UPDATED Preparatory Pathways and STEM Calculus Completion:

Implications of the AB 1705 Standards

FEBRUARY 2024 (ORIGINALLY PUBLISHED)

UPDATED JUNE 2024

New Appendix: Math Placement and Access To Calculus in the California Community Colleges

Introduction

Assembly Bill 1705 (AB 1705) seeks to strengthen students' completion of the first STEM Calculus course for Science, Technology, Engineering, and Math (STEM) programs across the California Community Colleges.[1] The law sets new standards for students' placement and first math enrollment to ensure STEM students begin in transfer-level coursework that best positions them to complete calculus requirements for their programs.[2]

This legislation specifically calls for colleges to provide evidence that STEM students benefit from enrollment in transfer-level preparatory coursework (e.g., College Algebra, Trigonometry, Precalculus) before they attempt STEM Calculus. To support colleges with this validation process and to inform their local response, the California Community Colleges Chancellor's Office partnered with The RP Group's Multiple Measures Assessment Project (see sidebar) to conduct statewide analyses that examine enrollments in the STEM Calculus pathway and subsequent persistence to and completion of calculus.

MMAP examined a cohort of more than 37,000 STEM majors with a first math enrollment in the California Community Colleges between 2012-2013 and 2019-2020 to determine – based on their high school math preparation or placement by the state's default precalculus placement rules – the implications of the AB 1705 standards in practice (see sidebar).[3] Analyses included a look at:

Multiple Measures Assessment Project (MMAP) Overview

This report was produced in partnership with The RP Group's Multiple Measures Assessment Project (MMAP). The RP Group launched MMAP in 2014 to support the advancement of developmental education reform in the California Community Colleges. MMAP now supports the California Community Colleges Chancellor's Office with the implementation of AB 705 and AB 1705, which seek to improve equitable placement into and completion of transfer-level English and math courses required for a student's program.

Learn more about this work at www.rpgroup.org/mmap.

[1] Find more information in the California Community Colleges' *AB 1705 Implementation Guide*.

[2] Transfer-level courses satisfy general education requirements for a baccalaureate degree from the California State University or University of California systems. Previous legislation (AB 705) set similar standards for placement into developmental education (pre-transfer-level courses).

[3] Find the methodology in Appendix A and cohort descriptions in Appendix B.

1. Who was highly unlikely to succeed when enrolled directly in STEM Calculus 1, the first STEM calculus course?
2. Who was more likely to complete STEM Calculus 1 when they started in a transfer-level preparatory course?
3. Who was more likely to persist to and complete STEM Calculus 2 when they started in a transfer-level preparatory course before completing STEM Calculus 1?

This report contains descriptive analyses. A separate technical report provides multivariate logistic regression analysis responding to these same questions while controlling for factors such as time elapsed between high school and college math enrollment, prior use of placement testing, student demographics, and institutional characteristics.[4]

Key Findings

In this section we present key findings and supporting analysis relevant to each of the three questions related to AB 1705 standards. We include additional findings on the association between STEM Calculus pathways, attrition in STEM programs and STEM equity.

The section on Key Findings is organized as follows:

- STEM Calculus 1 Completion with Direct Enrollment
- STEM Calculus 1 Completion with Transfer-level Preparation in College
- STEM Calculus 1 Completion and Features of the Preparatory Pathway
- STEM Calculus 2 Completion and Transfer-level Preparation

AB 1705 STEM Calculus Standards

AB 1705 specifies that colleges must prove the benefit of placement and enrollment in transfer-level math preparatory courses as a precursor to STEM Calculus 1 based on the following conditions:

- The student is highly unlikely to succeed in the first STEM calculus course without the additional transfer-level preparation.
- The enrollment in a transfer-level preparatory course will improve the student's probability of completing the first STEM calculus course.
- The enrollment in a transfer-level preparatory course will improve the student's persistence to and completion of the second calculus course if required for the major.

Key Terms

STEM Calculus 1: The first STEM Calculus course, equivalent to C-ID Math 210, 211 or first half of Math 900S.

