GAINING GROUND: Findings from the Dana Center Mathematics Pathways Impact Study

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Background/Context: To prepare incoming students for college-level math, many colleges offer preparatory courses known as developmental or remedial math. Large proportions of students are required to take these courses, but few ever successfully complete them.[1] Many practitioners and policymakers are working to improve developmental math courses,[2] but 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 aligns developmental and gateway college-level math content with students' career interests and revises math instruction to be more contextualized and student-centered. This study presents impact evaluation findings on the effectiveness of the DCMP.

Purpose/Objective/Research Question: This study is designed to provide evidence about the effectiveness of the DCMP and is focused on four research questions:

1. Do DCMP students have better academic outcomes than students in traditional developmental math?
2. To what degree is there fidelity to the DCMP model across colleges?
3. How do the curriculum and pedagogy in the DCMP courses differ from traditional developmental math?
4. What are the costs to the colleges to implement and maintain DCMP?

Setting: This study was conducted at four Texas colleges. These colleges were selected based on the strength of their implementation, ability to meet these sample size requirements, and interest in the research. They represent a diversity of geographic locations and student populations.

Participants: To evaluate the impact of DCMP, interested and eligible students were randomly assigned to program group or control group. To be eligible, students had to (1) be in need developmental math courses and (2) plan to pursue humanities or social sciences majors which were eligible for the alternative math pathways. 1,411 students from the four Texas colleges were enrolled into the study over the course of four semesters, from fall 2015 through spring 2017 (Table 1).

Intervention: The DCMP model in this study is a two-semester, two-course intervention (see Figures 1 and 2). Students in the program group start with a one-semester developmental math course, which is an accelerated model for with two developmental course need, with revised instruction and content. In the second semester, students are offered the opportunity to take a statistics or quantitative reasoning course to fulfill their math requirements.[3] In contrast, the

[1]Chen (2016); and Bailey, Jeong, and Cho (2010).

[2]Barnett et al. (2018); Jaggars, Hodara, Cho, and Xu (2014); Boatman (2012); Logue, Watanabe-Rose, and Douglas (2016).

[3]Though the colleges participating in the study also implemented college-level statistics and quantitative reasoning courses using curricula developed by the Dana Center, they generally only offered one or two sections of these courses, limiting access to students in the program group. Therefore, students who complete the DCMP developmental math course

control group had the opportunity to enroll in the colleges' standard developmental course sequence and college-level math courses.

Research Design: The study employs a randomized controlled trial design, which resulted in baseline equivalence across treatment and control students, meaning that changes in program students' outcomes can be attributed with a high level of confidence to the impact of the DCMP. The study also includes an implementation study of colleges' institutional and classroom implementation of the DCMP and the contrast between the DCMP courses and colleges' standard math courses. A survey was disseminated to study students (71% response rate) to garner their perspectives of math. A cost study also analyzes the costs of implementing DCMP in comparison with colleges' standard developmental sequence.

Data Collection and Analysis: Study participants completed a baseline survey prior to random assignment. College course placement and transcript data were collected from the colleges to ascertain students' level of developmental need and academic outcomes along with data from the National Student Clearinghouse data. The study employs a generalized linear model (GLM) to examine five key academic outcomes: completion of developmental math, completion of college-level math, math credits accumulated, total credits accumulated, and receipt of a degree or transfer to a four-year college. This report provides findings on students' outcomes over three semesters.

To assess fidelity and service contrast of the program, researchers surveyed students and visited each college and interviewed faculty, staff, and administrators; observed DCMP and non-DCMP classes; and conducted student focus groups. Researchers also collected cost data to analyze the startup and ongoing costs of the DCMP relative to colleges' standard courses.

Results: Overall, the study found that the four Texas colleges were largely successful in implementing the DCMP as designed at the institution level and in classrooms. Researchers found that DCMP's revised curricular and pedagogical design contrasted sharply with colleges' standard developmental and college-level algebra courses, with program and control group students having widely different experiences in their math learning and attitudes towards math (see Tables 2, 3, and 4). A few challenges, such as targeting all eligible students and aligning math policies with requirements at four-year colleges, remained.

