30.6	0.4	1.7	0.8320
Sixth semester	11.2	31.7	13.8	34.2	-2.6	1.8	0.1440
Seventh semester	14.7	35.6	15.0	35.5	-0.3	1.9	0.8790
Eighth semester	15.3	36.1	15.7	36.2	-0.4	2.0	0.8520
Ninth semester	16.3	37.0	15.6	36.2	0.7	2.0	0.7270
Tenth semester	17.4	37.9	15.1	35.9	2.3	2.0	0.2630

(continued)

Appendix Table A.4 (continued)

Outcome (%)	Program Group		Control Group		Estimated Effects		
	Mean	Standard Deviation	Mean	Standard Deviation	Mean Difference	Standard Error	P-Value
Ever enrolled in a four-year college							
First semester	1.5	12.2	1.0	10.4	0.5	0.6	0.4360
Second semester	4.2	20.1	3.0	17.2	1.2	1.0	0.2610
Third semester	7.1	25.7	6.7	25.0	0.5	1.4	0.7430
Fourth semester	10.6	30.8	11.0	31.3	-0.4	1.7	0.8110
Fifth semester	15.2	36.0	15.1	35.7	0.2	2.0	0.9250
Sixth semester	17.7	38.3	19.5	39.5	-1.8	2.1	0.4020
Seventh semester	21.8	41.4	24.3	42.7	-2.5	2.3	0.2690
Eighth semester	23.6	42.6	26.6	44.1	-3.0	2.4	0.2030
Ninth semester	27.1	44.6	29.7	45.6	-2.6	2.5	0.2980
Tenth semester	31.0	46.4	31.8	46.5	-0.8	2.5	0.7670
Ever received a certificate or degree							
First semester	0.2	4.8	0.3	6.0	-0.1	0.3	0.7480
Second semester	1.6	12.7	1.5	11.9	0.1	0.7	0.8560
Third semester	3.8	19.3	3.3	17.7	0.5	1.0	0.6480
Fourth semester	8.7	28.3	6.9	25.3	1.8	1.5	0.2340
Fifth semester	11.8	32.3	10.5	30.6	1.3	1.7	0.4570
Sixth semester	17.3	37.9	15.8	36.4	1.5	2.0	0.4500
Seventh semester	19.9	40.0	18.9	39.1	1.0	2.2	0.6290
Eighth semester	22.6	41.9	21.4	41.0	1.2	2.2	0.6020
Ninth semester	24.2	42.9	24.1	42.7	0.1	2.3	0.9570
Tenth semester	25.7	43.8	25.7	43.7	0.0	2.4	0.9980

(continued)

Appendix Table A.4 (continued)

Outcome (%)	Program Group		Control Group		Estimated Effects		
	Mean	Standard Deviation	Mean	Standard Deviation	Mean Difference	Standard Error	P-Value
Ever received a certificate							
First semester	0.0	0.0	0.2	4.2	-0.1	0.1	0.3210
Second semester	0.4	5.9	0.3	6.0	0.0	0.3	0.9580
Third semester	1.3	11.3	0.5	7.3	0.8	0.5	0.1560
Fourth semester	2.0	14.0	0.7	8.5	1.3	0.7	0.0550 *
Fifth semester	2.5	15.5	1.6	12.6	0.9	0.8	0.2510
Sixth semester	3.4	18.1	2.1	14.6	1.4	0.9	0.1350
Seventh semester	4.2	19.8	2.8	16.7	1.4	1.0	0.1690
Eighth semester	4.5	20.6	3.3	18.2	1.2	1.1	0.2420
Ninth semester	4.9	21.4	3.8	19.5	1.0	1.1	0.3490
Tenth semester	5.3	22.3	4.0	19.9	1.3	1.2	0.2460
Ever received an associate's degree							
First semester	0.2	4.8	0.3	6.0	-0.1	0.3	0.7480
Second semester	1.5	12.2	1.1	10.4	0.4	0.6	0.5540
Third semester	2.7	16.5	3.0	16.7	-0.2	0.9	0.8100
Fourth semester	6.8	25.3	6.4	24.3	0.4	1.3	0.7400
Fifth semester	9.3	29.1	9.1	28.7	0.2	1.6	0.8940
Sixth semester	14.1	35.0	14.0	34.6	0.1	1.9	0.9510
Seventh semester	16.0	36.8	16.5	37.1	-0.5	2.0	0.7930
Eighth semester	17.6	38.2	18.4	38.6	-0.7	2.1	0.7230
Ninth semester	18.8	39.2	20.2	40.0	-1.3	2.1	0.5270
Tenth semester	19.5	39.7	21.1	40.7	-1.6	2.2	0.4620