STEM Calculus 2: The second STEM Calculus course, equivalent to C-ID Math 220, 221 or second half of Math 900S.

STEM Calculus Pathway: STEM Calculus 1 and a transfer-level preparatory course (e.g., College Algebra, Trigonometry, Precalculus) or sequence of these courses as preparation for STEM Calculus 1.

Direct enrollment: Student's first math enrollment within the CCC system, not necessarily in the freshman year.

Throughput: Proportion of the cohort starting in a specified course who successfully completed, with a C or better, STEM calculus within the given time frame (STEM Calculus 1 within two years or STEM Calculus 2 within three years) anywhere in the CCC system.

[4] See technical report.

- Additional Considerations: Conditional Throughput
- Attrition in the Path to Calculus and STEM Programs
- Attrition in the Path to Calculus and STEM Equity

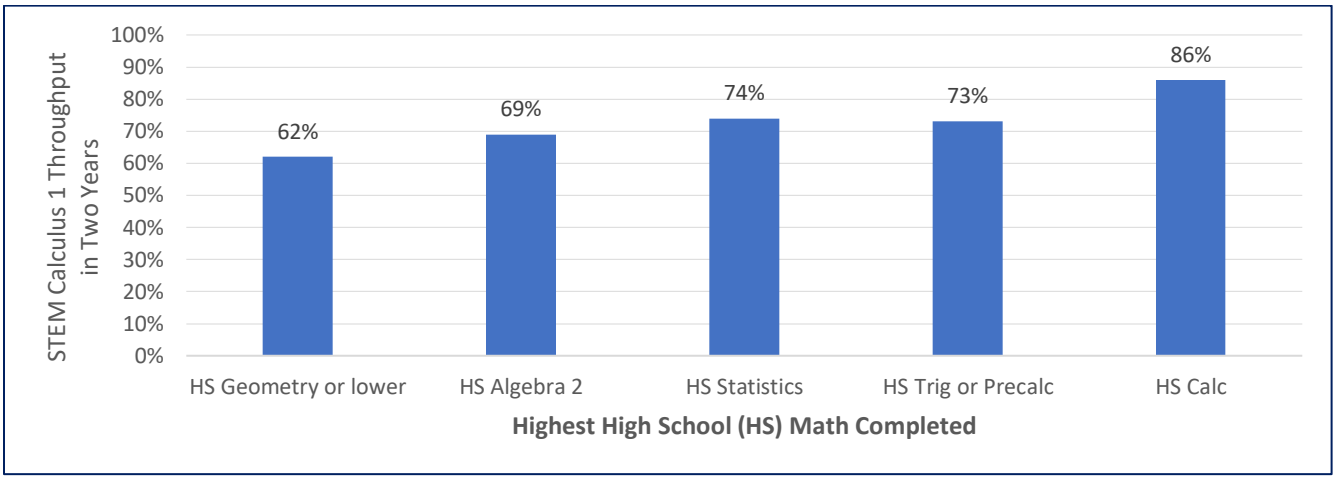
STEM Calculus 1 Completion with Direct Enrollment

Key Finding: *Based on high school GPA or high school math preparation, no group was highly unlikely to succeed in STEM Calculus 1 when directly enrolled and given two years.*

We examined students who enrolled directly in STEM Calculus 1 as their first community college math course and disaggregated them by high school math preparation level.[5] We calculated the proportion of students who completed the Calculus course with a C or better within two years – otherwise known as the completion rate or two-year "throughput" (see Key Terms).[6] Of the cohort in the STEM calculus pathway, 31% (11,648 of 37,232) started in STEM Calculus 1 during the period studied.

Across all levels of high school math preparation, STEM Calculus 1 throughput in two years was above 60% (Figure 1).[7]

Figure 1. STEM Calculus 1 Two-Year Throughput with Direct Enrollment, STEM Students Disaggregated by Highest High School Math Completed



Note: First CCC math enrollment in 2012-2013 through 2019-2020. See Appendix C for cohort counts.

