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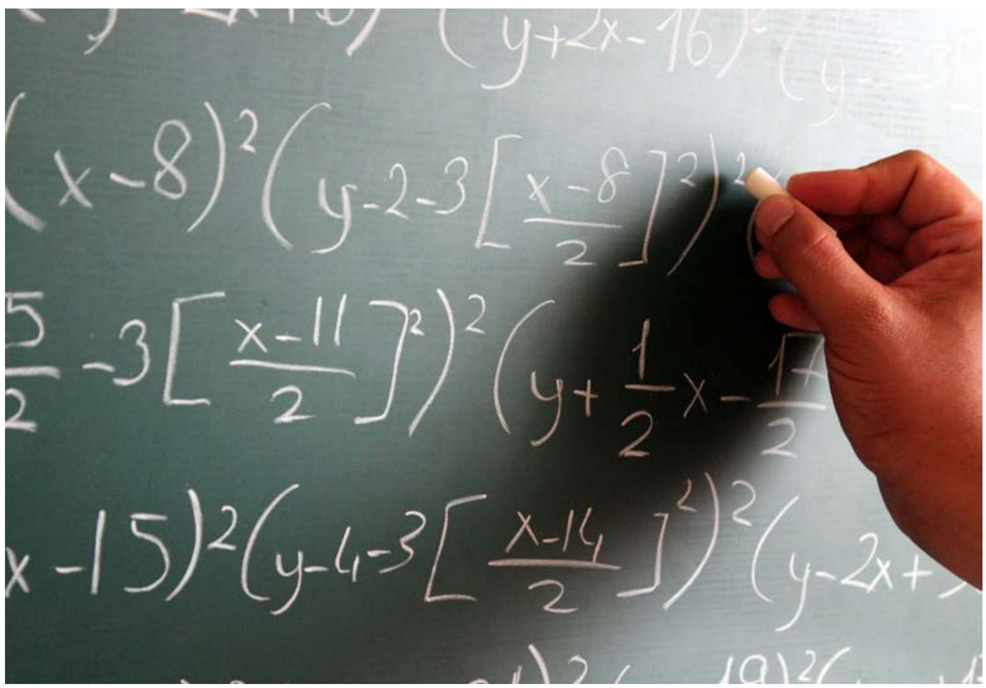
Reforming Math Pathways at California's Community Colleges



SUMMARY

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Technical appendices to this paper are available on the PPIC website.

The goal of developmental education (also known as remedial or basic skills education) is to help students acquire the skills they need to be successful in college courses, but its track record is poor. In fact, it is one of the largest impediments to student success in California's community colleges. Many students do need additional work to be ready for college, particularly in math. But every year hundreds of thousands of students are deemed underprepared for college and placed into developmental courses from which relatively few emerge. Throughout the state, community colleges are revising assessment and placement procedures to ensure that students who are ready for college are not placed in developmental education. And, given the high failure rates in traditional developmental courses, colleges are also experimenting with alternative curricular approaches.

In this report, a follow-up to our earlier statistical portrait of developmental education, we analyze two new reforms in developmental math, known as statistics pathways and compressed math pathways. Both approaches aim to reduce the amount of time students spend in developmental math by reducing the amount of coursework and eliminating exit points—transitions where students are likely to leave the developmental sequence due to failure to re-enroll in the next course in the sequence. Statistics pathways also aim to create an alternative non-algebra based sequence for students in majors that only require statistics (art, sociology, English, journalism, psychology, and other liberal arts and humanities fields). In comparing outcomes for students in these two approaches to those for students in traditional developmental pathways, we find that:

- **Outcomes are substantially better for students in the statistics pathway.** Almost half (49% in our model) of students who start the statistics pathway eventually complete a transfer-level math course, compared to only 16 percent of students who start the traditional developmental sequence with elementary algebra. Statistics students also earn more transfer units (39 versus 27) and are more likely to transfer within three years.
- **Outcomes for students in the compressed algebra pathway are somewhat better.** About one in four (28% in our model) students who take compressed algebra eventually complete a transfer-level math course, compared to only 15 percent of students who take the traditional two-course algebra sequence. They also earn more units (34 versus 27).
- **All student groups—including underrepresented students—have better outcomes in the statistics and compressed algebra pathways.** Across every ethnic group, gender, and income groups, students do

better in the reform pathways than in the traditional pathway. However, our findings suggest that gaps in achievement between groups might still exist even with the reforms.

- **The lowest levels of developmental math do not work.** Very few students who begin at the lowest level of developmental math—arithmetic—eventually complete a transfer-level math course. Compressed arithmetic and pre-algebra students do only marginally better, but even so fewer than 10 percent complete a transfer-level math course.

While some of these reforms are promising, there is a lot of room for improvement. Increasing enrollment in statistics and compressed math pathways would benefit many more students. But further efforts are necessary to enhance the efficacy of developmental education. Even in the statistics pathway, fewer than half of students complete a transfer-level math course. Better placement policies could also improve student outcomes. Some of the most recent efforts, including using high school courses and grades to place more students directly into transfer-level courses with co-requisite support, have potential. More work needs to be done to ensure that these and other reforms help students achieve long-term goals and to implement these reforms across the entire community college system.

Introduction

In California and across the country, a large number of entering students are deemed underprepared for transfer-level[1] work. Our earlier research has found that across the California Community Colleges (CCC) system, 80 percent of students entering community college enroll in at least one developmental (or remedial) education course in reading, writing, and/or math during their college careers. Systemwide, math is a bigger challenge than English, with 65 percent of students enrolling in at least one developmental math course, compared to 54 percent in English. While the majority of students who enroll in community college intend to transfer and earn a bachelor's degree,[2] it is estimated that only 24 percent of students deemed underprepared transferred after six years, compared to 65 percent of those deemed college ready. Students from low-income and underrepresented ethnic groups are disproportionately likely to enroll in developmental courses and more likely to enter developmental education sequences at lower levels (Cuellar Mejia, Rodriguez, and Johnson 2016).

The poor track record of developmental education comes at a tremendous cost. A recent study by the Center for American Progress finds that developmental education courses cost students and families $1.3 billion nationwide (Jimenez et al. 2016).[3] The high costs and persistent gaps in developmental education and graduation rates, together with a growing interest in improving student success, have led colleges and states across the country, including California, to implement curricular and placement reforms intended to transform developmental education (Bailey, Jaggars, and Jenkins 2015; California Acceleration Project 2015). This movement has been spurred by research findings in four important areas:

- Studies showing that large numbers of students drop out before making progress in college, and that the more levels in the developmental sequence, the lower their completion of college-level courses (Bailey, Jaggars, and Jenkins 2015; Bailey, Jeong, and Cho 2010; Cuellar Mejia, Rodriguez, and Johnson 2016);
- Evidence that traditional developmental math sequences have a mixed record at best (Bettinger and Long 2009; Boatman and Long 2010; Calcagno and Long 2008; Clotfelter et al. 2015; Dadgar 2012; Martorell and McFarlin 2011; Ngo and Melguizo 2016; Scott-Clayton and Rodriguez 2015);
- Studies questioning the accuracy of the standardized tests that sort students into different levels of developmental education (Scott-Clayton 2012; Scott-Clayton, Crosta, and Belfield 2014);
- Research suggesting that acceleration models show promise in improving students' progression through developmental education and into transfer-level coursework (Hayward and Willett 2014; Hern 2012; Hoang et al. 2017; Logue, Watanabe-Rose, and Douglas 2016; Sowers and Yamada 2015; Rutschow and Diamond 2015; Rutschow, Diamond, and Serna-Wallender 2017; Yamada and Bryk 2016).