(continued)

Appendix Table A.4 (continued)

Outcome (%)	Program Group		Control Group		Estimated Effects		
	Mean	Standard Deviation	Mean	Standard Deviation	Mean Difference	Standard Error	P-Value
Ever received a bachelor's degree							
First semester	0.0	0.0	0.0	0.0	0.0	0.0	
Second semester	0.0	0.0	0.0	0.0	0.0	0.0	
Third semester	0.0	0.0	0.0	0.0	0.0	0.0	
Fourth semester	0.1	3.4	0.2	4.2	-0.1	0.2	0.7480
Fifth semester	0.4	5.9	0.2	4.2	0.2	0.3	0.5390
Sixth semester	0.8	9.0	0.4	6.0	0.4	0.4	0.3020
Seventh semester	1.3	11.3	0.6	7.3	0.7	0.5	0.2040
Eighth semester	2.9	16.8	2.2	14.6	0.6	0.9	0.4580
Ninth semester	3.9	19.5	3.5	18.2	0.4	1.0	0.6910
Tenth semester	5.7	23.2	4.9	21.5	0.8	1.2	0.5310
Highest credential							
Certificate	3.5	18.4	2.1	14.6	1.4	0.9	0.1380
Associate's	15.8	36.6	18.0	38.3	-2.1	2.0	0.2910
Bachelor's	5.7	23.2	4.7	21.2	1.0	1.2	0.4360
Masters	0.0	0.0	0.2	4.2	-0.2	0.1	0.2110
Sample size (total = 1,411)	856		555				

SOURCES: Data provided by the Texas Education Research Center and the National Student Clearinghouse.

NOTES: Rounding may cause slight discrepancies in sums and differences.
Statistical significance levels are indicated as: *** = 1 percent; ** = 5 percent; * = 10 percent.
The p-value indicates the likelihood that the estimated impact (or larger) would have been generated by an intervention with zero true effect.

Appendix Table A.5
Completion of First College-Level Math Course, by Subgroup, Five Years After Random Assignment

		Program Group		Control Group		Estimated Effects				
Subgroup (%)	Sample	Mean	Standard Deviation	Mean	Standard Deviation	Mean Difference	Standard Error	P-Value	P-Value Difference in Effects	
Race/ethnicity									0.6920	
Black	178	32.0	46.7	23.4	43.2	8.7	7.4	0.2400		
Hispanic	764	47.2	50.0	40.4	49.1	6.8	3.7	0.0630 *		
White	193	33.4	47.5	32.8	47.0	0.6	7.2	0.9340		
Gender									0.0640	†
Female	866	45.8	49.9	36.4	48.2	9.4	3.4	0.0060 ***		
Male	432	33.8	47.2	35.0	48.1	-1.2	4.6	0.7890		
Planned enrollment prior to random assignment									0.8210	
Full time	826	43.8	49.6	37.2	48.5	6.6	3.5	0.0550 *		
Part time	524	33.9	47.5	28.5	45.0	5.4	4.2	0.1960		
Time between high school and college									0.8930	
Six months or less	820	43.8	49.7	38.2	48.6	5.6	3.5	0.1100		
More than six months	568	32.6	46.9	27.7	45.0	4.9	3.8	0.1990		
Placement level									0.0010	†††
College-ready or one level below	223	44.9	50.0	59.0	49.6	-14.1	6.8	0.0410 **		
Two or more levels below college-ready	1,188	38.3	48.7	28.9	45.3	9.4	2.8	0.0010 ***		
Sample size (total = 1,411)		856		555						

SOURCES: Data provided by the Texas Education Research Center and the National Student Clearinghouse.