STEM Calculus 1 throughput in two years was high for students who did not complete traditional calculus preparation (trigonometry or precalculus) while in high school. For example, 69% who

[5] See Appendix I for an overview of math placement policies, which differed substantially across colleges and across this window of time.

[6] AB 1705 requires placement and enrollment to maximize the probability of completion of math coursework that satisfies a requirement for the student's degree or program within ONE YEAR of the student's first math attempt (California Educational Code 78213 section (c)(1)). See Appendix C, Tables C5 and C6 for one-year throughput.

[7] Across all levels of high school math preparation, for direct enrollees into STEM Calculus 1 who completed the calculus course in two years, at least 69% passed (C or better) on the first attempt.

stopped out of math in high school after completing Algebra 2 passed the first STEM Calculus course within two years of their initial attempt without taking additional preparatory courses at the college. The throughput for those who completed high school statistics – a group that did not take Trigonometry or Precalculus before matriculating – was 74%. This outcome mirrored that of students who did complete these courses (73%). As expected, students who completed Calculus in high school and then repeated it once enrolled at the college had the highest throughput (86%).

Additional descriptive analysis based on the state's default precalculus placement rules produced similar results with two-year throughputs above 55% across placement levels (see Appendix C). We also conducted a series of multivariate regression analyses that supported these same findings after controlling for factors such as time elapsed between high school and college math enrollment, prior use of placement testing, student demographics, and institutional characteristics.[8]

Based on these analyses, no group defined by level of high school math preparation would be considered as highly *unlikely* to succeed with direct enrollment.

STEM Calculus 1 Completion with Transfer-level Preparation in College

Key Finding: *Across all levels of high school math preparation and placement, preparatory college coursework was associated with lower STEM Calculus 1 throughput relative to direct enrollment into calculus.*

To address the AB 1705 "improves the probability of completion" standard, we compared two-year throughput for STEM students who began in Calculus to those who began in a transfer-level preparatory course in the path to Calculus. While it varies by college, this path typically includes one to three courses, such as College Algebra, Trigonometry, and/or Precalculus or some combination. Notably, none of these pathway courses satisfy STEM program requirements. Of the cohort, 69% (25,675 of 37,232) started in one of these preparatory college courses during the period studied.

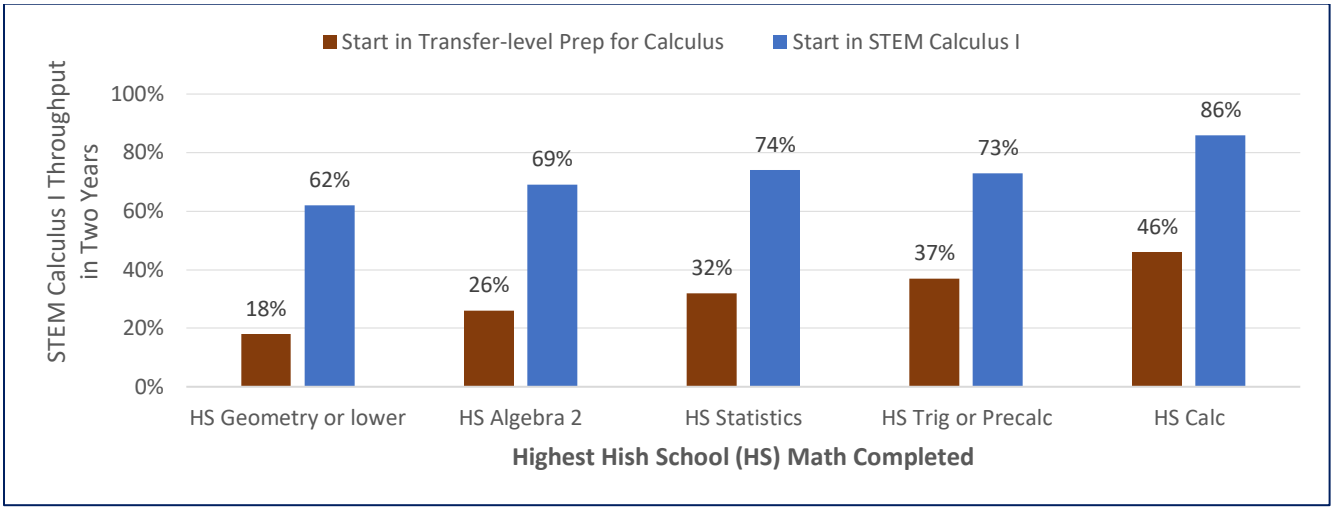
Our analysis did not identify a group of students – based on high school math preparation – who had a higher probability of completing STEM Calculus 1 when they started in a transfer-level preparatory course (Figure 2). Students who began in courses in the STEM Calculus path were much less likely to complete the first STEM Calculus course compared to their peers with similar high school math preparation who began directly in Calculus. Notable findings from this analysis include:

