

Executive Summary | November 2019

Gaining Ground

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CENTER FOR THE ANALYSIS OF
POSTSECONDARY READINESS



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Overview

Analyses of literacy and numeracy levels worldwide by the Organisation for Economic Cooperation and Development suggest that the U.S. population has one of the lowest numeracy levels among industrialized nations. Although education leaders and math experts have recognized this problem for years and sought to address it, many people in the United States continue to struggle with learning math. While postsecondary schools have sought to prepare incoming students for college-level math with a curriculum known as developmental or remedial math, however, the problem has persisted. Schools require large proportions of entering college students to take these courses, which can take multiple semesters to complete. And far too few of these students ever successfully complete them. As a result, many practitioners and policymakers focused on improving developmental math courses by shortening the course sequences that students are required to take or streamlining the content in an effort to get students into college-level courses more quickly. Nevertheless, to date, few reforms have focused on changing the *type* of math that students learn and *how* they learn it.

To meet this challenge, the Charles A. Dana Center at the University of Texas at Austin developed the Dana Center Math Pathways (DCMP), which diversifies the math course content that students take so it better aligns with their career interests. The Dana Center also developed curricula for three math pathways, which revise the content and instruction in developmental and college-level math classes while also streamlining the typical two-semester developmental math series into one semester. Starting in 2014, researchers from the Center for the Analysis of Postsecondary Readiness — a partnership between the Community College Research Center at Teachers College, Columbia University, and MDRC, as well as research scholars from several universities — began studying the DCMP curricular models using a randomized controlled trial at four Texas community colleges. This report analyzes the implementation of the curricular models at the institutional and classroom levels and the contrast of the new models with traditional developmental and college-level math classes, the impact of the DCMP on students' academic outcomes for up to four semesters, and the DCMP's costs compared with colleges' standard course pathways.

Overall, the study found that the four Texas colleges revised many institutional policies, enabling them to implement the DCMP and offer DCMP courses to many more students than was done before the study. Virtually all DCMP developmental and college-level courses remained faithful to the DCMP's revised curricular and pedagogical design, which contrasted sharply with colleges' standard developmental course offerings and college-level algebra courses. However, colleges experienced some challenges, such as targeting all students who were eligible for the DCMP and aligning the new math policies with requirements of four-year colleges to which their students were likely to transfer.

After three semesters, the DCMP had a positive impact on students' completion of the developmental math sequence, increasing their likelihood of taking and passing college-level math and the number of math credits earned. Researchers also saw a small impact on early cohorts' attainment of a certificate. They found no impacts on overall credit accumulation or on receipt of an associate's degree or transfer to a four-year college, although it was unlikely to see such impacts in so short a time. The study found that both start-up costs and net ongoing direct costs to the colleges from the DCMP are fairly low, although the colleges also received many supports from the Dana Center that are not included in these estimates.

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Executive Summary

Analyses of literacy and numeracy levels worldwide by the Organisation for Economic Cooperation and Development suggest that the U.S. population has one of the lowest numeracy levels among developed nations. Sixty-four percent of American adults are unable to use math and interpret math problems that most higher-level jobs require, and a full 30 percent can perform only basic mathematical computations such as arithmetic or solve simple one-step operations such as counting.¹ These findings reveal the critical need to improve American adults' math skills.

Even in the U.S. educational context, many people continue to struggle with learning math, and college preparatory math classes, also known as developmental or remedial math, present a particular challenge. The challenges with developmental education — and developmental math, in particular — have become well known. Large proportions of students — up to 70 percent in two-year colleges and 40 percent in four-year colleges — enter college taking developmental classes, and around half of these students never complete their developmental math requirements.² Studies have also shown that the methods used to teach these courses are often not aligned with the instructional methods that math experts recommend.³ Given that developmental math can cost students and their families upward of \$1 billion per year for the students who take these courses, many of whom never earn a degree, the need to improve developmental math students' success is critical.⁴

¹Organisation for Economic Cooperation and Development, *Key Facts About the Survey of Adult Skills (PIAAC)* (Paris, France: Organisation for Economic Cooperation and Development, n.d.); Program for the International Assessment of Adult Competencies, and Institute of Education Sciences National Center for Education Statistics, *PIAAC: What the Data Say About the Skills of U.S. Adults* (Washington, DC: National Center for Education Statistics, n.d.).

²Xianglei Chen, *Remedial Coursetaking at U.S. Public 2- and 4-Year Institutions: Scope, Experience, and Outcomes*, NCES 2016-405 (Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education, 2016); Thomas Bailey, Dong Wook Jeong, and Sung-Woo Cho, "Referral, Enrollment, and Completion in Developmental Education Sequences in Community Colleges," *Economics of Education Review* 29, 2 (2010): 255-270. Chen's study only looked at students who enrolled in courses rather than students referred to these courses, while the Bailey, Jeong, and Cho (2010) study analyzed developmental education referrals.