In California, little is known about what works and whether underrepresented and low-income students are being well served by the new courses at the heart of new interventions intended to improve developmental math outcomes. As reforms are expanded, research is needed to determine if initial positive impacts persist and whether they hold for diverse student groups across the system. Our study aims to help fill this knowledge gap: using quantitative and qualitative data, we seek to determine whether and to what extent new courses in developmental math

[1] While the term "college level" is often used interchangibly with "transfer level," in California there is an important distinction, as not all college-level courses transfer to a four-year college. This distinction is especially important when discussing math enrollment and completion, as intermediate algebra is not transferrable, but it counts toward the completion of an associate degree. In this report, we use the term "transfer level" throughout and limit the use of "college level" only when the research cited uses this term specifically.

[2] The National Center for Education Statistics (NCES) reports that 81 percent of community college students indicate that they intend to earn a bachelor's degree or higher (Horn and Skomsvold 2011).

[3] The cost estimation uses 2014 data files from National Center for Education Statistics IPEDS data system and Complete College America's "Co-requisite Remediation: Spanning the Completion Divide" data set. See Jimenez et al. (2016) for a detailed description of the cost estimation.

improve outcomes for diverse groups of community college students.[4] This report focuses on the two most common reforms: statistics and compressed math pathways.[5] Both approaches aim to reduce the amount of coursework and eliminate exit points—transition points at which students might drop out.

In this report, we look at the aims and impact of the two most common reforms. To help explain our quantitative results, we bring in key themes that emerged in qualitative semi-structured interviews we conducted with community college faculty, staff, and administrators who have been involved with statistics and compressed math pathways.[6] We conclude with a set of policy recommendations based on this research.

Transforming the Developmental Math Landscape

In California, traditional developmental math sequences have generally been comprised of a four-level algebra-based course sequence intended to prepare students for transfer-level math. The courses are generally lecture based—Grubb et al. (2011) have characterized the approach as "remedial pedagogy" involving decontextualized drill and practice. The lowest level of the traditional math sequence is basic arithmetic (four levels below transfer), followed by pre-algebra (three levels below), beginning algebra (two levels below), and intermediate algebra (one level below). A student who begins at the lowest level would need to enroll in developmental math for at least four terms before s/he can take a transfer-level math course. Prior research has found that the level at which a student enters is strongly linked to completion (Bailey, Jeong, and Cho 2010; Cuellar Mejia et al. 2016), and lengthy developmental math sequences are often blamed for the poor outcomes of developmental math students (Cuellar Mejia et al. 2016; Hern 2010; Hern and Snell 2013; Hodara 2013). In California, the level at which students enter the developmental math sequence has been determined primarily by their performance on a standardized placement test (Rodriguez et al. 2016).

Students deemed underprepared for transfer-level math are required to complete the developmental sequence up to intermediate algebra in order to enroll in courses needed for transfer, such as pre-calculus or statistics. The completion of intermediate algebra is also a requirement for students who want to earn an associate degree but do not intend to transfer.

Over the past several years, practitioners have begun to reassess the assumption that all transfer-level math courses require knowledge of algebra, and an increasing number of colleges have concluded that only those with majors such as business, science, technology, engineering, and math should be required to complete the algebra-based sequence. Students with liberal arts and humanities majors (e.g., art, sociology, English, journalism, psychology) could be better served by a developmental math pathway that prepares them for statistics or another quantitative reasoning course (e.g., statistics, liberal arts math for elementary school teachers). Colleges have begun experimenting with alternative developmental math pathways that accelerate a student's progression through the sequence and better align with his or her program of study. These efforts have been boosted by national and state entities—including the California Acceleration Project (CAP), the Carnegie Foundation for the Advancement of Teaching (CFAT), and the Charles A. Dana Center—which have worked with practitioners to

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[4] The vast majority of students in our developmental math cohorts are of traditional college age 24 or younger). For example, 92 percent of students in the statistics pathway and 90 percent of their counterparts in the traditional developmental math pathway are 24 or younger.

[5] See Technical Appendix C for a summary of the other developmental math reforms being implemented across the state.

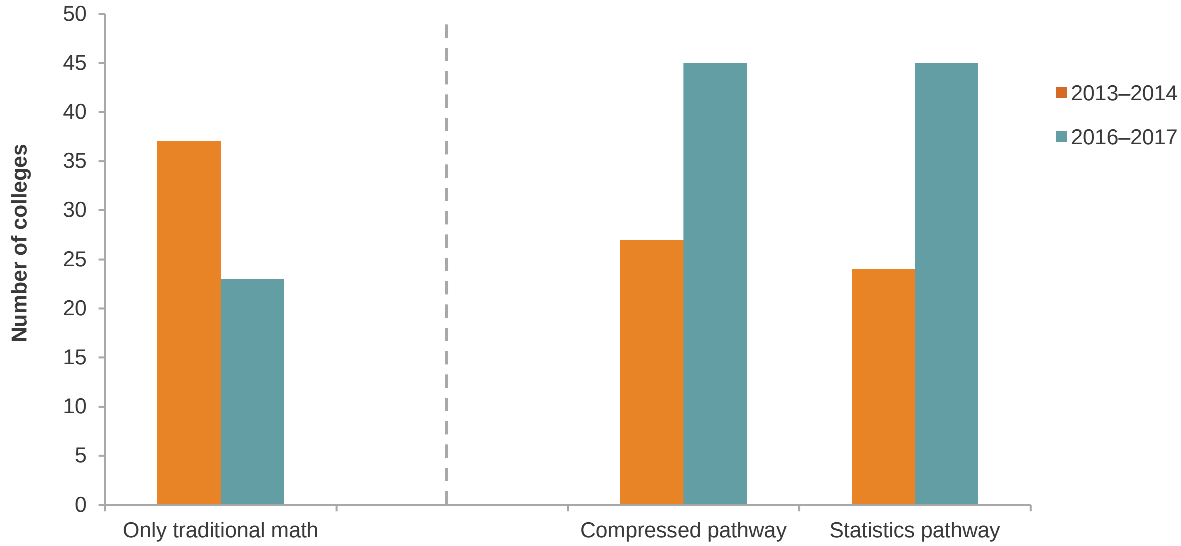
[6] In the summer of 2017, we spoke with 15 individuals—11 faculty, 2 administrators, and 2 research staff—at 8 colleges across the state. We chose a group of colleges that are representative of the different reforms (Statway, CAP, and Compression at upper/lower levels or both) and varying scales of implementation.See Technical Appendix A for more details on our methods and analysis.

develop instructional resources, provide professional development opportunities, and engage with professional math societies.

It is important to note that even though an increasing number of colleges across the state have begun to reform developmental math, our scan revealed that 20 percent (23 colleges) have not implemented any curricular reform (Figure 1). Furthermore, many colleges that *have* experimented with reforms continue to rely mostly on the traditional developmental math approach. During the 2015–16 academic year, less than 10 percent of developmental math enrollment statewide was in an alternative course formats.

FIGURE 1

Statistics and compressed math pathways have grown significantly



SOURCE: Authors' 2016–17 estimates based on an exhaustive scan of CCC catalogs and websites for courses offered in 2016–17.

Statistics Pathways Have Been Adopted at Many Community Colleges

Many California community colleges have implemented accelerated statistics pathways which are intended to align more closely with the programs of study of the students—mostly liberal arts and humanities majors—who take them (Burdman 2015; Hern 2010; Hern and Snell 2013). Through an exhaustive scan of college catalogs, websites, and student enrollment data, we found that, as of the 2016–17 academic year, 45 of the state's 113 community colleges offered accelerated statistics pathway courses. Colleges in our sample began offering statistics pathways as early as the 2009–10 academic year. We found that the number of colleges offering statistics pathway courses starting the summer of 2016 jumped by more than one-third (13 colleges). The early growth of statistics pathways was probably hampered by University of California (UC) and California State University (CSU) prerequisites: both systems required intermediate algebra for statistics courses. UC removed the intermediate algebra prerequisite for students on an alternative statistics pathway in 2015 (UC Board of Admissions and Relations with Schools 2015). CSU, on the other hand, accepted statistics pathway courses only on a pilot basis until August 2017, when it issued an executive order that removed the intermediate algebra requirement and made clear that students completing a transfer-level math course via a statistics pathways could satisfy their mathematics/quantitative reasoning general education requirement at CSU (CSU Office of the Chancellor 2017).Until very recently, community college faculty and staff continued to have concerns about the transferability of statistics pathways, which made them less likely to offer these pathways or to increase the number of sections.