- Of the students who completed Calculus in high school but then began in a lower-level course in college, only 46% completed STEM Calculus 1 within two years, compared to 86% who started in STEM Calculus 1.
- When students who completed Trigonometry or Precalculus in high school repeated the college versions of these courses, only 37% completed STEM Calculus 1 within two years, compared to 73% who started in STEM Calculus 1.

[8] See technical report.

- Similarly, only 18% of students with the lowest level of high school math preparation (Geometry or lower) who began in a preparatory course completed STEM Calculus 1 in two years, compared to 62% who started in STEM Calculus 1.

Figure 2. STEM Calculus 1 Two-Year Throughput, STEM Students Disaggregated by Starting Level and Highest High School Math Completed



Note: First CCC math enrollment in 2012-2013 through 2019-2020. See Appendix C for cohort counts.

We again see the benefit of students completing more advanced high school math before they matriculate. Students with lower levels of high school math preparation who started in STEM Calculus 1 completed at higher rates in a two-year period than better-prepared students who started in preparatory courses. For example, students who completed Algebra 2 in high school and then enrolled directly in STEM Calculus 1 had higher completion rates than students who completed Calculus in high school and then started in a preparatory course after they matriculated, with throughput rates of 69% and 45% respectively.

We replicated this descriptive analysis using the state's default precalculus placement rules and found similar patterns (see Appendix C). We also examined the relationship between high school math preparation and Calculus 1 throughput from various college math starting points in our logistic regression models. Again, the logistic regression analyses supported the findings of the descriptive work when controlling for factors such as the time elapsed between high school and college math enrollment, prior use of placement testing, student demographics and institutional characteristics. In additional decision tree analysis, starting level in the college calculus pathway and high school GPA were the best predictors of two-year calculus throughput.[9]

[9] See technical report.

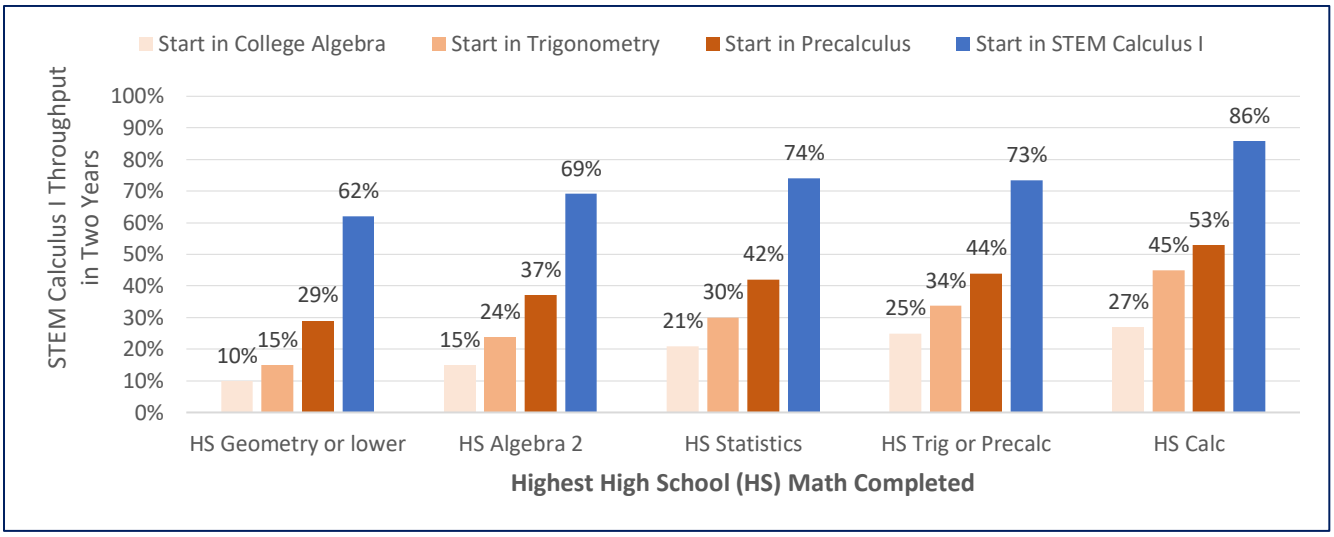
STEM Calculus 1 Completion and Features of the Preparatory Pathway