³James W. Stigler and James Hiebert, *The Teaching Gap: Best Ideas from the World's Teachers for Improving in the Classroom* (New York: The Free Press, 1999); James Hiebert, "What Research Says About the NCTM Standards," pages 5-23 in J. Kilpatrick, W. G. Martin, and D. Schifter (eds.), *A Research Companion to Principles And Standards For School Mathematics* (Reston, VA: National Council of Teachers of Mathematics, 2003); Karen B. Givvin, James W. Stigler, and Belinda J. Thompson, "What Community College Developmental Mathematics Students Understand About Mathematics, Part 2: The Interviews," *MathAMATYC Educator* 2, 3 (2011); James W. Stigler, Karen B. Givvin, and Belinda J. Thompson, "What Community College Developmental Mathematics Students Understand About Mathematics," *MathAMATYC Educator* 1, 3 (2010): 4-16; W. Norton Grubb, *Basic Skills Education in Community Colleges: Inside and Outside of Classrooms* (New York: Routledge, 2013).

⁴Elisabeth A. Barnett, Peter Bergman, Elizabeth Kopko, Vikash Reddy, Clive R. Belfield, and Susha Roy, *Multiple Measures Placement Using Data Analytics: An Implementation and Early Impacts Report* (New York: Center for the Analysis of Postsecondary Readiness, 2018); Laura Jimenez, Scott Sargrad, Jessica Morales, and

With these troubling statistics in mind, many colleges, systems, and states have taken bold action to reform developmental education, making changes to everything from the way that they assess students' college readiness to the structure and sequencing of developmental education courses — and many reforms are showing promising results in rigorous studies.⁵ Nevertheless, few of these changes have sought to address some of the most challenging problems with developmental and college-level math: course content and teaching methods. Multiple math pathways, which diversify the math course pathways and content that students are required to take based on their intended careers, is one mechanism for addressing these issues. Rather than the “algebra-for-all” model that has been typical in most colleges, math pathways align math content with students' majors; students who concentrate in fields such as social sciences or nursing take statistics courses, for example, while humanities majors might take quantitative literacy courses. Additionally, many math pathways models also replace typical lecture-based teaching with instructional techniques that have been shown to be effective at increasing student engagement and learning.⁶ These methods include activities such as contextualizing math learning within real-life situations or promoting active, student-centered learning models that make students active participants in problem solving.

This report presents the findings of a study of a popular math pathways innovation, the Dana Center Mathematics Pathways (DCMP, formerly the New Mathways Project). It examines the effects of the implementation of the DCMP's curricular models, which entail changes in both math content and instructional methods in developmental education and college-level courses while also accelerating developmental students' progress into college-level math.⁷ This is one of

Maggie Thompson, *Remedial Education: The Cost of Catching Up* (Washington, DC: The Center for American Progress, 2016).

⁵Barnett et al. (2018); Shanna Smith Jaggars, Michelle Hodara, Sung-Woo Cho, and Di Xu, “Three Accelerated Developmental Education Programs: Features, Student Outcomes, and Implications,” *Community College Review* 43, 1 (2014): 3-26; Angela Boatman, *Evaluating Institutional Efforts to Streamline Postsecondary Remediation: The Causal Effects of the Tennessee Developmental Course Redesign Initiative on Early Student Academic Success* (New York: National Center for Postsecondary Research, 2012); Alexandra W. Logue, Mari Watanabe-Rose, and Daniel Douglas, “Should Students Assessed as Needing Remedial Mathematics Take College-Level Quantitative Courses Instead? A Randomized Controlled Trial,” *Educational Evaluation and Policy Analysis* 38, 3 (2016); Elizabeth Zachry Rutschow, Maria Scott Cormier, Dominique Dukes, and Diana E. Cruz Zamora, *The Changing Landscape of Developmental Education Practices: Findings from a National Survey and Interviews with Postsecondary Institutions* (New York: Center for the Analysis of Postsecondary Readiness, 2019).

⁶Michelle Hodara, *Reforming Mathematics Classroom Pedagogy: Evidence-Based Findings and Recommendations for the Developmental Math Classroom* (New York: Community College Research Center, Teachers College, Columbia University, 2011); Vilma Mesa, Sergio Celis, and Elaine Lande, “Teaching Approaches of Community College Mathematics Faculty: Do They Relate to Classroom Practices?” *American Educational Research Journal* 51, 1 (2014): 117-151; Thomas P. Carpenter, Megan Loef Franke, and Linda Levi, *Thinking Mathematically: Integrating Arithmetic and Algebra in Elementary School* (Portsmouth, NH: Heinemann, 2003).