After three semesters, 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 (see Tables 5 and 6). Researchers found no impacts on overall credit accumulation or on receipt of an associate 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 DCMP are fairly low.

Conclusions: This research reveals that revised math pathways can improve students' math learning experiences, attitudes towards math, and success in developmental and college-level

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were offered the opportunity to enroll in either the colleges' standard statistics and quantitative reasoning courses or those that used the DCMP curricula.

math courses. Critical to future research will be to see whether these short-term outcomes translate into longer-term impacts on students' graduation rates.

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Table 1

Baseline Characteristics of Full Sample by Site

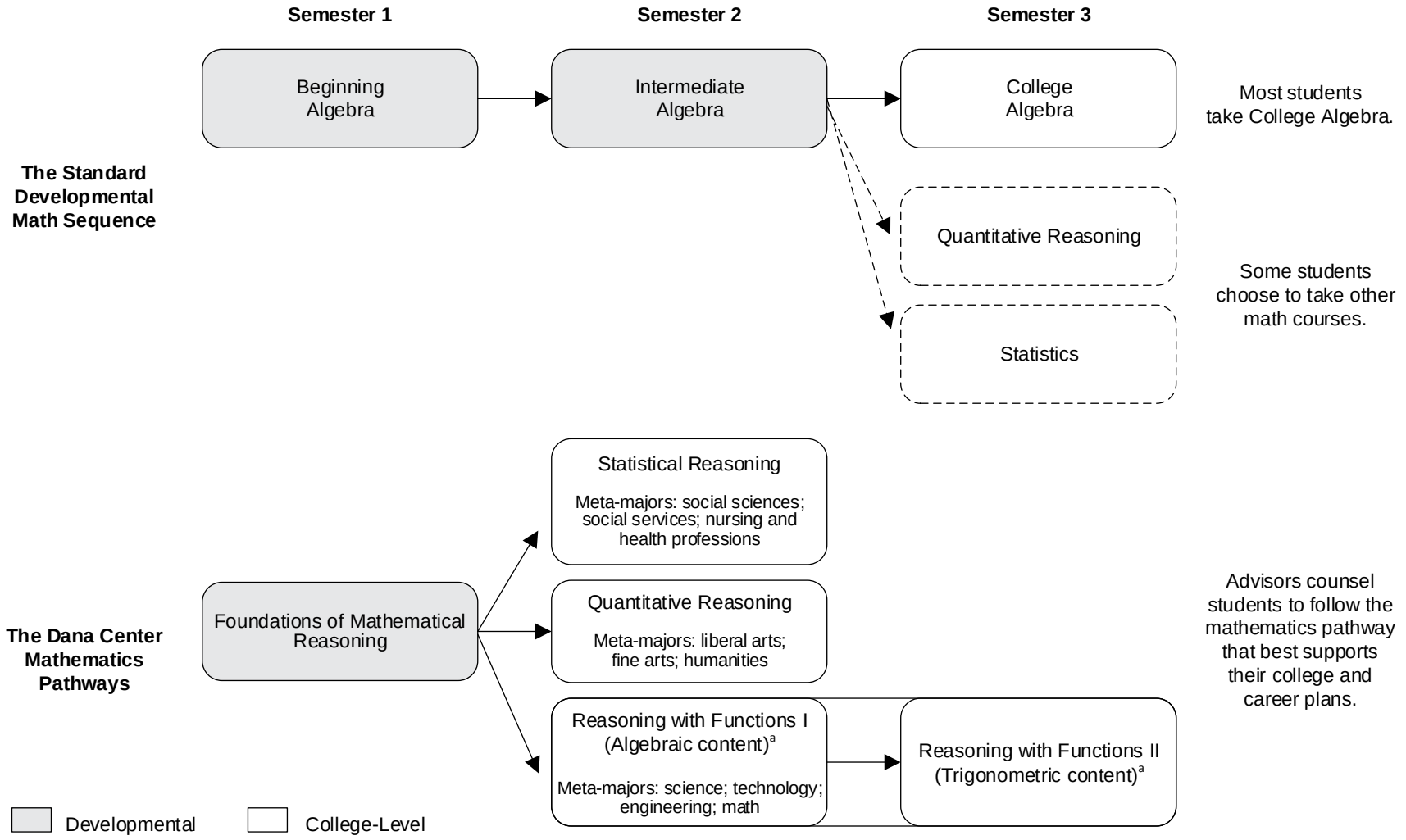
Characteristic	Brookhaven	Eastfield	El Paso	Trinity Valley	All Colleges
Age (years)	24.0	21.1	23.5	22.3	22.5
Male (%)	33.3	37.6	17.5	37.5	30.6
Missing	6.3	12.6	5.6	5.8	8.0
Race/ethnicity (%)					
White	7.9	7.4	6.3	33.1	13.7
Black	12.7	17.4	0.9	21.5	12.6
Hispanic	61.1	54.1	82.5	15.7	54.1
Other	6.3	2.0	1.3	2.5	2.3
Missing	11.9	19.1	9.1	27.3	17.3
Planned full-time enrollment (12 credits or more) this semester (%)	37.6	51.4	62.0	79.9	61.2
Has failed a high school or college math class in the past (%)	50.0	28.0	31.4	28.1	31.1
Missing	2.4	12.8	4.3	4.7	7.0
Math placement[a] (%)					
College-ready or exempt	7.1	2.0	1.5	3.3	2.6
Placed 1 level below college-ready	21.4	4.1	16.5	17.6	13.2
Placed 2 levels below college-ready	71.4	93.9	79.0	79.1	83.2
Placed 3 levels below college-ready	0.0	0.0	3.0	0.0	1.0
Enrolled within 12 months of high school graduation (%)	68.3	70.1	67.5	69.5	68.9
Sample size	126	460	462	363	1,411