Key Finding: *Across all levels of high school math preparation and placement, longer paths were associated with higher rates of attrition and lower STEM Calculus 1 throughput in a two-year timeframe.*

Since the path to STEM Calculus 1 differs across colleges, both in the type and the number of preparatory courses leading up to Calculus, we also examined how these features related to Calculus 1 throughput.

When disaggregating preparatory courses by course type (College Algebra, Trigonometry, Precalculus), a consistent pattern emerged across the levels of high school math preparation. Two-year throughput in STEM Calculus 1 was highest for students who began in that course and decreased progressively for those starting in Precalculus, Trigonometry, and College Algebra (Figure 3).

Figure 3. STEM Calculus 1 Two-Year Throughput, STEM Students Disaggregated by Starting Course and Highest High School Math Completed



Note: First CCC math enrollment in 2012-2013 through 2019-2020. See Appendix C for cohort counts.

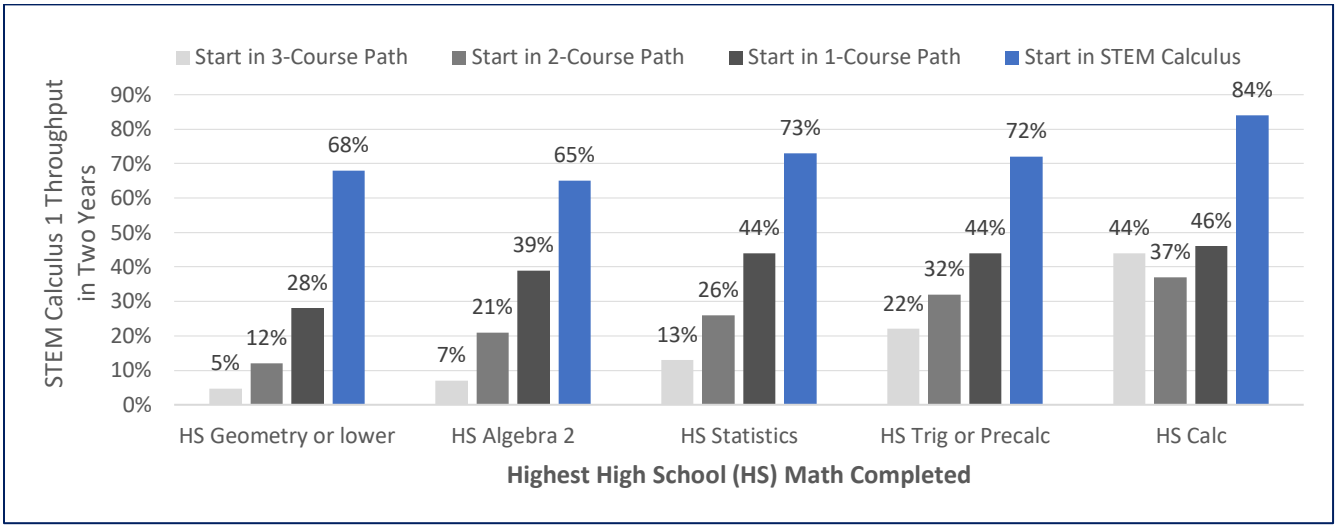
The lower levels of calculus throughput associated with College Algebra may have less to do with the course itself and more to do with its position as the first course in a multi-course sequence. Not all colleges included College Algebra in their pathway, but when they did, it was part of a two- or three-course path to Calculus and usually the first course in the sequence. By contrast, Precalculus was frequently the immediate precursor to Calculus, meaning that successful students had access to STEM Calculus 1. In other words, for students starting in College Algebra, there might be a greater risk of attrition in a longer pathway than for students starting in Precalculus. We investigate the relationship between pathway length (number of courses in the pathway) and calculus throughput next.