⁷The DCMP curricular models are one version of the DCMP that colleges can choose to implement. Colleges may also choose to implement a broader version of the DCMP model that does not use the DCMP curricula. As Chapter 2 discusses, this broader model is based on the Dana Center's four principles for the DCMP and allows colleges more flexibility in structuring course sequences and revising course content and instruction.

three primary studies by the Center for the Analysis of Postsecondary Readiness (CAPR), a joint venture of MDRC and the Community College Research Center at Teachers College, Columbia University, and supported by the U.S. Department of Education's Institute for Education Sciences. Using a randomized controlled trial, this evaluation examines how four Texas community colleges implemented the DCMP at their institutions in developmental and college-level classrooms and looks at the differences in instruction between these courses and colleges' standard math courses. Additionally, the study analyzes the impact of the DCMP on students' academic outcomes for up to four semesters and compares the costs of the initiative with colleges' standard course pathways.

Overall, the study reveals that colleges remained faithful to the DCMP curricular models, making major changes to intra- and cross-institutional policies that supported the DCMP's implementation at a larger scale. Students in DCMP courses had strikingly different instructional experiences from the experiences of students in standard courses. While lecture and individualized work dominated standard classes, over two-thirds of the DCMP students noted that they worked regularly with other students to solve math problems contextualized in real-life situations. After three semesters, the researchers saw strong and statistically significant impacts on DCMP students' completion of developmental and college-level math courses.⁸ The DCMP did not affect students' persistence in college; overall credit accumulation; or successful completion of a degree, certificate, or transfer to a four-year institution after three semesters, though those effects are unlikely to emerge in so short a period. After initial start-up costs for the DCMP program, colleges were able to implement it at relatively low cost. Ongoing costs were, on average, \$19,340 per year, less than 1 percent of the colleges' overall annual operating revenue.

Why Implement Math Pathways?

The preponderance of evidence shows that there is a disconnect between the demands of the 21st century economy and the math education that postsecondary schools typically offer their students. Although postsecondary schools traditionally require college-level algebra for graduation, only 22 percent of workers are able to use math that is more complicated than decimals, fractions, and percentages.⁹ Many more require basic middle school math and quantitative literacy skills, such as interpreting graphs and charts, or being able to answer math problems that occur in everyday life.¹⁰ Moreover, studies have shown that traditional developmental math courses rely on outdated instructional methods, such as rote memorization of math formulas

⁸Statistical significance measures the likelihood that a relationship exists between two variables that is not the result of chance.

⁹Michael J. Handel, "What Do People Do At Work? A Profile of U.S. Jobs from the Survey of Workplace Skills, Technology, and Management Practices (STAMP)," *Journal for Labour Market Research* 49 (2016): 177-197.

¹⁰John P. Smith, "Tracking the Mathematics of Automobile Production: Are Schools Failing to Prepare Students for Work?" *American Educational Research Journal* 36, 4 (1999): 835-878; Celia Hoyles, Celia, Richard Noss, and Stefano Pozzi, "Proportional Reasoning in Nursing Practice," *Journal for Research in Mathematics Education* 31, 1 (2001): 4-27.

and routine practice, rather than the active learning, concept-based models that are the norm in nations with high math achievement.¹¹

The implementation of multiple math pathways models has become a popular mechanism for responding to these challenges. Rather than requiring students to take algebra courses that will not be relevant to their future work, math pathways allow students to take math courses that are more aligned with their future careers. These pathways are often built around three core math subjects: quantitative literacy for humanities majors; statistics for social and health sciences majors; and a calculus pathway for students majoring in science, technology, engineering, or mathematics (STEM). Many models also begin with an accelerated and revised developmental course, and prominent models such as Carnegie Math Pathways' Statway/Quantway and the DCMP have provided curricula that promote more student-centered instruction in which students work together and take an active role in problem solving and sharing strategies.¹² More than 30 percent of public two-year and four-year colleges report having implemented these pathways on a nationally representative survey in 2016. Quasi-experimental studies and randomized controlled trials have begun to show the promise of these pathways models in increasing developmental students' completion of college-level math and accumulation of credits.¹³ However, despite the increasing popularity of math pathways models, very few rigorous studies have examined their effects on students' outcomes, and none has examined how differing instructional environments may affect students' learning experiences and attitudes toward math.

The DCMP in Texas

The Charles A. Dana Center at the University of Texas at Austin launched the DCMP in 2011 and, with the support of the Texas Association of Community Colleges, garnered the agreement of all 50 Texas community colleges to implement the DCMP at their institutions. Based around four key principles, the DCMP aims to help colleges implement math pathways aligned with students' programs of study in both developmental and college-level courses, develop strategies to support students as learners, and integrate evidence-based curricular and pedagogical strategies in these courses.¹⁴ The Dana Center is now heavily involved in promoting the implementation of

¹¹Stigler and Hiebert (1999); Hiebert (2003); Givvin, Stigler and Thompson (2011); Stigler, Givvin, and Thompson (2010); Lindsey E. Richland, James W. Stigler, and Keith J. Holyoak, "Teaching the Conceptual Structure of Mathematics," *Educational Psychologist* 47, 3 (2012): 189-203; Grubb (2013).