Community colleges across the state have approached the implementation of statistics pathways in a variety of ways. We found that 20 colleges offer statistics pathways developed by the California Acceleration Project (CAP), a faculty-led professional development network that helps California community colleges reform developmental education practices. An additional eight colleges are participating in the Statway program, a standardized accelerated statistics pathway designed by the Carnegie Foundation for the Advancement of Teaching that integrates transfer-level statistics with developmental math supports. Other colleges are offering statistics pathways that were developed locally, with no direct support from CAP or Statway.

All of these approaches shorten the path to and through transfer-level statistics, largely for liberal arts and humanities majors—faculty members we interviewed commented that these pathways better serve "non-STEM students who only need stats" for their majors. These reforms have also shifted from the traditional lecture-based approach to one that integrates group work and higher levels of peer and faculty interaction, and moved away from decontextualized math problems to those that are relevant to everyday life. Faculty consistently commented on the importance of group work and activity-based learning in building "strong community in the classroom" and creating an environment that facilitates "active learning." This teaching approach was also thought to facilitate a more "student-centered learning environment" in which teachers actively engage with students. Faculty members and administrators also said that getting students engaged in this style of teaching and learning did not come easily. When instructors switched to group and activity-based learning, as opposed to lectures and problem sets, students "pushed back" and "struggl[ed] early on" because they are not used to writing in math and because they were used to lectures. But faculty noted that at the end of the semester the group work aspect was one of the things students liked about the class. One faculty member noted that when instructors frame the approach as one that "builds teamwork and communication"—characteristics that employers value—students better understand its value.[7]

Most community colleges that have adopted statistics pathways (24) have pre-algebra prerequisites; these may decrease the pathway's acceleration effect.[8] Only seven have no prerequisites at all (Figure 2). Colleges with no prerequisites allow any student to enroll, regardless of math placement or prior math coursework; for the majority, however, placement into elementary algebra or completion of pre-algebra is a prerequisite for enrollment.

Students learn about the pathways primarily from counselors during the orientation and/or assessment process, and by word of mouth. Faculty and staff reported that students often choose to enroll in the statistics pathway because it is more aligned with their program of study and can be completed in less time. Faculty also noted that some students enroll because they face math anxiety or because they have struggled in algebra. Indeed, we learned that statistics pathways also provide non-academic support by incorporating units or modules that address the affective learning domain—which includes aspects of learning that are emotion-based, such as self-confidence. Modules focus on how to study, how to talk to counselors, grit, and growth-mindset. Faculty described integrating these topics into the first few weeks of their courses—for example, showing videos on grit and giving students extra points for activities that help them succeed in the classroom (e.g., going to orientation, registration, and counseling). Our study and the emerging literature on statistics pathways suggests these supports

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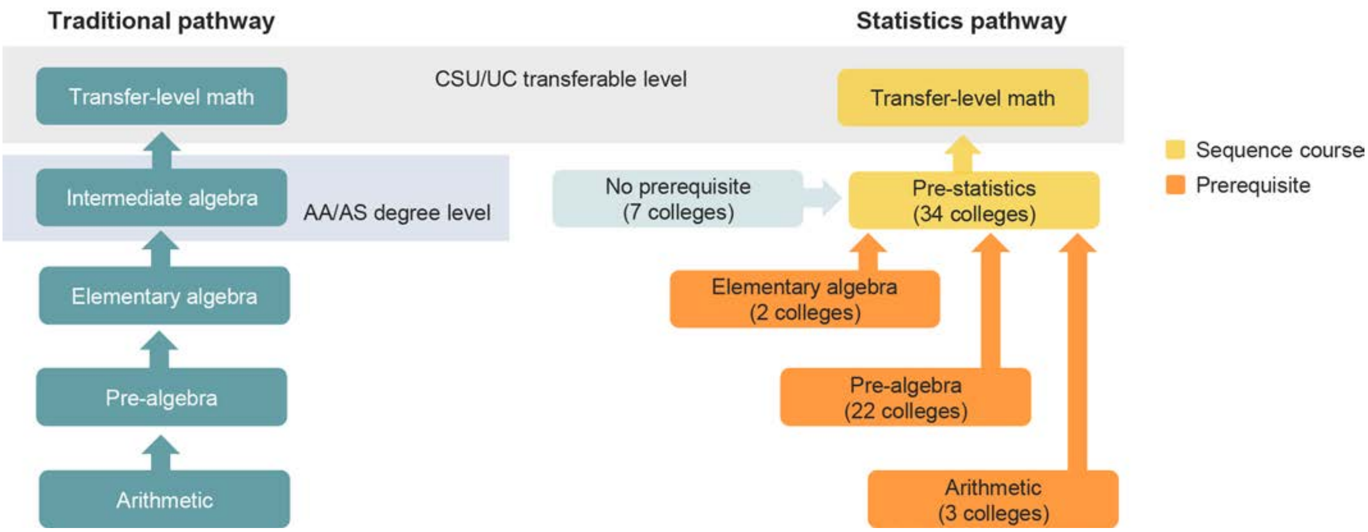
[7] The use of technology (e.g., TinkerPlots and StatCrunch) was also seen as helpful in promoting discovery learning and providing opportunities for students to visualize data and experiment with modeling distributions, for example. There were mixed opinions about online homework—one faculty member said that it disadvantages students with no access to computers at home and does not allow for partial credit, while others believed it was helpful in supporting student success because it provides immediate feedback.

[8] Given that the way the pathway was developed and implemented may impact student outcomes, our analysis includes college fixed effects to address this potential source of bias.

are particularly helpful to those who have been historically underrepresented in higher education (Hayward and Willett 2014; Logue, Watanabe-Rose, and Douglas 2016). There is a growing body of evidence suggesting the integration of these units helps students develop the skills they need, both in the classroom and in other spaces of the college and beyond (Dweck 2006; Dweck, Walton, and Cohen 2014).

FIGURE 2
Traditional math and statistics pathways



SOURCE: Authors scan of 2016–2017 California community college catalogs and websites.

NOTES: The majority of statistics pathway students fulfil their transfer-level math requirement with transfer-level statistics, either general (offered in the math department) or specialized (offered in psychology, political science, etc.). Additionally, statistics pathway courses at some colleges (6) also lead to other non-STEM transfer-level math courses such as liberal arts math.