NOTES: Rounding may cause slight discrepancies in sums and differences.
Distributions may not add to 100 percent because categories are not mutually exclusive.
Statistical significance levels are indicated as: *** = 1 percent; ** = 5 percent; * = 10 percent.
The p-value indicates the likelihood that the estimated impact (or larger) would have been generated by an intervention with zero true effect.
Differential statistical significance levels are indicated as ††† = 1 percent, †† = 5 percent, † = 10 percent.

Appendix Table A.6
College-Level Credits Earned, by Subgroup, Five Years After Random Assignment

Subgroup (%)	Sample	Program Group		Control Group		Estimated Effects			
		Mean	Standard Deviation	Mean	Standard Deviation	Mean Difference	Standard Error	P-Value	P-Value Difference in Effects
Race/ethnicity									0.6460
Black	178	28.10	37.20	23.17	28.97	4.94	5.73	0.3900	
Hispanic	764	34.90	35.61	34.54	36.88	0.36	2.68	0.8930	
White	193	28.00	37.88	30.61	40.15	-2.61	5.92	0.6600	
Gender									0.3670
Female	866	35.11	37.14	33.36	38.11	1.76	2.62	0.5030	
Male	432	27.42	32.92	29.44	33.31	-2.02	3.25	0.5360	
Planned enrollment prior to random assignment									0.9960
Full time	826	35.83	38.18	35.58	38.42	0.25	2.72	0.9260	
Part time	524	23.50	29.75	23.23	31.27	0.27	2.77	0.9220	
Time between high school and college									0.9040
Six months or less	820	35.71	37.07	35.19	38.20	0.52	2.70	0.8490	
More than six months	568	23.28	31.69	23.22	30.94	0.06	2.66	0.9830	
Placement level									0.1170
College-ready or one level below	223	34.34	37.52	41.22	35.79	-6.88	5.17	0.1850	
Two or more levels below college-ready	1,188	30.05	35.12	28.19	35.72	1.85	2.08	0.3730	
Sample size (total = 1,411)		856		555					

SOURCES: Data provided by the Texas Education Research Center and the National Student Clearinghouse.

NOTES: Rounding may cause slight discrepancies in sums and differences.
Distributions may not add to 100 percent because categories are not mutually exclusive.
Statistical significance levels are indicated as: *** = 1 percent; ** = 5 percent; * = 10 percent.
The p-value indicates the likelihood that the estimated impact (or larger) would have been generated by an intervention with zero true effect.
Differential statistical significance levels are indicated as ††† = 1 percent, †† = 5 percent, † = 10 percent.

Appendix Table A.7

Credential Attainment or Transfer to Four-Year College, by Subgroup, Five Years After Random Assignment