¹²<https://carnegiemathpathways.org>; Pamela Burdman, Kathy Booth, Chris Thorn, Peter Riley Bahr, Jon McNaughtan, and Grant Jackson, *Multiple Paths Forward: Diversifying Mathematics as a Strategy for College Success* (San Francisco: WestEd and Just Equations, 2018); Dana Center Mathematics Pathways, *DCMP Curriculum Design Standards* (Austin, TX: Dana Center Mathematics Pathways, 2017).

¹³Logue, Watanabe-Rose, and Douglas (2016); Jon Norman, *Pathways Post-Participation Outcomes: Preliminary Findings* (Stanford: Carnegie Foundation for the Advancement of Teaching, 2017).

¹⁴For more information, see <https://dcmathwathways.org/dcmp>.

the DCMP nationwide and works with more than 15 states to help them implement multiple math pathways.¹⁵

The Dana Center also created curricula that colleges could use to support the implementation of the developmental and college-level math courses in three pathways (statistics, quantitative literacy, and a path to calculus) at their colleges. (See Figure ES.1.) These curricular models begin with a condensed developmental math course that is targeted to students assessed as needing one to two developmental courses,¹⁶ followed by an introductory college-level math class for each math pathway, respectively. The curricula for DCMP developmental and college-level math courses apply active learning and contextualized math instructional models that emphasize collaborative student learning and require students to demonstrate their ability to read, write, and communicate orally about their math learning. (See Table ES.1.) This study is focused on the implementation and effects of this curricular model.

CAPR's Evaluation of the DCMP

CAPR's evaluation of the DCMP consists of three primary components: (1) an investigation of colleges' institutional implementation of the DCMP curricular pathways, their fidelity to the DCMP curricular models, and the contrast between the DCMP courses and colleges' standard developmental and gateway college-level courses;¹⁷ (2) an impact study investigating the effects of the DCMP on students' academic outcomes; and (3) a cost study. CAPR researchers conducted the study at four colleges in Texas (El Paso Community College, Trinity Valley Community College, and two colleges from the Dallas County Community College District — Brookhaven College and Eastfield College). The key outcomes tracked in the study include completion of the developmental math sequence, completion of a college-level math course, math credits earned, total credits earned, and receipt of a degree or transfer to a four-year college.

Advisors identified students who were interested in and eligible for participating in the DCMP based on their need for developmental math and intended major. They randomly assigned students to either the program group or the standard group. Program group students had the opportunity to enroll in the DCMP, which consists of a one-semester accelerated developmental math course followed by a college-level statistics or quantitative reasoning course in the second

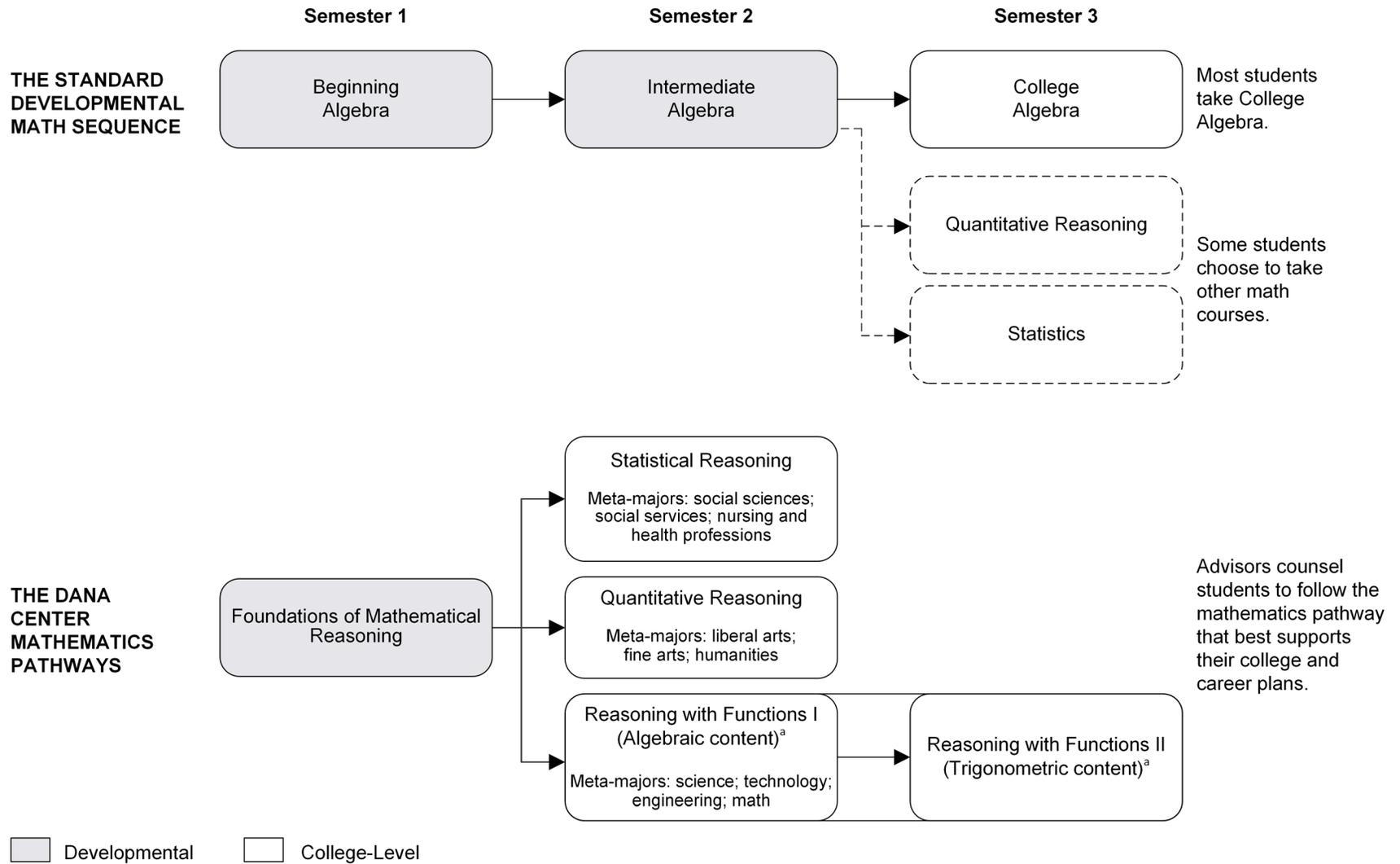
¹⁵California, Georgia, Maine, Maryland, New Mexico, Colorado, Indiana, Missouri, Montana, Nevada, Ohio, Arkansas, Massachusetts, Michigan, Oklahoma, Washington and North Carolina (<https://dcmathpathways.org/where-we-work>).