Statistics Pathways Have Had a Significant Impact

We find strong improvements in short- and medium-term outcomes for statistics pathway students, including completion of the developmental education sequence, enrollment in and completion of transfer-level math, transfer credits, and the attainment of associate degrees and vocational certificates. Most of the improvement lies in the completion of developmental education requirements, but we observe lower levels of attrition all along the pathway. With fewer transitions from one course to the next, there is less attrition. Out of a typical cohort of 100 students, 71 complete the statistics pathway developmental course, 58 subsequently enroll in transfer-level math course, 44 pass the transfer-level math course, and 27 earn associate degree or certificates or transfer to four-year colleges. Before reaching proficiency in transfer-level math, students in the statistics pathway have three potential exit points: before completing the statistics pathway course, enrolling in the transfer-level course, and completing the transfer-level course. In contrast, the traditional math pathway has five exit points.[9]

If they had taken the traditional developmental math sequence, most statistics pathway students would have started their developmental sequence in beginning algebra then moved on to intermediate algebra before taking transfer-level math, meaning they would have to complete two developmental education courses rather than just the statistics pathway course. Out of a typical cohort of 100 students in the traditional pathway, 64 complete elementary algebra, 44 subsequently enroll in intermediate algebra, 38 pass intermediate algebra, 22 enroll in

[9] There is even an exit point *before* a student enters college: some students who are placed in developmental math courses never enroll. Using data from 57 colleges in 7 states, (Bailey et al. 2010) found that about 30 percent of students referred to developmental education never even enrolled in the first course of the sequence. Unfortunately, because our student records depend on course transcripts, we are not able to determine the number of students who never enroll.

transfer-level math, and 16 will complete a transfer-level course. In all, we lose 84 of the 100 traditional math pathway students, 48 who fail one of three courses and 36 who fail to enroll for the next sequence in the series. With fewer exit points, we lose a total of 56 students in our statistics pathway: 43 through course failures and 13 through enrollment failures (Figure 3). Simply put, statistics pathways work better for students because the sequence is short and the transitions are clearer.[10] For example, students in statistics pathway courses know that the next course in the sequence is a transfer-level statistics course, whereas students in the traditional math pathway have a wider range of transfer-level math courses to choose from, making the transition less clear.[11] In our sample, very few students move from the traditional math pathway to the statistics pathway, and even fewer move from the statistics pathway to the traditional math pathway.

FIGURE 3

Students who begin in a statistics pathway are much more likely to complete a transfer-level course

SOURCE: Authors' analyses of California Community College student data.

NOTE: Student cohorts are followed for three years. See Technical Appendix A for details on data and methods.

Faculty noted that reducing the time in developmental math is critical because "life happens": the longer students are in developmental math, the more likely it is that a non-academic situation can get them off track. Given the high levels of attrition observed in traditional developmental math sequences (Cuellar Mejia et al. 2017; Bailey et al. 2010), the reduction of exit points in the statistics pathway is undoubtedly a key contributor to improved student outcomes.

A critical concern is whether the abbreviated statistics pathway adequately prepares students for transfer-level work. Our analyses suggest that it does. Among those who complete the developmental sequence, statistics pathway students are more likely to enroll in a transfer-level quantitative course than traditional math students and just as likely to pass the transfer-level course once enrolled.[12] Moreover, in the three-year time frame for our

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[10] Once a student starts one of the pathways, they tend to stay on that pathway. For students who do wish to switch pathways, colleges are starting to experiment with bridge courses to help facilitate tranistions from statistics to algebra based pathways.

[11] Statway is explicitly designed to ensure this pathway. Also, the new guided pathways initiative is designed to improve transitions, making clear what course sequences students need to achieve their goals and ensuring that those courses are available.

[12] For statistics pathway students, the most common transfer-level course is statistics.

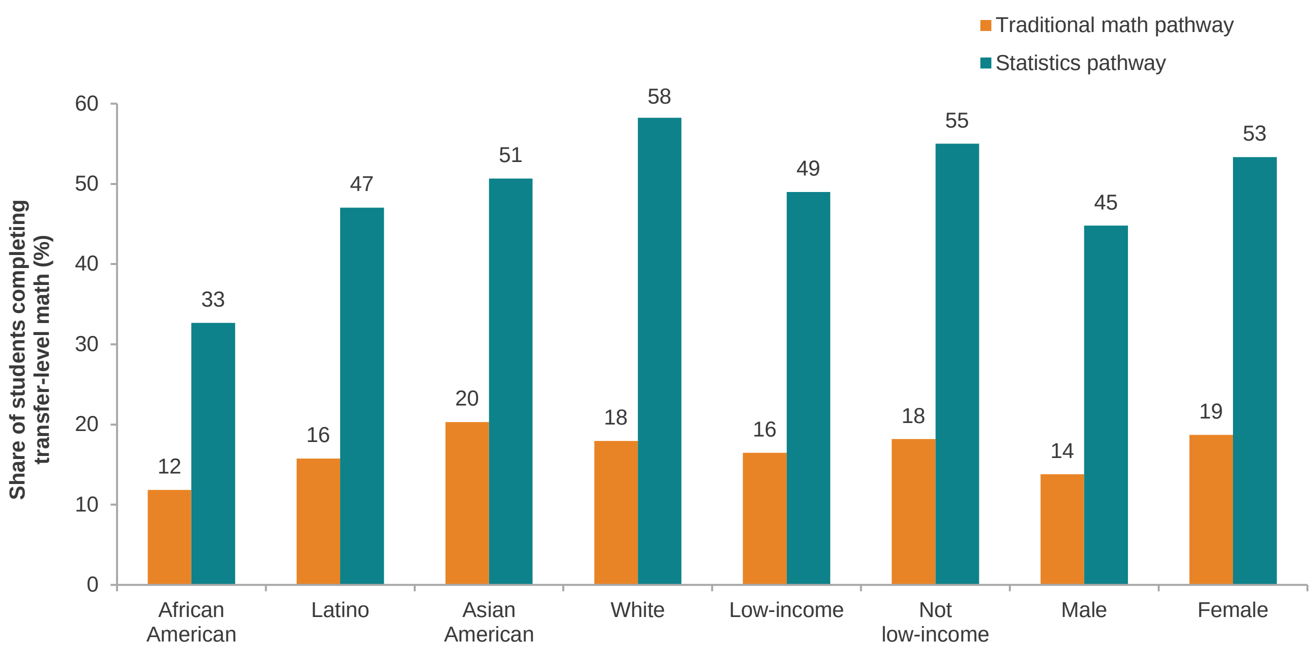
cohort, statistics pathway students earned more transfer-level credits than students in the traditional pathway (39 units versus 27 units) and were more likely to transfer within three years (15% versus 7%) or achieve any medium-term success, including earning associate degrees or vocational certificates (27% versus 13%).

Importantly, our results hold when we control for demographic characteristics, the colleges attended, the departments offering developmental courses, and the term during which a course was taken between statistics pathway students and traditional math students (see Technical Appendix A for more on this). In other words, we find no evidence that statistics pathway students perform better than traditional math students because they are a priori better students or because they attended better colleges.

Across a broad range of students, the statistics pathway outperforms the traditional math pathway. As shown in Figure 4, for every racial and ethnic group, for men as well as women, and for low-income as well as higher-income students, the statistics pathway yields significant improvements in student outcomes. Even so, gaps remain. In particular, African American students have less success in the statistics pathway than other students.[13] And although differences in statistics pathway outcomes for other groups are not statistically significant, the data suggest that groups that have worse outcomes in traditional math, including Latinos, low-income students, and men, also have worse outcomes in the statistics pathway.

FIGURE 4

Statistics pathways are better for a broad range of students



SOURCE: Authors' statistical models of student outcomes based on California Community College student data.

NOTE: See Technical Appendix A for details on data and methods. Differences in outcomes across student groups within the traditional pathway are all statistically significant; differences within the statistics pathway are significant only for African Americans.

[13] These results are consistent with the findings of Hayward and Willett (2014) which found improvements in student outcomes for every group, but gaps between groups remain even with the new reform courses.

Compressed Developmental Math Combines Courses to Shorten Pathways

Realizing that spending so much time, money, and energy on courses that do not count toward a degree or transfer[14] can be detrimental to student success, many colleges have begun to adopt an approach known as compression. Compression combines two sequential developmental courses into a single one-semester course. This reduces the opportunities for a student to leave the sequence. Compressed courses seek to streamline content—they reduce the amount of time spent on review and eliminate redundancies. In our interviews, faculty noted the value of learning and retaining math through practice and constant reinforcement—both which they felt were supported by the compressed math approach.

According to our scan of catalogs and websites, a total of 45 community colleges offer at least one compressed course. The most commonly offered courses either combine arithmetic and pre-algebra (28 colleges) or elementary and intermediate algebra (21 colleges). Our scan found that only five colleges compress the entire developmental math sequence. A college that compresses the full developmental math sequence reduces the length by half, from four courses to two, while colleges that only compress part of the sequence eliminate one level, reducing it from four to three.