For this analysis, we looked at the cohort starting in a transfer-level preparatory course in the STEM Calculus pathway in 2018-2019 and 2019-2020 and tracked them for two years from initial math enrollment. We restricted this cohort to the two academic years after the fall 2018 statewide discontinuation of placement testing because some colleges subsequently lengthened their paths to

STEM Calculus in response to the curtailment of developmental education. Students were categorized by the number of preparatory courses their college required, given their starting point, before they had access to STEM Calculus 1.

Longer paths to STEM Calculus were associated with lower two-year calculus throughput for students who did not complete Calculus in high school (Figure 4).[10] This consistent pattern of lower throughput with increasing path length mirrors the attrition that is well-documented in studies of developmental math sequences.[11]

Figure 4. STEM Calculus 1 Two-Year Throughput, STEM Students Disaggregated by Path Length (Number of Preparatory Courses in the Path STEM Calculus) and Highest High School Math Completed



Note: First CCC math enrollment in 2018-2019 and 2019-2020. See Appendix D for cohort counts.

STEM Calculus 2 Completion and Transfer-level Preparation

Key Finding: *Across all levels of high school math preparation and placement levels, students completed the second STEM Calculus course at higher rates within three years if they began in STEM Calculus 1 rather than a preparatory course prior to Calculus 1.*

For this analysis, we restricted the cohort to students in STEM programs that require a second Calculus course and reduced the timeframe to allow for the calculation of a three-year throughput rate.[12] We looked at students who enrolled in College Algebra, Trigonometry, Precalculus, or STEM Calculus 1 in the academic years from 2012-2013 through 2018-2019 and tracked their throughput for

[10] In Figure 4, the anomaly for high school calculus-completers starting in a three-course path represents only 49 students across three colleges, comprising 0.5% of high school calculus-completers.

[11] Referral, enrollment, and completion in developmental education sequences, Bailey, et.al., 2010; Improving Developmental and College-Level Mathematics: Prominent Reforms and the Need to Address Equity, Brathwaite, et.al., 2020; Preparing Students for Success in California's Community Colleges, Johnson, et.al., 2016