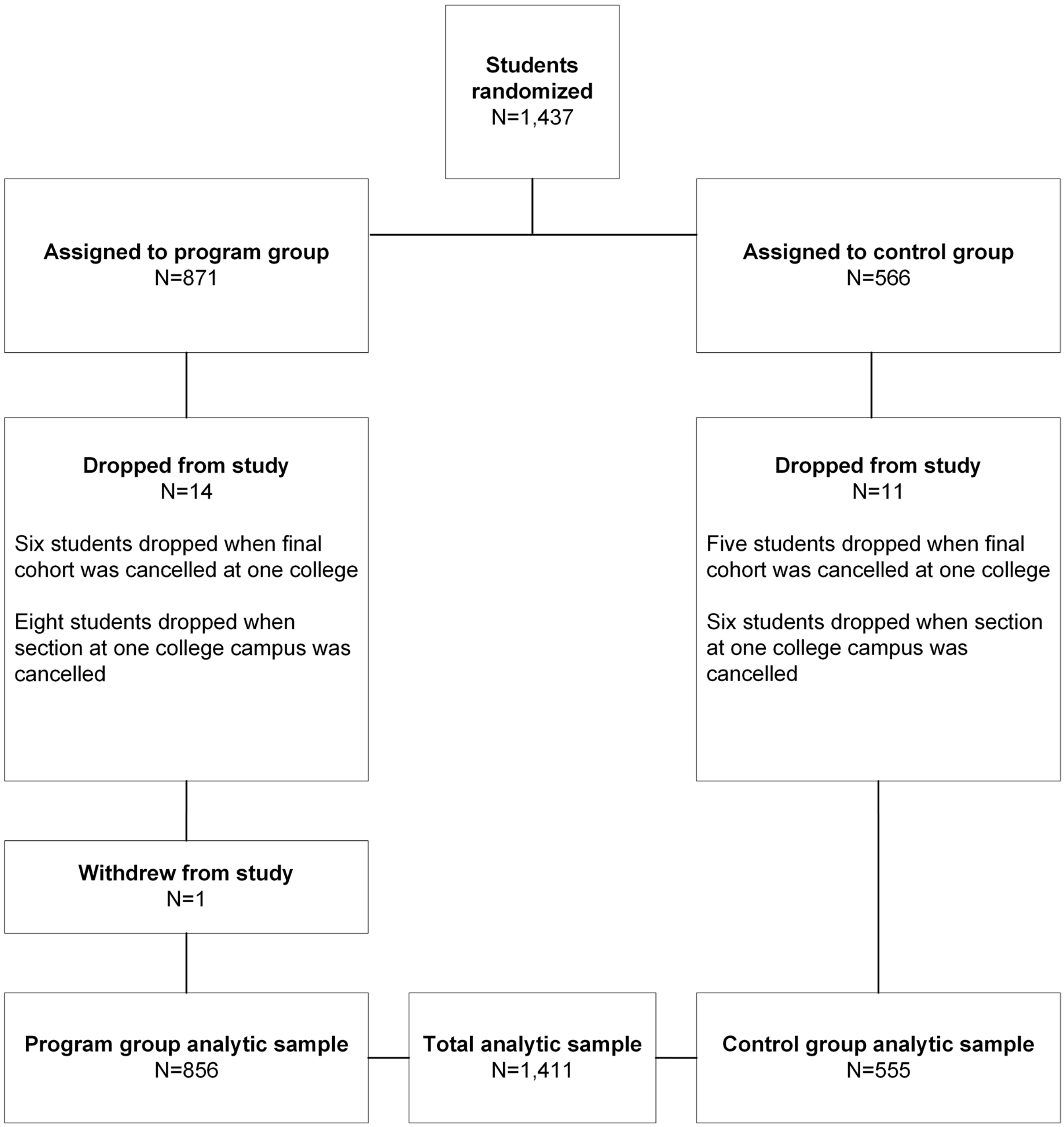
Subgroup (%)	Sample	Program Group Mean	Program Group Standard Deviation	Control Group Mean	Control Group Standard Deviation	Estimated Effects Mean Difference	Estimated Effects Standard Error	Estimated Effects P-Value	P-Value Difference in Effects
Race/ethnicity									0.3990
Black	178	33.1	47.0	26.3	45.1	6.9	7.5	0.3640	
Hispanic	764	36.5	48.2	33.2	47.3	3.4	3.6	0.3470	
White	193	24.8	43.2	30.4	46.4	-5.6	6.7	0.4050	
Gender									0.8410
Female	866	35.9	48.0	33.3	47.2	2.7	3.4	0.4300	
Male	432	31.1	46.4	29.6	45.8	1.5	4.6	0.7420	
Planned enrollment prior to random assignment									0.7970
Full time	826	35.7	48.0	32.8	47.1	2.9	3.4	0.3980	
Part time	524	29.0	45.6	27.5	44.5	1.5	4.1	0.7110	
Time between high school and college									0.9340
Six months or less	820	36.5	48.3	34.4	47.5	2.1	3.5	0.5490	
More than six months	568	26.7	44.4	25.1	43.3	1.7	3.8	0.6620	
Placement level									0.3560
College-ready or one level below	223	44.1	49.9	47.0	50.1	-2.9	6.9	0.6740	
Two or more levels below college-ready	1,188	30.8	46.1	26.8	44.4	3.9	2.7	0.1460	
Sample size (total = 1,411)		856		555					