Compression is the acceleration strategy that is most similar to the traditional math sequence—one faculty member we spoke to described it as "very traditional to an extent." Indeed, compressed courses typically merge two algebra-based math courses into one, and the compressed content is often de-contextualized and lecture-based with little or no non-academic support provided. One of the main differences is that the student takes two semesters worth of math in an intensive manner over one semester for nine units instead of five units for elementary algebra and five units for intermediate algebra. Students can enroll in the compressed arithmetic and pre-algebra course if they place into the arithmetic, and they can enroll in compressed elementary and intermediate algebra if they completed pre-algebra or if they placed into elementary algebra (Figure 5). Faculty and staff reported that students commonly learn about the course from counselors, word of mouth, or flyers in prerequisite classrooms (such as pre-algebra). Ultimately, faculty and staff reported that a primary reason students choose to enroll in the compressed math courses is so that they can complete the math sequence in less time.

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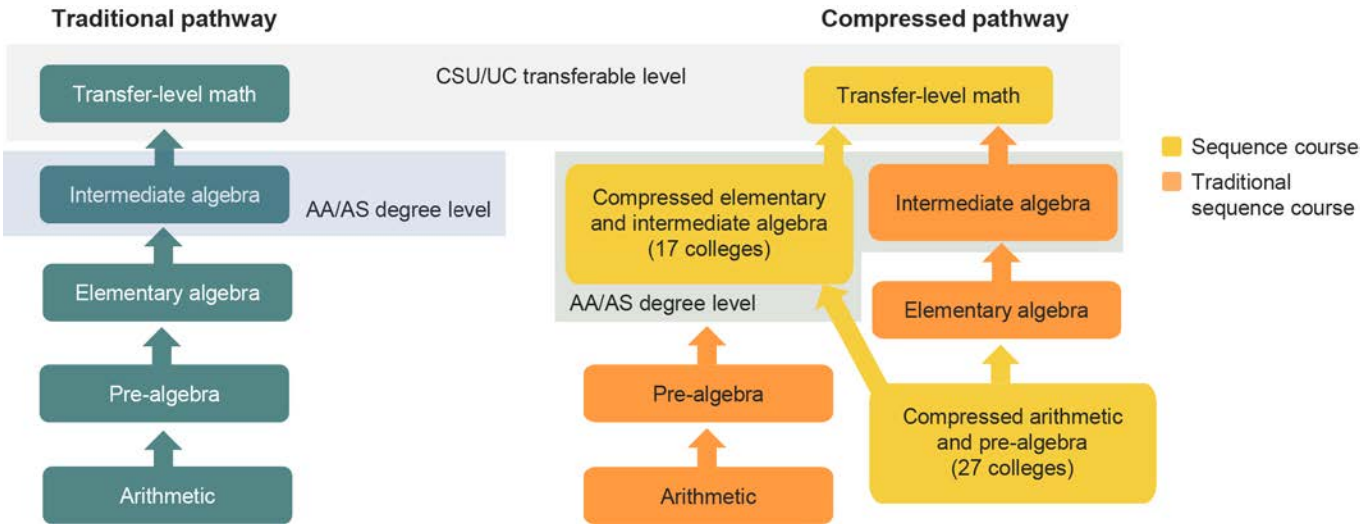
[14] To earn an associate degree, students starting in the lowest developmental math course spend up to three terms in courses that do not count toward the degree. Students intending to transfer spend four terms in developmental math, since they are required to complete a transfer-level math course.

FIGURE 5

Traditional and compressed math pathways



SOURCE: Authors scan of 2016–2017 California community college catalogs and websites.

NOTE: Five colleges offer both types of compression in our analytical sample, allowing for the yellow pathway.

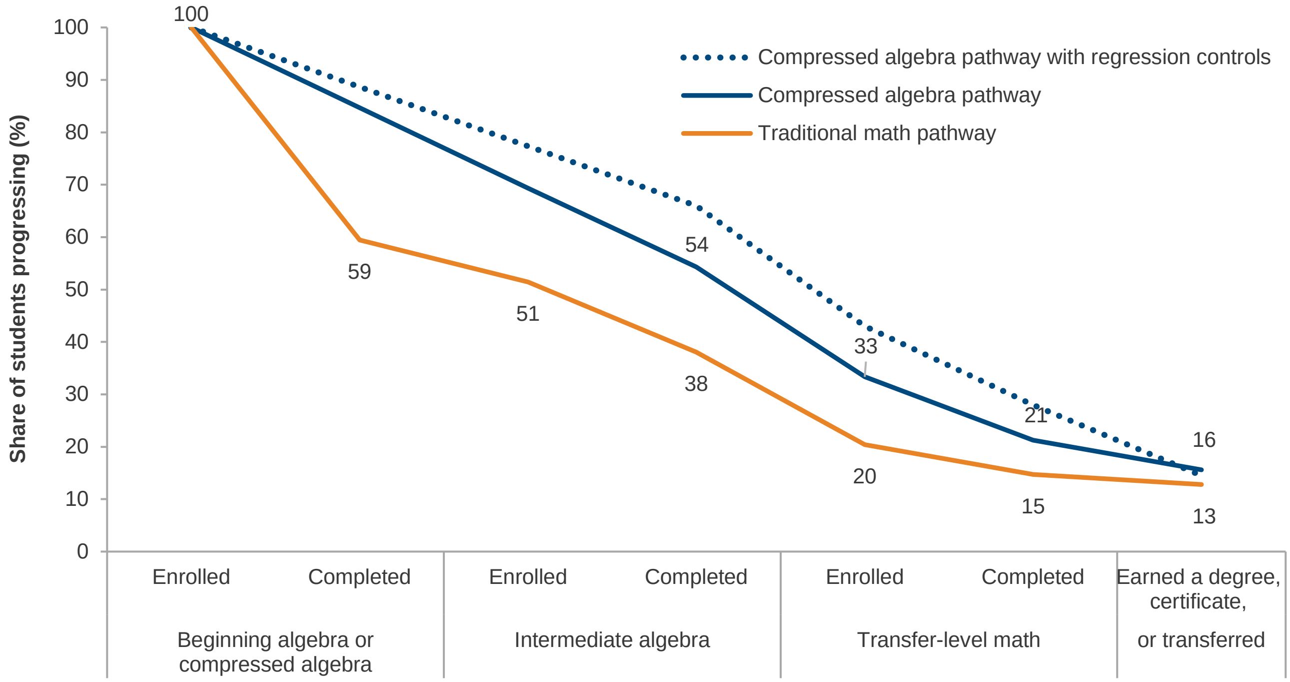
Compressed elementary and intermediate algebra has had a modest impact

We find moderate improvements in early outcomes and some medium-term outcomes for compressed algebra students, including completing the developmental math sequence, enrolling in transfer-level math, and completing transfer-level math. We also find that students in the compressed algebra pathway end up earning more transferrable units.

One of the primary reasons compressed algebra moves more students into transfer-level math is because it has fewer exit points than in the traditional math pathway (Figure 6). Out of a typical cohort of 100 students in the compressed algebra pathway, 54 will complete the compressed algebra course, 33 will subsequently enroll in transfer-level math, and 21 will pass the transfer-level course. That pathway has three potential exit points (completing the compressed algebra course, enrolling in the transfer-level course, and completing the transfer-level course). In contrast, the traditional math pathway has five exit points. Out of a typical cohort of 100 students in the traditional pathway, 59 will complete elementary algebra, 51 will subsequently enroll in intermediate algebra, 38 will then pass intermediate algebra, 20 will enroll in transfer-level math, and 15 will complete the transfer-level course. In all, we lose 85 of the 100 traditional math pathway students, 59 who fail one of three courses and 26 who fail to enroll for the next sequence in the series. With fewer exit points, we lose a total of 79 students in our compressed algebra pathway, 58 through course failures but only 21 through enrollment failures. Our regression model that controls for differences in students and institutional characteristics shows a slightly more optimistic picture, with 28 compressed algebra students making it all the way through developmental math and passing a transfer-level math course. Even so, the vast majority do not pass a transfer-level math course, and very few transfer within three years (9% versus 7% in the traditional math pathway) or successfully complete college (16% versus 13%).