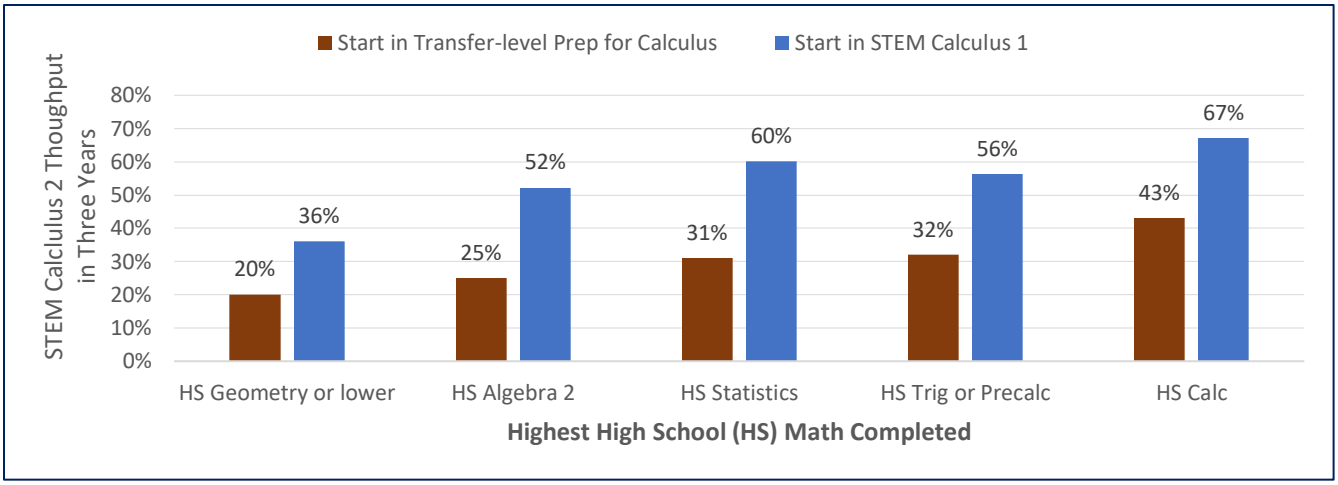
[12] Based on the C-ID Transfer Model Curricula. Note: this restriction removed biology majors (the largest group) from the original cohort STEM majors.

three years from their initial math enrollment. Of the identified cohort (N = 15,472), 64% began in a transfer-level preparatory course prior to STEM Calculus 1.

Relative to AB 1705's "improves the probability of completion" standard for Calculus 2, our analysis did not find a group of students – based on high school math preparation – who had a higher likelihood of completing STEM Calculus 2 when they started in the preparatory path to STEM Calculus 1 (Figure 5). When comparing students with the same level of high school math preparation, those who started college math directly in STEM Calculus 1 were much more likely to complete STEM Calculus 2 than those who started below the first Calculus course in the sequence.

The long-term effects of higher levels of high school math preparation remained, as did the performance of students who completed statistics in high school and started in STEM Calculus 1 without having completed Trigonometry or Precalculus in high school or college. Their STEM Calculus 2 throughput (60%) was higher than the throughput for students with more traditional high school math preparation (56%).

Figure 5. STEM Calculus 2 Three-Year Throughput, STEM Students Disaggregated by Starting Level and Highest High School Math Completed



Note: First CCC math enrollment in 2012-2013 through 2019-2020. See Appendix E for cohort counts and disaggregation by preparatory course type.

Additional Considerations: Conditional Throughput

Key Takeaway: *Restricting access to STEM Calculus 1 was associated with small to modest gains in conditional throughput for students with lower levels of high school math preparation.*

In this analysis, we calculate a two-year conditional throughput for Calculus 1, which is an adjustment to the Calculus 1 throughput that restricts the original cohort to the subset of students who attempt STEM Calculus 1.[13] This method excludes nearly 40% of the students in the original