¹⁶During the period of this study, the assessment of students' college readiness is based on a Texas-wide placement test for entering students called the Texas Success Initiative Assessment (TSIA) or their ACT or SAT scores. The Texas Higher Education Coordinating Board sets the cutoff score at which students are deemed college-ready or in need of developmental courses, and a range of scores that qualify students for developmental courses, below which students must seek alternative services. Colleges have the discretion to set their own cutoff scores within this range to determine students' level of developmental need and the number of developmental courses they must take.

¹⁷A gateway course is the first college-level course that a student takes.

Figure ES.1

**A Comparison of Mathematics Courses
for Students with Two Levels of Developmental Need**



NOTE: ^aEvaluation of Reasoning with Functions I and II is outside of the scope of this study.

Table ES.1

Key Distinctions Between Standard Math Courses and DCMP Courses

Program Component	Standard Math Courses	DCMP Courses
Course Structure		
Course sequence	The number of courses required depends on the student's level of developmental need.	Students with one or two levels of developmental need take only one developmental course.
Math content	Developmental courses emphasize algebraic skills and are designed to lead to college-level algebra.	The developmental course emphasizes quantitative literacy, statistics, and algebraic reasoning skills. College-level courses are diversified based on major.
Instruction and curricular materials		
Curricular materials	Varies; traditionally, the curricula focus on discrete skills and topics.	Curricula are organized around broad mathematical concepts and big ideas.
Pedagogical approach	Varies; traditionally, classes are lecture-based.	Instruction employs a variety of approaches including small-group work, class discussions, and interactive lectures. Students are actively involved in analyzing data and problem-solving.
Constructive perseverance	Varies; this is not a focus in standard math instruction.	Students develop metacognitive skills such as the ability to work through challenging tasks and self-monitor learning.
Problem solving	Varies; traditionally, students learn formula-based applications and rote practice using one solution method.	Instruction supports applying previously learned skills to unfamiliar and nonroutine problems; students develop multiple strategies and solution methods.
Context and interdisciplinary connections	Varies; generally, the use of formulas, equations, and symbols are taught as discrete skills.	Math problems are contextualized around real-life situations and/or integrate academic disciplines; curricula use real data sets and incorporate realistic applications.
Reading and writing	Varies; there are traditionally some word problems. Class is focused on equations and rote practice in applying formulas.	Students develop the ability to read about math and explain solutions in writing.
Use of technology	Varies; instruction is traditionally textbook-based. There is limited use of calculators.	Students regularly use calculators and computers in class and at home

SOURCE: Dana Center Mathematics Pathways (2017).

semester.¹⁸ The standard group had the opportunity to enroll in the colleges' standard algebra-focused developmental course offerings, and once college-ready, could enroll in any college-level math course. Students entered the study from fall 2015 through spring 2017 for a total sample of 1,411 students across the four colleges.

CAPR researchers made field visits to each of the colleges to assess the implementation of the DCMP courses and their contrast with standard math courses, which included interviews with faculty, staff, and administrators; observations of DCMP and non-DCMP classes; and student focus groups. They distributed surveys to students when they entered the study and again near the end of their first semester in the study.¹⁹ CAPR researchers also collected college course placement and transcript data to ascertain students' level of developmental need and academic outcomes. Finally, they collected cost data from college administrators involved with the program to analyze the startup and ongoing costs of the DCMP relative to colleges' standard courses. This report provides findings on students' outcomes over three semesters for the entire sample and four semesters of findings for the first three cohorts.