FIGURE 6

Students who begin in compressed algebra are more likely to complete a transfer-level course



SOURCE: Authors' analyses of California Community College student data.

NOTE: See Technical Appendix A for details on data and methods.

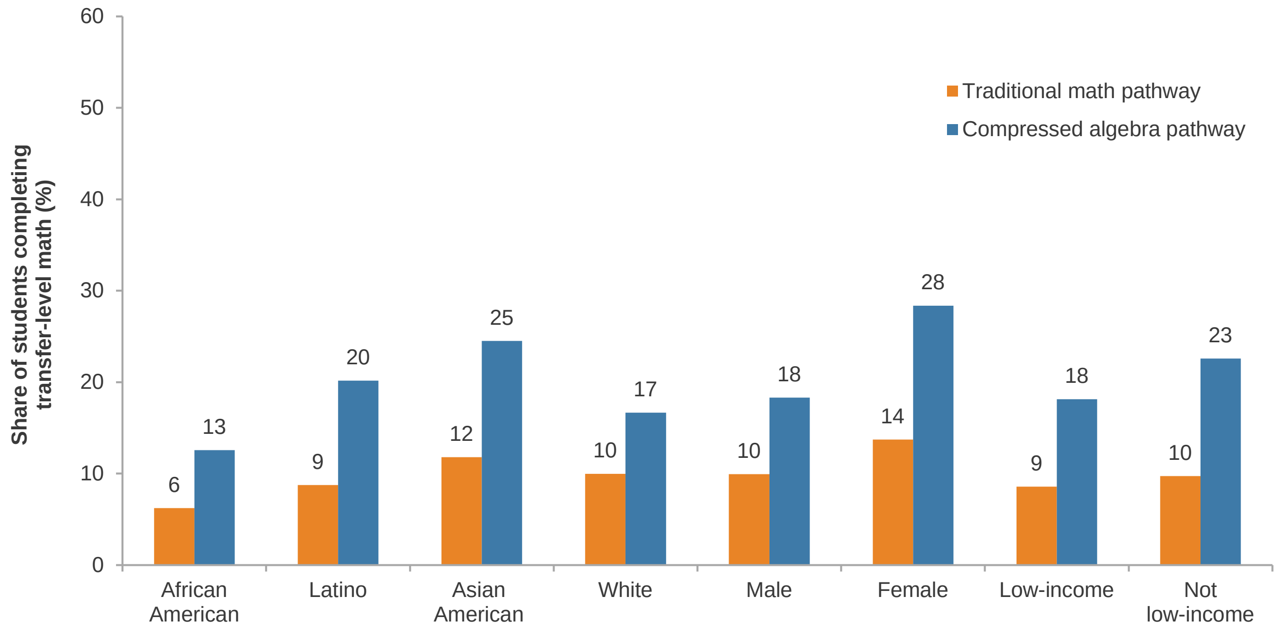
However, the magnitude of these improvements in short-term outcomes is only about half of what we observe in the statistics pathway. Moreover, compressed algebra students are only very slightly more likely to succeed in medium-term outcomes, including earning an associate degree or a vocational certificate, or transferring. Faculty noted that covering the material of two courses in a single semester can be grueling and difficult for some students. In fact, one faculty member noted that one of the things students like least is the workload—he tries to explain from the start that this course will help get them to the transfer-level math quicker, but that because it is an intensive course it will require more effort to avoid falling behind—this can happen much more quickly than in a single course. The high unit load and fast pace of the course were mentioned as barriers for students who receive time-and-a-half for testing—these students could easily miss out on material covered while they are completing a test. Also, studies have found decontextualized content, lecture-based teaching, and a lack of non-academic support to be ineffective (Grubb et al. 2012).

In the compressed algebra pathway, the largest single source of attrition is failure in the compressed algebra course. Moreover, students who complete the compressed algebra course and enroll in transfer-level math are less likely to pass the transfer-level math course than those who took the traditional math pathway. Still, because so few traditional math pathway students make it through the two developmental math courses, completion of transfer math (also known as throughput) is higher among those in the compressed pathway (33% versus 20%). Importantly, students in the compressed algebra pathway do go on to earn more transfer units than those in the traditional pathway (34 units versus 27 units) and are slightly more likely to transfer, earn an associate's degree, or earn a certificate.

The compressed algebra pathway moderately outperforms the traditional math pathway across a broad range of students (Figure 7). But for every group, the effects are not large with the vast majority of students failing to complete a transfer-level math course. The data suggest that some groups have worse outcomes in compressed algebra than others, but none of the differences are statistically significant.

FIGURE 7

Compressed algebra pathways are better for a broad range of students



SOURCE: Authors' statistical models of student outcomes based on California Community College student data.

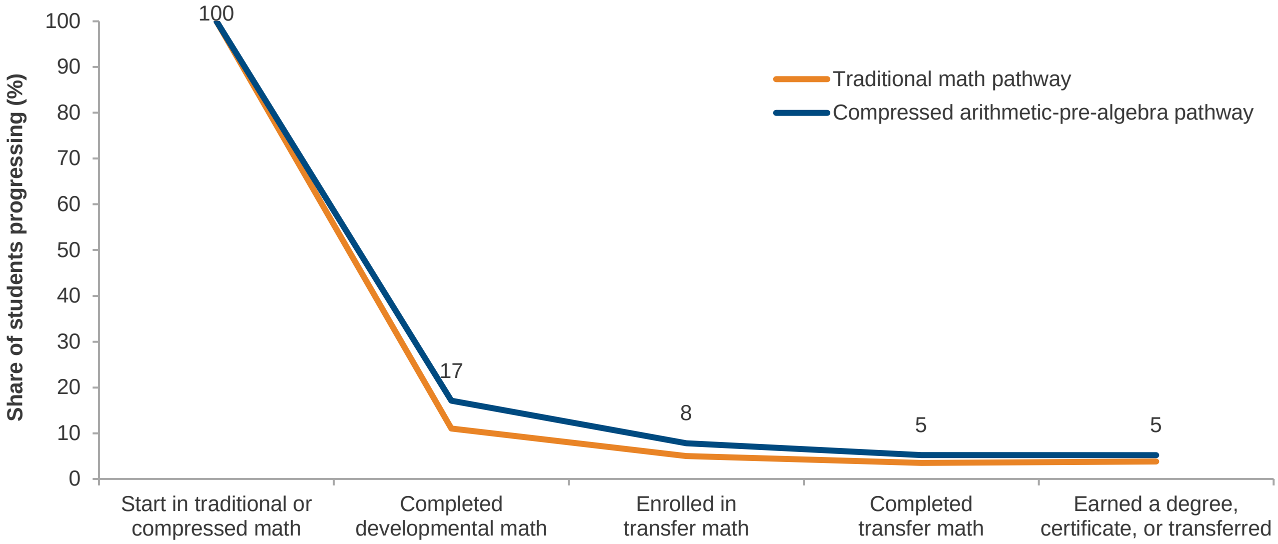
NOTE: See Technical Appendix A for details on data and methods. Differences in outcomes across student groups within the traditional pathway are all statistically significant; differences within the statistics pathway are not statistically significant.