SOURCE: Researchers' calculations using data from a baseline survey of students participating in the study and administrative student data. The students completed the baseline survey immediately prior to random assignment, during the study intake process.

NOTES: Rounding may cause slight discrepancies in sums and differences.
Missing values are only shown for items with more than 5 percent missing values
[a]While course names vary between colleges, math courses three levels below college-readiness are frequently referred to as "Pre-Algebra" or "Early Math." Similarly, courses two levels down may be referred to as "Beginning Algebra" and courses one level down may be referred to as "Intermediate Algebra."

Figure 1

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



NOTE: [a]Evaluation of Reasoning with Functions I and II is outside of the scope of this study.

Figure 2

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

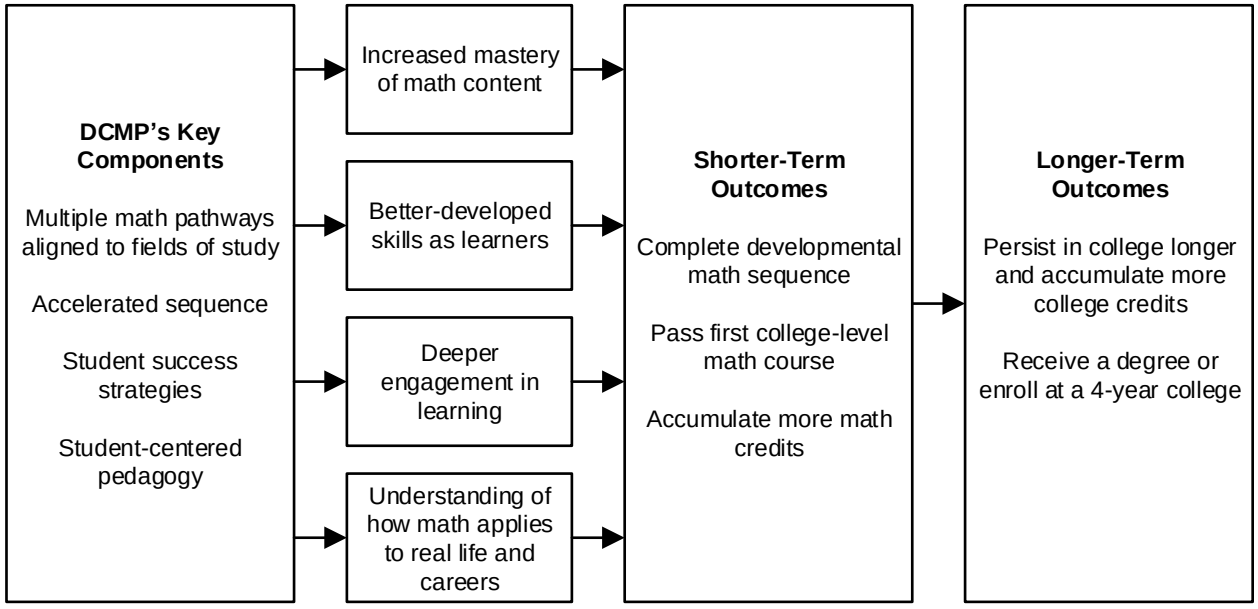


Table 2

Presence of Active Learning, Problem-Solving, and Constructive Perseverance in Developmental Math Classes, Student Survey Responses

Response (%)	Program Group	Control Group	Difference	P-Value
Active Learning				
Always or often during class:				
Students worked on problems on their own	31.9	58.9	-27.0***	0.000
Student worked with other students on problems	73.2	17.6	55.6***	0.000
Students worked in small groups	74.7	15.8	58.9***	0.000
Student explained work to other students	56.2	13.7	42.5***	0.000
Students discussed and shared strategies	69.2	31.9	37.4***	0.000
Problem-Solving and Constructive Perseverance				
Always or often during class:				
Instructor encouraged students to find own way	64.4	42.4	22.0***	0.000
Instructor showed class multiple ways to solve problems	66.7	53.5	13.3***	0.000
Homework prepared students for next class	65.8	54.7	11.2***	0.000
Homework tested students' understanding	66.6	51.9	14.8***	0.000
Agreed or strongly agreed with the following statements about math class:				
You learned how to struggle through problems	65.4	54.5	10.9***	0.001
You tried to work through problems even if instructor hadn't yet taught how	58.1	52.4	5.8*	0.076
Thought the following statements were always or mostly true about math class enrolled in:				
Instructor did not let people give up	68.3	55.9	12.3***	0.000
Instructor expected you to solve problems on your own	40.9	27.0	14.0***	0.000
Sample size (total = 1,411)	856	555		

SOURCE: Researchers' calculations based on a survey of study participants at Brookhaven, Eastfield, El Paso, and Trinity Valley Community Colleges.

NOTES: Rounding may cause slight discrepancies in sums and differences.

Statistical significance levels are indicated as: *** = 1 percent; ** = 5 percent; * = 10 percent.

All cohorts received this survey near the end of their first semester in the study except for the fall 2015 cohort. Students in this cohort, who took the survey during their second semester, were asked about their math class from the previous semester.

The survey was sent to 1,411 students. The overall survey response rate was 71 (71 percent in the program group and 70 percent in the control group). No more than 4 percent of survey respondents failed to respond to any specific item.

Students not taking a math class were not asked to respond to these survey items. Researchers used imputed values of 0 for these students.