Findings

Key findings from the study include:

- **Colleges were able to revise many institutional policies that enabled them to implement the DCMP and offer DCMP courses to many more students than was possible before the study began, though challenges remained with targeting all eligible students.**

The four colleges that participated in the study were successful in implementing a number of complex institutional changes to support the expansion of the DCMP. These changes included revising math requirements for majors that would be better aligned with statistics and quantitative reasoning courses, changing advising practices so that they could more readily identify students' majors and place them in the appropriate math sequences, and ensuring 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. As a result of these revisions, each of the colleges offered three sections or more during most of the semesters of the study. Three of the colleges had started with only one or no DCMP developmental course section.

However, while colleges were able to enroll more students in the study, none of the colleges targeted and brought in all the students who were likely eligible for the study, often because

¹⁸Though the colleges participating in the study also implemented college-level statistics and quantitative reasoning courses using DCMP curricula, they generally only offered one or two sections of these courses, making it difficult for students in the program group to enroll. Therefore, successful DCMP students were offered the opportunity to enroll in the colleges' standard statistics and quantitative reasoning courses as well as those that used the DCMP curricula.

¹⁹The first cohort (fall 2015) of students received the survey toward the end of their second semester of the study (spring 2016). Unlike the other cohorts, these students were asked questions regarding their math class in the previous semester.

of the extra advising time needed to place students in the correct pathway or the lack of clarity about alignment of policies and math requirements with four-year colleges.

- **Although colleges were successful at revising most intra-institutional practices, it remained challenging to align policies with those of four-year colleges.**

The colleges in the study were able to successfully negotiate with many four-year colleges to ensure that students' math courses would be accepted upon transfer, which may have been in part a result of the written agreements that CAPR researchers and the Dana Center helped broker with these colleges. However, while colleges made good progress with these efforts, negotiations sometimes remained challenging because some four-year colleges wanted to require specific types of math courses for particular majors (such as Statistics for Psychology for psychology majors). As a result, some advisors had concerns about placing students in the program, which led to difficulties with student recruitment in the first two semesters. For instance, some advisors were hesitant to put nursing students, a high enrollment major, into math pathways courses because some four-year colleges continued to require college-level algebra courses for this major.

- **Virtually all the developmental and college-level DCMP courses remained faithful to the DCMP's revised curricula and pedagogy, although the implementation of active learning, constructive perseverance,²⁰ and reading and writing was less consistent in some small classes and in some classes with English language learners.**

Classroom observations, instructor interviews, and student focus groups revealed that the schools implemented virtually all DCMP courses with relatively strong fidelity to the model. Students in most classes worked collaboratively to solve multistep word problems, using a method or an answer derived in an initial question to solve additional and more complicated queries. Students were also observed sharing strategies and demonstrating their understanding of math concepts orally or in writing. In focus groups, students regularly commented on the course's distinct pedagogy, and instructors generally reported following the revised instructional practices recommended by the DCMP curricula. In responses to the survey students received near the end of their first semester in the study, an overwhelming majority of program group students reported working with other students in small groups, solving real-life problems, reading, writing out their reasoning, and orally sharing their work using math terminology.

- **Instruction in DCMP courses contrasted strongly with colleges' standard developmental course offerings and college-level algebra courses.**

In contrast to DCMP classes, instruction in the colleges' standard developmental and algebra classes typically centered on lecture and individual student work. Students rarely interacted with one another, although they interacted with the teacher in response to a question posed to the

²⁰Constructive perseverance is a student's ability to work through challenging problems.

class. On the student survey, less than 30 percent of students in the standard group reported regularly working with other students on problems, working in small groups, explaining their work orally, or writing out their reasoning. Less than 40 percent reported regularly reading in class or learning math in the context of real-life situations.

- **After three semesters, the DCMP had a positive impact on students' completion of the developmental math sequence and their likelihood of taking and passing college-level math, and the number of math credits they earned. The study found no impacts on overall credit accumulation or on a preliminary measure of successful college completion, none of which is likely to occur in this short timeframe.**

Students participating in the DCMP were 8 percentage points more likely to pass a developmental math course and almost 24 percentage points more likely to complete the developmental math sequence and become college-ready during their first three semesters after entering the study compared with their standard group peers. Program group students were also 11 percentage points more likely to pass a college-level math course during their second semester, and 7 percentage points more likely to have ever passed a college-level math class by the end of their third semester. DCMP students also, on average, earned 0.2 more college-level math credit than the standard group, and both groups had similar overall credit accumulation during the first three semesters. While preliminary findings show a small impact of the DCMP on earning a certificate by the end of two years of college, the study found no impact on the combined measure of earning a degree or transferring to a four-year college during the three-to-four-semester follow-up period.