Compressed Arithmetic and Pre-algebra Has Not Improved Outcomes

We find virtually no meaningful improvements in short- and medium-term outcomes for compressed pre-algebra students. With fewer exit points, compressed pre-algebra students are more likely to complete the developmental math sequence, but even so relatively few go on to enroll in and complete transfer-level math (Figure 8). Only 5 out of 100 compressed pre-algebra students will complete a transfer-level math course, compared to 4 out of 100 students in the traditional math pathway. Controlling for student and institutional differences, we estimate that 8 students in the compressed pre-algebra pathway could be expected to complete a transfer-level math course.

FIGURE 8

Students who begin in a compressed arithmetic and pre-algebra have poor outcomes



SOURCE: Authors' analyses of California Community College student data.

NOTE: Regression model results are not shown because they are not signicantly different than the descriptive results shown. See Technical Appendix A for details on data and methods.

While poor outcomes may be partly related to weak academic preparation, it is clear that the long sequences in developmental education and the assessment policies used to place them there are also a problem. Traditional math students who start in arithmetic face up to nine exit points along the road to completing a transfer-level math course. Most compressed pre-algebra students face seven exit points. The only compressed pre-algebra students who face fewer exit points are those that also take compressed algebra upon completing compressed pre-algebra, a sequence we observe at only five community college campus. Those students still face five exit points, but completion of transfer-level math was higher (19% of the cohort) at that campus than at any other campus.

Students still spend far too many terms in developmental courses before attempting to complete a transfer-level math course, and perhaps longer if they fail a course or take a break between courses. In short, the boost obtained by eliminating exit points in the statistics pathways or through compression at both levels is completely wiped out when colleges only compress at the lowest level.

Addressing Persistent Equity Gaps

Our research suggests that while developmental math reforms help improve outcomes for all students, they do not seem to be closing gaps between student groups. Faculty acknowledged that there was "still room for improvement" on the equity front, and a recent infusion of equity funding is poised to help colleges address persistent gaps.

Equity has only recently become a motivation for reform. Math faculty we spoke to noted repeatedly that equity and addressing equity gaps were not primary motivators for reform in the early phases of the work. We learned that a primary motivator was to provide all students at their college with "one more option" besides the traditional developmental math sequence. However, faculty did say that upon examining outcome data for statistics pathways, they began to see improvements in success for all groups. In fact, one faculty member noted that at their college they found "narrowing achievement gaps" and this was the "impetus for scaling the statistics pathway." Faculty shared that more recently, equity funding, which was first provided to colleges during the 2014–15 academic year to help improve access and outcomes for disadvantaged students, has been used to implement and scale reforms. Indeed, the increased attention to equity at the system level[15] and recent scaling of reforms has coincided with a significant boost in funding for student equity plans, which went from slightly more than $50 million in 2014–15 to $155 million in 2015–16 (California Community Colleges 2017; Legislative Analyst's Office 2016b).

Professional development can help address gaps. Faculty were candid in sharing that "some gaps persist" but that "prior to this [statistics pathway] they were huge." Faculty told us that the colleges and organizations that developed the statistics pathways, including CAP and the Carnegie Foundation, provide professional development to help faculty better support the learning of underrepresented groups. This includes support for writing tests that are not biased and workshops on teaching men of color.

At one college, an approach known as "ordered pairs" was considered to be among the most effective because it allows new instructors to ask questions and learn from their more experienced peers. Faculty also valued the opportunity to get together in person or over video conferencing to talk about what happens in an accelerated course, look back at the facilitation notes and activity packet, and discuss opportunities for improvement. Faculty also identified the mentoring programs as helpful in supporting their teaching in the statistics pathway. We learned that funding provided through student equity initiatives, the Basic Skills Student Outcomes and Transformation grants (BSSOT) and other grants are commonly used to support faculty attendance at conferences and participate in campus-based professional development. This funding stream has the potential to support interventions that could address achievement gaps.

Colleges have begun to consider the equity implications of student assessment and placement. Our interviewees shared that during the 2013–14 academic year, colleges were mostly relying on standardized tests to determine placement into the math sequence. Our prior research finds that this is not an uncommon practice in California (Rodriguez et al. 2016). But there is mounting evidence that this is not the best approach when the goal is to increase the accuracy of placement (Scott-Clayton 2012; Scott-Clayton et al. 2015). Faculty also reported that advisors often promote the traditional sequence, especially to students who are undecided about their majors. Several faculty and administrators noted that they saw opportunities for change on the horizon, as colleges have begun to adopt multiple measures—including high school GPA and prior performance in math—and guided pathways initiatives, which advise students to enroll in the math pathway that best aligns with their interests in a broad grouping of majors.

PPIC research finds that students of color are more likely to be placed at the lowest developmental levels—and that this placement severely limits their likelihood of completing a transfer-level math course and of ever earning a degree or transferring to a four-year school (Cuellar Mejia et al. 2016). Two colleges we spoke with mentioned that they are planning or have already eliminated the lowest level(s) of developmental math. One college eliminated three levels, leaving only the intermediate algebra course with just-in-time remediation on arithmetic or pre-algebra concepts; the other college dropped arithmetic from its credit offerings and those who still feel like they need it can take it as a non-credit course. The primary motivation for these changes was the fact that very few students make it out when they begin at the lowest levels.

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[15] For a history and description of student equity efforts at the CCC system level see the "Student Services and Special Programs Student Equity Fact Sheet."

Recommendations

California's community colleges are in the midst of numerous reforms designed to improve student success. Because developmental education is such a large impediment to so many students, many of the reforms focus on ways to move students to transfer-level courses more quickly and at higher rates.

The good news is that new approaches in developmental math work. Students who take nontraditional pathways in developmental math are more likely to complete the developmental math sequence and are more likely than students who take the traditional pathway to eventually complete a transfer-level math[16] course, such as statistics or pre-calculus. Students in the nontraditional pathways also went on to earn more transfer units than students in the traditional pathway. The best outcomes are in the statistics pathway—students who take this pathway are almost three times as likely to complete a transfer-level math course and twice as likely to earn associate degrees or vocational certificates, or transfer to four-year colleges. Our results hold for every group of students, across gender, race/ethnicity, and income. At almost every college implementing reforms, students who took the new pathways had better outcomes than those in the traditional pathways.

The bad news is that even with the reforms in place, most students do not successfully complete transfer-level math. Compression had the least dramatic results: within three years of enrolling, only 21 percent of students who took compressed algebra completed a transfer-level course in math (compared to 15% in the traditional sequence); even worse, only 5 percent of compressed arithmetic/pre-algebra students completed a transfer-level math course (compared to 4% in the traditional sequence). The share of students with successful final outcomes—earning an associate degree or vocational certificate or transferring within three years—was essentially the same in the compression pathways as in the traditional math pathways.

We conclude by offering several recommendations that can help community colleges expand developmental math reforms and ensure their effectiveness across a diverse student population.

Increase enrollment in statistics pathways. Because we find that students in statistics pathways substantially outperform their peers who take the traditional developmental math sequence, we recommend that colleges enroll more students in statistics pathways if statistics satisfies math requirements for their programs of study. For the many students who do not need an algebra-based transfer-level math course for their intended baccalaureate major, the statistics pathway is much more likely to lead to positive short- and medium-term outcomes. Colleges will need to increase the number of statistics pathway offerings to ensure that all eligible students have an opportunity to enroll. Colleges will also need to educate students about the advantages and disadvantages of the statistics pathway. The primary disadvantage has to do with the restriction for STEM majors—to address this issue, some colleges have begun to offer bridge math courses to facilitate the transition of students who wish to change from a liberal arts to a STEM major, for example. At least one college has successfully included intermediate algebra concepts in its statistics pathway courses.