SOURCES: Data provided by the Texas Education Research Center and the National Student Clearinghouse.

NOTES: Rounding may cause slight discrepancies in sums and differences.
Distributions may not add to 100 percent because categories are not mutually exclusive.
Statistical significance levels are indicated as: *** = 1 percent; ** = 5 percent; * = 10 percent.
The p-value indicates the likelihood that the estimated impact (or larger) would have been generated by an intervention with zero true effect.
Differential statistical significance levels are indicated as ††† = 1 percent, †† = 5 percent, † = 10 percent.

Appendix Figure A.1

Construction of Analysis Sample



References

Bailey, T. (2009). *Rethinking Developmental Education in Community College* (CCRC Brief No. 40). Community College Research Center, Teachers College, Columbia University. https://files.eric.ed.gov/fulltext/ED504329.pdf

Bailey, T., Jeong, D. W., & Cho, S.-W. (2010). Referral, Enrollment, and Completion in Developmental Education Sequences in Community Colleges. *Economics of Education Review*, *29*(2), 255-270. https://doi.org/10.1016/j.econedurev.2009.09.002

Bickerstaff, S., Beal, K., Raufman, J., Lewy, E., & Slaughter, A. (2022). *Five Principles for Reforming Developmental Education: A Review of the Evidence*. Center for the Analysis of Postsecondary Readiness. https://www.mdrc.org/publication/five-principles-reforming-developmental-education-review-evidence

Boatman, A., & Long, B. T. (2018). Does Remediation Work for All Students? How the Effects of Postsecondary Remedial and Developmental Courses Vary by Level of Academic Preparation. *Educational Evaluation and Policy Analysis*, *40*(1), 29-58. https://doi.org/10.3102/0162373717715708

Chen, X. (2016). *Remedial Coursetaking at U.S. Public 2- and 4-Year Institutions: Scope, Experience, and Outcomes* (NCES 2016-405). National Center for Education Statistics, Institute of Education Sciences, Department of Education. https://nces.ed.gov/pubs2016/2016405.pdf

Chen, X., Caves, L., Pretlow, J., Caperton, S., Bryan, M., & Cooney, D. (2020). *Courses Taken, Credits Earned, and Time to Degree: A First Look at the Postsecondary Transcripts of 2011–12 Beginning Postsecondary Students* (NCES 2020-501). National Center for Education Statistics, Institute of Education Sciences, Department of Education. https://nces.ed.gov/pubs2020/2020501.pdf

Cullinan, D. (2023). *Dana Center Math Pathways Long-Term Follow-Up Cost Brief*. [Unpublished manuscript]. MDRC.

Dadgar, M. (2012). *Essays on the Economics of Community College Students' Academic and Labor Market Success* [Doctoral dissertation, Teachers College, Columbia University].