Table 3

Presence of Contextualization, Reading and Writing, and Technology in Developmental Math Classes, Student Survey Responses

Response (%)	Program Group	Control Group	Difference	P-Value
Always or often during class:				
Problems used information from real life	57.5	22.5	34.9***	0.000
Students had to read	63.8	35.1	28.7***	0.000
Students were asked to write out reasoning	59.1	20.2	38.9***	0.000
Students were asked to explain work orally using math terminology	56.2	28.2	28.0***	0.000
Students used a computer in class or at home	61.4	52.2	9.2***	0.005
Agreed or strongly agreed with the following statements about math class enrolled in:				
Class was taught using real-life problems	70.0	37.9	32.2***	0.000
Class taught you to think more about what you're learning	76.3	59.2	17.1***	0.000
Sample size (total = 1,411)	856	555		

SOURCE: Researchers' calculations based on a survey of study participants at Brookhaven, Eastfield, El Paso, and Trinity Valley Community Colleges.

NOTES: Rounding may cause slight discrepancies in sums and differences.

Statistical significance levels are indicated as: *** = 1 percent; ** = 5 percent; * = 10 percent.

All cohorts received this survey near the end of their first semester in the study, except the fall 2015 cohort. This cohort, which took the survey during its second semester, was asked to think about their math class from the previous semester when responding to questions.

The survey went to 1,411 students. The overall survey response rate was 71 (71 percent in the program group and 70 percent in the control group). No more than 4 percent of survey respondents failed to respond to any specific item.

Students not taking a math class were not asked to respond to these survey items. Researchers used imputed values of 0 for these students.

Table 4

Students' Perspectives on their Developmental Math Class, and Impacts on their Attitudes Toward Math

Response (%)	Program Group	Control Group	Difference	P-Value
Perspectives on Developmental Math Class[a]				
Difficulty of math class enrolled in:				
Easy or very easy	25.8	22.0	3.8	0.178
About right	48.1	38.3	9.7***	0.003
Difficult or very difficult	13.5	22.0	-8.5***	0.000
Thought the following statements were always or mostly true about math class enrolled in:				
You felt bored during class	12.0	14.4	-2.4	0.271
You paid attention during class	77.7	69.9	7.8***	0.006
You went to class unprepared	4.6	3.7	0.9	0.500
You worked very hard on your math	71.0	66.0	5.0*	0.098
What you learned was interesting	51.1	36.9	14.2***	0.000
You use the math you learned for daily activities	45.8	23.1	22.7***	0.000
Class made you more confident in math ability	54.3	46.8	7.5**	0.023
Class increased your interest in math	36.3	28.2	8.1***	0.009
Impacts on Attitudes Toward Math[b]				
Agree or strongly agree with the following statements				
Confidence in and enjoyment of math:				
Intelligence is born and can't be changed	9.2	8.8	0.4	0.814
The more you work at math the better you'll be	59.0	62.2	-3.1	0.334
You are confident with math	38.2	38.1	0.1	0.984
You know you can handle difficulties in math	41.5	39.2	2.4	0.462
Learning math is enjoyable	38.2	38.6	-0.4	0.901
Utility of math				
You understand how math will be needed in your future	68.7	61.4	7.3**	0.020
You use the math you learned in everyday life	53.9	37.7	16.2***	0.000
Sample size (total = 1,411)	856	555		

SOURCE: Researchers' calculations based on a survey of study participants at Brookhaven, Eastfield, El Paso, and Trinity Valley Community Colleges.

NOTES: Rounding may cause slight discrepancies in sums and differences.

Statistical significance levels are indicated as: *** = 1 percent; ** = 5 percent; * = 10 percent.

All cohorts received this survey near the end of their first semester in the study, except the fall 2015 cohort. This cohort took the survey during its second semester and was asked to think about its math class from the previous semester when responding to questions.

The survey went to 1,411 students. The overall survey response rate was 71 (71 percent in the program group and 70 percent in the control group). No more than 4 percent of survey respondents failed to respond to any specific item.

[a]Students not taking a math class were not asked to respond to these survey items. Researchers used imputed values of 0 for these students.

[b]All students were asked survey questions about their attitudes toward math, regardless of whether they were currently taking a math class.