- **Exploratory analyses suggest that the impacts of the DCMP were greater for part-time students and students assessed as needing multiple developmental courses.**

Exploratory analyses of different subgroups in the sample suggest that the impacts of the DCMP may have been concentrated in the group of students who were lower performing on the math placement exam before entering college (those who were assessed as needing two or three developmental courses, representing 84 percent of the study sample). The program also appears to be somewhat more effective for part-time students (who tend to struggle more with academic performance and credit accumulation and are more likely to drop out) compared with full-time students. In general, analyses suggest that students performed equally well in the DCMP program group regardless of their race, ethnicity, or gender.

- **Both start-up costs and net ongoing direct costs to the college from the DCMP in this study are fairly low, though the colleges also received many supports from the Dana Center that are not included in these estimates.**

The average institutional start-up cost, or costs associated with initially implementing the DCMP, was about \$140,450 per college over two years. Most of the start-up costs were for administration and included any administrative support, which ranged from working to align the courses, planning which courses would be offered, providing clerical support for the DCMP, and

conducting communications and leadership meetings about the DCMP. The ongoing net cost of the DCMP, or the cost to the colleges after initial implementation for activities beyond what is needed for standard developmental math, for one school year was \$19,340 per school on average. The main ongoing net cost was for faculty member training and stipends. Both start-up costs and net ongoing direct costs on an annual basis are less than 1 percent of the colleges' annual operating revenue.

However, colleges did receive many additional supports from the Dana Center for implementing the DCMP, such as faculty member training, assistance in negotiating policies with four-year colleges, and site visits from Dana Center leaders, which the colleges received free of charge. The estimated start-up costs to the Dana Center for these services was \$295,057.

Implications of the Study Findings

Key implications are:

- **The DCMP is effective in helping students succeed in college math. It is too soon to assess the DCMP's effect on students' longer-term academic outcomes.**

Students in the program group significantly increased their completion of developmental and college-level math, and early impacts suggest that the DCMP may have been effective in helping students' reach the longer-term outcome: receipt of a certificate. However, it is too soon to tell whether the DCMP affects students' persistence, overall credit accumulation, and receipt of an associate's degree. A longer timeframe for analyzing these outcomes will be particularly important, given that many students in the study were enrolled part time.

- **Pairing the DCMP with other interventions may bolster students' achievement.**

The DCMP could be connected with other developmental reforms that have shown promise for improving students' success, and in fact such connections are already under way. For instance, in 2017, the state of Texas legislated that postsecondary institutions offer developmental courses as corequisites to college-level courses, meaning that students receive developmental supports while enrolled in college-level math. The Dana Center has developed curricula and supports to aid colleges in implementing these mandates with the DCMP. A rigorous study of a corequisite math pathways model at the City University of New York (CUNY) has revealed the strong impacts that corequisite math pathways can have on developmental students' completion of a college-level math class.²¹

Pairing the DCMP with more comprehensive reforms may also be promising. These reforms include programs such as CUNY's Accelerated Study in Associate Programs (ASAP), which provides multiple financial and social supports to students throughout their college career,

²¹Logue, Watanabe-Rose, and Douglas (2016).

or guided pathways, which provides students with more structured guidance and supports for career and course pathways in an effort to help them complete college as efficiently as possible.²² Rigorous studies of ASAP reveal large effects on helping students reach difficult-to-achieve measures such as graduation. Additionally, because these types of comprehensive reforms focus less often than the DCMP on changes to course content and instruction, the DCMP may provide complementary supports to students' success within these larger initiatives.

- **It is possible to improve students' experiences with math.**

Many postsecondary reforms have shied away from attempts to change classroom instruction. Some of this may stem from a desire to preserve faculty members' autonomy — as well as from research showing that it is extremely difficult to change faculty members' teaching methods.²³ Despite these impediments, the Dana Center was able to develop a curricular model that the colleges under study implemented successfully, dramatically changing students' experiences with learning math. While teachers encountered challenges implementing some parts of the curricula, by and large, most were able to provide a qualitatively different instructional experience for students. Surprisingly, they accomplished these changes with relatively limited training. Nearly all instructors participated in a multiday training event on the DCMP curricula with Dana Center staff, and many also voluntarily participated in online forums and mentoring that supported the implementation. Many instructors also reported that preparing to teach these classes was time-intensive in their initial semester because they required using new instructional approaches. However, most were able to successfully make these changes even in their first semester of teaching this curriculum.

- **The striking contrast in instruction between the DCMP and the colleges' standard courses suggests that college leaders and reformers should pay much more attention to math teaching methods in higher education.**

DCMP courses tended to actively engage students, in terms of their class activity as well as the nature of the material. In contrast, observations and interviews with instructors of standard developmental and college-level algebra classes presented a sobering view of the integration of these practices college-wide. Very few students in these traditional courses interacted with one another or reported understanding how they would use the math they were learning in their everyday lives. Classes tended to be silent except for the teacher's lecturing and requests for solutions to problems. Such findings reveal that instruction in many postsecondary math classes has a long way to go toward adopting the types of student-centered, contextualized learning practices that math experts recommend.²⁴

²²Davis Jenkins, Hana Lahr, and John Fink, *Implementing Guided Pathways: Early Insights From the AACC Pathways Colleges* (New York: Community College Research Center, 2017).