Douglas, D., Logue, A. W., & Watanabe-Rose, M. (2023). The Long-Term Impacts of Corequisite Mathematics Remediation with Statistics: Degree Completion and Wage Outcomes. *Educational Researcher*, *52*(1), 7-15. https://doi.org/10.3102/0013189x221138848

Douglas, D., McKay, H., & Edwards, R. (2020). *Accelerating Mathematics: Findings from the AMP-UP Program at Bergen Community College*. Rutgers School of Management and Labor Relations, Education and Employment Research Center. http://files.eric.ed.gov/fulltext/ED608780.pdf

Edgecombe, N. (2011). *Accelerating the Academic Achievement of Students Referred to Developmental Education*. (CCRC Working Paper No. 30). http://files.eric.ed.gov/fulltext/ED516782.pdf

Gordon, S. P. (2008). What's Wrong with College Algebra? *PRIMUS*, *18*(6), 516-541. https://doi.org/10.1080/10511970701598752

Hayward, C., & Willett, T. (2014). *Curricular Redesign and Gatekeeper Completion: A Multi-College Evaluation of the California Acceleration Project*. The Research and Planning Group for California Community Colleges. https://rpgroup.org/Portals/0/Documents/Archive/California-Acceleration-Project-Evaluation_Report_Final.pdf

Hern, K., & Snell, M. (2014). The California Acceleration Project: Reforming Developmental Education to Increase Student Completion of College-Level Math and English. *New Directions for Community Colleges, 167,* 27-39. https://doi.org/10.1002/cc.20108

Herriott, S., & Dunbar, S. (2009). Who Takes College Algebra? *PRIMUS*, *19*, 74-87. https://doi.org/10.1080/10511970701573441

Hodara, M., & Xu, D. (2016). Does Developmental Education Improve Labor Market Outcomes? Evidence From Two States. *American Educational Research Journal*, *53*(3), 781-813. https://doi.org/10.3102/0002831216647790

Jaggars, S. S., Edgecombe, N., & Stacey, G. W. (2014). *What We Know About Accelerated Developmental Education*. Community College Research Center, Teachers College, Columbia University. http://files.eric.ed.gov/fulltext/ED565668.pdf

Logue, A. W., Douglas, D., & Watanabe-Rose, M. (2019). Corequisite Mathematics Remediation: Results Over Time and in Different Contexts. *Educational Evaluation and Policy Analysis*, *41*(3), 294-315. https://doi.org/10.3102/0162373719848

Logue, A. W., Watanabe-Rose, M., & Douglas, D. (2016). Should Students Assessed as Needing Remedial Mathematics Take College-Level Quantitative Courses Instead? A Randomized Controlled Trial. *Educational Evaluation and Policy Analysis*, *38*, 578-598. https://doi.org/10.3102/0162373716649056

Martinson, K., Cho, S.-W., Gardiner, K., & Glosser, A. (2018). *Washington State's Integrated Basic Education and Skills Training (I-BEST) Program in Three Colleges: Implementation and Early Impact Report*. (OPRE Report No. 2018-87). Office of Planning, Research, and Evaluation, Administration for Children and Families, U.S. Department of Health and Human Services. https://www.acf.hhs.gov/opre/report/washington-states-integrated-basic-education-and-skills-training-i-best-program-three

Martinson, K., Cho, S.-W., Glosser, A., Loya, K., & Dastrup, S. (2021). *Washington State's Integrated Basic Education and Skills Training (I-BEST) Program: Three-Year Impact Report* (OPRE Report No. 2021-102). Office of Planning, Research, and Evaluation, Administration for Children and Families, U.S. Department of Health and Human Services. https://www.acf.hhs.gov/opre/report/washington-states-integrated-basic-education-and-skills-training-i-best-program-three-0

Martorell, P., & McFarlin Jr., I. (2011). Help or Hindrance? The Effects of College Remediation on Academic and Labor Market Outcomes. *Review of Economics and Statistics*, *93*(2), 436-454. https://doi.org/10.1162/REST_a_00098

Miller, C., & Weiss, M. J. (2021). Increasing Community College Graduation Rates: A Synthesis of Findings on the ASAP Model From Six Colleges Across Two States. *Educational Evaluation & Policy Analysis*, *44*(2), 210–233. https://doi.org/10.3102/01623737211036726

National Center for Education Statistics. (2021). Table 311.40. Percentage of First-Year Undergraduate Students Who Reported Taking Remedial Education Courses, by Selected Student and Institution Characteristics: Selected Years, 2003-04 Through 2015-16. In Digest of Education Statistics (Ed.). Institute of Education Sciences, U.S. Department of Education.