Table 5

Impacts on College Registration and Developmental Math Class Enrollment and Pass Rates

Outcome (%)	Program Group	Control Group	Difference (Impact)	P-Value
First semester				
Registered in first semester	89.4	87.7	1.7	0.327
Ever enrolled in developmental math class	80.2	72.5	7.7***	0.001
Ever passed developmental math class	49.8	40.5	9.4***	0.001
Ever passed developmental math, among enrolled	*62.1*	*55.8*		
Ever withdrew from developmental math class	6.5	6.6	-0.2	0.909
Completed developmental math sequence[a]	47.4	11.4	36.1***	0.000
Second semester				
Registered in second semester	65.9	65.5	0.4	0.879
Ever enrolled in developmental math class	84.8	78.6	6.2***	0.003
Ever passed developmental math class	56.7	47.8	8.9***	0.001
Ever passed developmental math, among enrolled	*66.9*	*60.9*		
Ever withdrew from developmental math class	8.3	11.1	-2.7*	0.084
Completed developmental math sequence[a]	53.6	28.5	25.1***	0.000
Third semester				
Registered in third semester	48.3	47.7	0.5	0.846
Ever enrolled in developmental math class	85.6	80.2	5.4***	0.007
Ever passed developmental math class	58.7	50.7	8.0***	0.003
Ever passed developmental math, among enrolled	*68.6*	*63.2*		
Ever withdrew from developmental math class	9.3	12.5	-3.2*	0.054
Completed developmental math sequence[a]	57.0	33.5	23.5***	0.000
Sample size (total = 1,411)	856	555		

SOURCES: Researchers' calculations using transcript data provided by Dallas County Community College District, El Paso Community College, and Trinity Valley Community College.

NOTES: Rounding may cause slight discrepancies in sums and differences.

Estimates are adjusted to account for the various community college campuses students attended and the four different semesters during which students were randomly assigned.

Outcomes shown in italics are nonexperimental. Statistical significance tests are not conducted on nonexperimental outcomes.

Statistical significance levels are indicated as: *** = 1 percent; ** = 5 percent; * = 10 percent.

[a] Students are included in "Completed Developmental Math Sequence" if they completed the highest-level developmental math class or enrolled in a college-level math class. It is possible under some circumstances for a student to enroll in college-level math without ever taking or passing a developmental math class (that is, students can retake the math entrance exam).

Table 6

Impacts on College-Level Math Class Enrollment and Pass Rates

Outcome (%)	Program Group	Control Group	Difference (Impact)	P-Value
Second semester				
Ever enrolled in college-level math class	28.3	10.8	17.5***	0.000
Ever passed college-level math class	19.5	8.5	11.1***	0.000
Ever passed college-level math, among enrolled	*70.1*	*73.8*		
Ever withdrew from college-level math class	5.4	1.3	4.1***	0.000
Third semester				
Ever enrolled in college-level math class	35.9	23.2	12.7***	0.000
Ever passed college-level math class	25.3	18.5	6.8***	0.002
Ever passed college-level math, among enrolled	*70.8*	*78.8*		
Ever withdrew from college-level math class	7.5	3.4	4.1***	0.002
Ever enrolled in second college-level math class[a]	6.9	4.0	2.9**	0.020
Ever passed second college-level math class[a]	3.2	1.6	1.5*	0.070
Sample size (total = 1,411)	856	555		

SOURCES: Researchers' calculations using transcript data provided by Dallas County Community College District, El Paso Community College, and Trinity Valley Community College.

NOTES: Rounding may cause slight discrepancies in sums and differences.

Estimates are adjusted to account for the various community college campuses students attended and the four different semesters during which students were randomly assigned.

Outcomes shown in italics are nonexperimental. Statistical significance tests are not conducted on nonexperimental outcomes.

Statistical significance levels are indicated as: *** = 1 percent; ** = 5 percent; * = 10 percent.

[a] Researchers calculated enrollment in and passing of a second college-level math class as students who enrolled in or earned more than three credits in college-level math.