²³Janet Quint, *Professional Development for Teachers: What Two Rigorous Studies Tell Us* (New York: MDRC, 2011).

²⁴National Research Council, *Eager to Learn: Educating Our Preschoolers*, Committee on Early Childhood Pedagogy: Barbara T. Bowman, M. Suzanne Donovan, and M. Susan Burns, eds. (Washington,

- **Postsecondary education policymakers need to integrate student-centered, contextualized instructional models such as the DCMP throughout their math programs to improve students' confidence, engagement, and enjoyment of math.**

Even among the students in this study, far too many continue to struggle with math. After three semesters, more than 40 percent of program group students and more than 65 percent of standard group students had not completed their developmental math requirements after three semesters, and only 25 percent of DCMP students had successfully completed a college-level math course. Additionally, while many students in the DCMP developmental course indicated that their math class had increased their enjoyment of and confidence in math, the majority did not report feeling more confident in math or enjoying math learning. This finding suggests that while a class can improve some students' perspectives of math, there is a need for much more fundamental reforms aimed at building their enjoyment and confidence with math over time.

As such, mathematicians, instructors, and policymakers might consider seeking to develop more engaging math content and instructional approaches that can help build students' interest in math over time. Such initiatives such as Building Educated Leaders for Life (BELL) and the Success for All Middle School Mathematics Program have focused on developing more effective math instructional models in kindergarten through grade 12.²⁵ Postsecondary leaders could turn to centers such as Patrick Henry Community College's SCALE Institute, Project Kaleidoscope, or the Dana Center's FOCI model, which works with instructors in person and remotely to help them integrate active learning and other promising instructional techniques into math courses.²⁶

- **Educators need to develop stronger measures of math teaching and learning to better understand how to improve students' long-term outcomes.**

This study is one of a few that has attempted to assess how an intervention to change instruction in developmental classes and how students' experiences in the classroom may affect their understanding, engagement, and enjoyment of math. However, more accurate and uniformly applied measures of instruction and student learning might provide more comprehensive answers to the question of how to improve math learning. Specifically, very few instruments exist to measure whether and how courses achieve their stated objectives. Additionally, educators need new mechanisms for assessing students' acquisition and application of math skills in real-life settings

DC: National Academy Press, 2001); National Council of Teachers of Mathematics, *Principles and Standards for School Mathematics* (Reston, VA: National Council of Teachers of Mathematics, 2000); Committee on the Undergraduate Program in Mathematics of the Mathematical Association of America, *Undergraduate Programs and Courses in the Mathematical Sciences: CUPM Curriculum Guide 2004* (Washington, DC: The Mathematical Association of America, 2004).

²⁵MDRC, *Math Matters* (New York: MDRC, 2015).

²⁶For more information on SCALE, visit the website of the Southern Center for Active Learning Excellence <http://scaleinstitute.com/>; for more information on FOCI, visit the Focused Online Collaborative Interactions website <https://www.utdanacenter.org/our-work/higher-education/higher-education-services/foci/>; and for more information on Project Kaleidoscope, visit the Association of American Colleges and Universities website, <https://www.aacu.org/pkal>.

to better understand whether and how what the students take away is aligned with their lives and careers. The development of these new measures, and the research findings that come from them, represent the next frontier for improving the field's understanding of how to improve students' math learning and engagement.

Conclusion

Recent research on developmental education reform has shown that many structural and sequencing reforms, such as allowing students to take developmental education and college-level courses simultaneously or compressing two-semester developmental courses into one semester, hold promise for improving developmental students' outcomes.²⁷ However, most of these studies have focused on helping students get through math. Far fewer have focused on effective ways to attract students to math and math-focused careers.

Building an interest and engagement in math is critical to the future of the U.S. economy and students' ability to earn living-wage jobs as the labor market demands candidates with strong logic and critical thinking skills as well as the ability to interpret the myriad charts, graphs, and statistics integral to many jobs. As international studies have revealed, most American adults are currently unable to demonstrate these skills effectively, which makes their ability to secure and keep these jobs much more difficult. This research reveals the critical need to find ways to improve people's understanding of math and how it applies to their everyday life and work. And it finds that the method at the heart of the DCMP curricular models — and the instructional methods national experts recommend — can positively change students' math abilities and perspectives in two semesters. These findings raise the prospects for solutions to Americans' innumeracy epidemic, if educators integrate this type of instruction in many more math courses across the country.

²⁷For examples, see Logue, Watanabe-Rose, and Douglas (2016); Boatman (2012); Jaggars, Hodara, Cho, and Xu (2014).

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