National Center for Education Statistics. (2022). Table 318.45. Number and Percentage Sistribution of Acience, Rechnology, Wngineering, and Mathematics (STEM) Degrees/Certificates Conferred by Postsecondary Institutions, by Race/Ethnicity, Level of Degree/Certificate, and Sex of Student: Academic Years 2011-12 Through 2020-21. In Digest of Education Statistics (Ed.). Institute of Education Sciences, U.S. Department of Education.

Norman, J. R., Yamada, H., & Huang, M. (2018). *Degree Attainment and Transfer Among Statway© Students: A Propensity Score Matched Analysis of Outcomes*. [Manuscript submitted for publication]. Carnegie Foundation for the Advancement of Teaching. https://carnegiemathpathways.org/wp-content/uploads/2021/03/Degree-Attainment-and-Transfer-among-Statway-Students-2.pdf

Perin, D. (2011). Facilitating Student Learning Through Contextualization: A Review of Evidence. *Community College Review*, *39*(3), 268-295. https://doi.org/10.1177/0091552111416227

Ran, F. X., & Lin, Y. (2022). The Effects of Corequisite Remediation: Evidence From a Statewide Reform in Tennessee. *Educational Evaluation & Policy Analysis*, *44*(3), 458-484. https://doi.org/10.3102/01623737211070836

Richardson, C. (2021). *Corequisite Mathematics Toolkit*. Charles A. Dana Center at The University of Texas at Austin & Strong Start to Finish. https://strongstart.org/wp-content/uploads/2021/08/SSTFToolkit_DanaCenter_Final-1.pdf

Sanabria, T., Penner, A., & Domina, T. (2020). Failing at Remediation? College Remedial Coursetaking, Failure and Long-term Student Outcomes. *Reseach in Higher Education*, *61*(4), 459-484. https://doi.org/10.1007/s11162-020-09590-z

Scrivener, S., & Weiss, M. (2022). *Findings and Lessons from a Synthesis of MDRC's Postsecondary Education Research*. MDRC. https://www.mdrc.org/publication/findings-and-lessons-synthesis-mdrc-s-postsecondary-education-research

Weiss, M. J., Scrivener, S., Slaughter, A., & Cohen, B. (2021). An On-Ramp to Student Success: A Randomized Controlled Trial Evaluation of a Developmental Education Reform at the City University of New York. *Educational Evaluation and Policy Analysis*, *43*(4), 555-586. https://doi.org/10.3102/01623737211008901

Whinnery, E., & Odekar, V. (2021). *50-State Comparison: Developmental Education Policies*. Education Commission of the States. https://www.ecs.org/50-state-comparison-developmental-education-policies/

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. https://doi.org/10.1177/0091552117743789

Yamada, H., Bohannon, A. X., Grunow, A., & Thorn, C. A. (2018). Assessing the Effectiveness of Quantway®: A Multilevel Model With Propensity Score Matching. *Community College Review*, *46*, 2570187. https://doi.org/10.1177/0091552118771754

Yamada, H., & Bryk, A. S. (2016). Assessing the First Two Years' Effectiveness of Statway®: A Multilevel Model With Propensity Score Matching. *Community College Review*, *44*, 179-204. https://doi.org/10.1177/0091552116643162

Zachry Rutschow, E., Sepanik, S., Deitch, V., Raufman, J., Dukes, D., & Moussa, A. (2019). *Gaining Ground: Findings from the Dana Center Mathematics Pathways Impact Study*. Center for the Analysis of Postsecondary Readiness. https://ccrc.tc.columbia.edu/publications/gaining-ground-dana-center-mathematics-pathways.html