As they expand statistics pathways, colleges will need to hire new faculty and train existing faculty to teach. In our interviews, faculty and department chairs noted that faculty typically volunteer to teach in the statistics pathway; many often make the transition from having only taught algebra-based math and are trained in the new curriculum by CAP, Statway, or statistics specialists hired by the college. But colleges should eliminate rules that prevent them from hiring instructors who majored in statistics to teach these courses, both to expand the pool and take advantage of subject expertise. Counselors should be trained and placement processes should be modified to

[16] Transfer-level math refers to any math that is transferrable to a four-year university and includes statistics, pre-calculus, trigonometry, college algebra, applied calculus, math for teachers, liberal arts math, among others.

ensure that students take the appropriate math pathway for their programs of study or areas of interest. The recent elimination of the intermediate algebra prerequisite for statistics at CSU is likely to encourage colleges across the state to adopt or scale statistics pathway offerings.

Focus compression efforts on algebra. As we have seen, students in compressed algebra courses outperform their peers in traditional algebra courses; however, the gains are not as large in magnitude as they are for the statistics pathway. Compressed courses can serve STEM students by accelerating their progress to pre-calculus; but most students still do not pass transfer-level math. To better serve students who require calculus for their program of study and who are placed in elementary algebra, **we recommend that colleges increase enrollment in compressed algebra** relative to the traditional two-course sequence of elementary algebra and intermediate algebra. Implementing this reform would require fewer other changes than the statistics pathway reform: the content of the compressed course is virtually the same as that of the two-sequence course. While instructors would benefit from pedagogical training in teaching compressed courses, and we also recommend switching to activity-based instruction (see below), they would not need a different knowledge base.

Consider curricular reform for compressed algebra. Our research suggests that there may be room for more comprehensive curricular reform in the compressed algebra pathway. Given that the integration of group work, activity-based learning and non-academic supports into the statistics pathway was considered to be key in supporting student success, colleges may want to consider reforming the teaching and learning in the compressed algebra curriculum by incorporating these strategies. A shift away from a traditional lecture-based approach to one that involves group work and activity based learning would comprise a significant shift in teaching and learning. As with statistics pathways, colleges will need to be provided with ample resources to ensure that faculty engage in professional development opportunities to support these efforts. Colleges may be able to tap into resources provided by the Basic Skills Initiative, Equity funding, Basic Skills Student Outcomes Transformation Grants, and Guided Pathways initiatives to support reform and professional development efforts. Additionally, organizations such as the California Acceleration Project, the Dana Center Math Pathways Project, and the Carnegie Foundation may be able to provide professional support for curricular reform in compressed math pathways.

Consider eliminating the lowest levels of developmental math. Our analyses of compression at the lowest levels of developmental math—arithmetic and pre-algebra—show virtually no improvement over the dismal student outcomes in the traditional sequence that begins with arithmetic**. We recommend that colleges consider eliminating the lowest levels of developmental education in math**. We suspect that the small number of students who begin at the lowest level and eventually pass a transfer-level math course could have done so even if they started higher in the sequence, and some who are discouraged by the long sequence might have made it to transfer-level math with a shorter sequence. Some colleges have already eliminated these lowest levels, and a few have even eliminated all but one course (either statistics pathway or intermediate algebra) with positive gains in completion of transfer-level math. For students who would benefit from developing arithmetic and pre-algebra skills, colleges could consider offering just-in-time remediation in a higher-level math course (e.g., co-requisite support for compressed algebra). Alternatively, colleges could provide lower-level math courses as non-credit math offerings.

Support equity initiatives. Many of these reforms were implemented before new funding designed to reduce equity gaps became available. As colleges move forward with these and other reforms, **we recommend a continuous cycle of monitoring achievement gaps for different student subgroups and developing plans for addressing them**. Although the statistics and compressed algebra pathways led to much better outcomes for a broad range of students, gaps in outcomes persist across races/ethnicities, genders, and levels of income. Colleges have begun to explore professional development to help address these gaps. For example, colleges have used equity funding to provide faculty training on teaching and supporting diverse groups of students and strategies for eliminating bias from exams. It is important that equity funding be used not only to identify gaps and support the implementation of equity-minded reform efforts, but also to monitor the effectiveness of these efforts. Strategies that are found to be successful should be promoted for wider adoption, while those that are not should be replaced.

Integrate developmental math reforms with guided pathways. Even though our research finds that statistics and compressed algebra pathways work over the short- and medium-term, most students still fail to progress through the math sequence and complete transfer-level courses. And even when students do experience positive impacts of developmental math reforms in the short-term, research suggests that these positive impacts generally fade over time (Boatman 2012; Edgecombe et al. 2013). One possible reason for this is the fact that math reforms have generally focused on transforming only the developmental math sequence itself—with little or no attention paid to the knowledge, skills, and supports students need to be successful in college beyond the math sequence. Math pathways reforms are unlikely to have a long-term impact if they are done in isolation. The guided pathways framework offers a promising opportunity for improving student outcomes in developmental education and sustaining these impacts over time. In theory, guided pathways address the student experience from entry to completion by mapping college pathways to a student's end goal (Bailey, Jaggars, and Jenkin 2015). This includes:

- Providing a range of math pathways (e.g., statistics, quantitative reasoning, and STEM) that align with a small set of meta-majors (e.g., liberal arts, STEM, business, and health);
- Supporting guided major exploration, a critical step in ensuring that students—especially those who are undecided about their majors—enter the appropriate math pathway;
- Clearly delineating program requirements so that students know which courses they need to complete for each program of study; and
- Providing proactive and integrated academic and non-academic supports, for example by embedding these supports in classrooms or providing counselors specializing in meta-majors.

The statistics pathways partly address some of the shortfalls by providing a math sequence for non-STEM students and incorporating academic and non-academic supports into the curriculum. Guided pathways could help ensure that similar work happens across the curriculum and that **additional support—academic, non-academic, financial, and counseling—is integrated to promote improved student access, success, and equity.**

Encourage developmental math innovation and research. Colleges are beginning to experiment with other new approaches to reforming developmental math. These efforts have been partly supported by targeted funding and professional networks and organizations, including the Basic Skills Initiative (BSI), Basic Skills Student Outcomes Transformation grants, Student Equity funding, Student Success and Support Program (SSSP), the California Acceleration Project, the Carnegie Foundation, and Complete College America. **We recommend encouraging new and promising innovations and evaluating their effects on student outcomes and equity**.

One promising approach that has recently gained popularity is known as the co-requisite model. This approach allows developmental math students to simultaneously enroll in a transfer-level math course, such as pre-calculus or statistics, and a support course—a companion developmental math course, lab time, or supplemental instruction that provides just-in-time remediation. This approach is new to California; as of fall 2016, only five community colleges had begun offering co-requisite math. Given that the co-requisite approach provides access to transfer-level math upon college entry, it is quite likely to have a greater impact on transfer-level math completion and equity than models that require prerequisite developmental math. Early accounts from Cuyamaca College suggest that transfer-level math completion is nearly seven times higher in the year after implementation. Additionally, transfer-level math completion has improved for all racial/ethnic groups. Still, as is the case with statistics and compressed algebra pathways, more work is needed to close achievement gaps between the groups.

Improve placement policies and processes. Another promising approach is to improve placement processes so that more students bypass developmental education entirely and instead begin their community college career in transfer-level math classes. In our interviews, faculty and administrators highlighted the importance of not just reforming developmental math sequences, but assessment and placement policies as well. For example, some colleges have begun to use multiple measures, including high school coursework and grades in addition to assessment exams, and the placement of students directly into college-level courses has increased—at one college, student eligibility for transfer-level math rose from 14 percent to 71 percent.

Although reforms that reduce the number of students placed in remedial education could substantially improve outcomes, there will continue be a need some form of developmental education. Our results suggest that focusing on statistics rather than algebra could improve outcomes for many students, and that shortening course sequences will lead to more student success. As colleges adopt and expand innovative reforms, further research will be needed to guide implementation and improvement efforts and ensure that reforms contribute to the closing of equity gaps. Because the number of students affected by developmental education is so large, even modest improvements in student success will allow many more thousands of students in California to reach their academic goals, thereby improving their own well-being and that of the state.

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