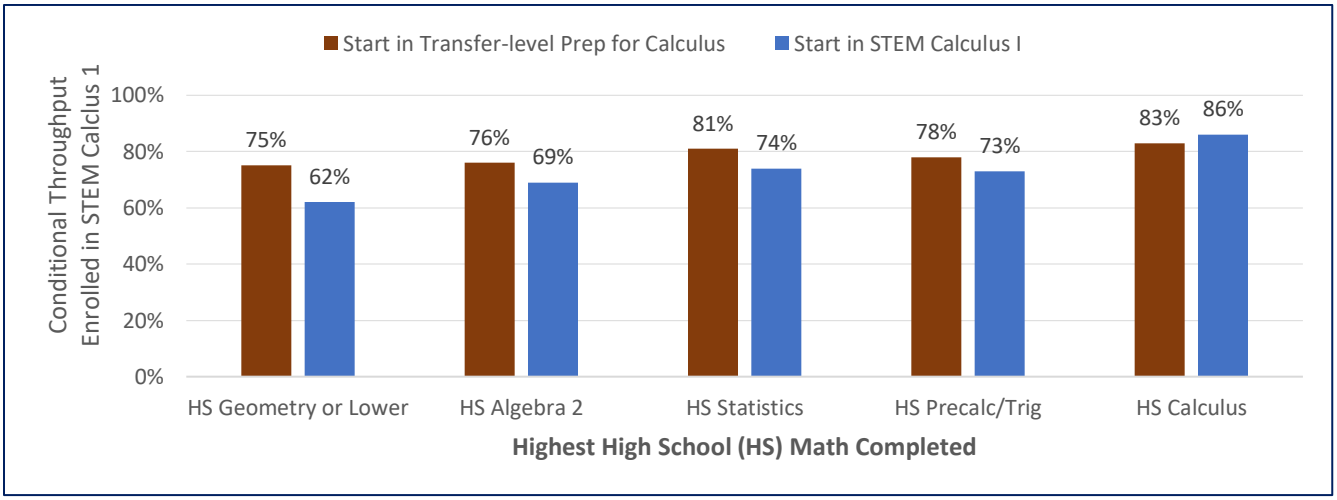
[13] For example, if 100 students start in Precalculus, and 60 progress to Calculus, and 30 pass Calculus, the throughput is 30/100=30%, but the conditional throughput is 30/60 = 50%.

cohort (14,585 students excluded) who started in a preparatory course but did not enroll in Calculus within the two-year timeframe. We include this analysis as a contrast to throughput because it resembles the kind of analysis colleges traditionally have used to justify establishing a prerequisite. **It is important to note that "conditional throughput" does not meet the validation requirements of AB 1705** because it does not measure the overall impact of a college's placement policies and initial course enrollment patterns on STEM students' completion of the first Calculus course required for their program. Invisible in the conditional throughput calculation are the students who could have succeeded in Calculus if they had started there.

Restricting access to Calculus was associated with small to modest gains in conditional Calculus throughput after preparatory coursework relative to direct enrollment for students with the same level of high school math preparation (Figure 6), except in the case of students who completed calculus in high school. High school calculus completers who began in a preparatory course at the college had a 3-percentage point lower conditional throughput rate compared to those who enrolled directly, and 43% were lost to attrition before reaching Calculus.

Students with progressively lower levels of high school math preparation had incremental improvements in conditional calculus throughput with additional college coursework prior to Calculus but much greater levels of attrition in the calculus pathway (Table 1). For example, for those who completed Trigonometry or Precalculus in high school, their conditional throughput improved by 5 percentage points with preparatory coursework at the college, but 50% of those starting in the calculus pathway in college did not attempt STEM Calculus 1 within two years. Those who completed Algebra 2 in high school gained 7 percentage points, but 63% were lost to attrition.

Figure 6. STEM Calculus 1 Conditional Throughput in Two Years, STEM Students Disaggregated by Starting Level and Highest High School Math Completed



Note: First CCC math enrollment in 2012-2013 through 2019-2020. Students are tracked for two years from first math course enrollment. Those who do not enroll in Calculus are excluded from the calculation. See Appendix F for cohort counts and disaggregation by preparatory course type.

Table 1. Attrition in Path to STEM Calculus 1 (%), STEM Students Disaggregated by Highest High School Math Completed

Highest High School Math Completed	Start in Transfer-level Calculus Prep	No STEM Calculus 1 Attempt in Two Years	% Attrition
HS Geometry or lower	2,638	1,994	76%
HS Algebra 2	7,396	4,689	63%
HS Statistics	2,482	1,450	58%
HS Trig or Precalculus	8,432	4,174	50%
HS Calculus	3,340	1,428	43%
Missing Some HS Math Data	1,296	850	66%
TOTAL	25,584	14,585	57%

Note: First CCC math enrollment in 2012-2013 through 2019-2020. Students are tracked for two years from first math course enrollment.

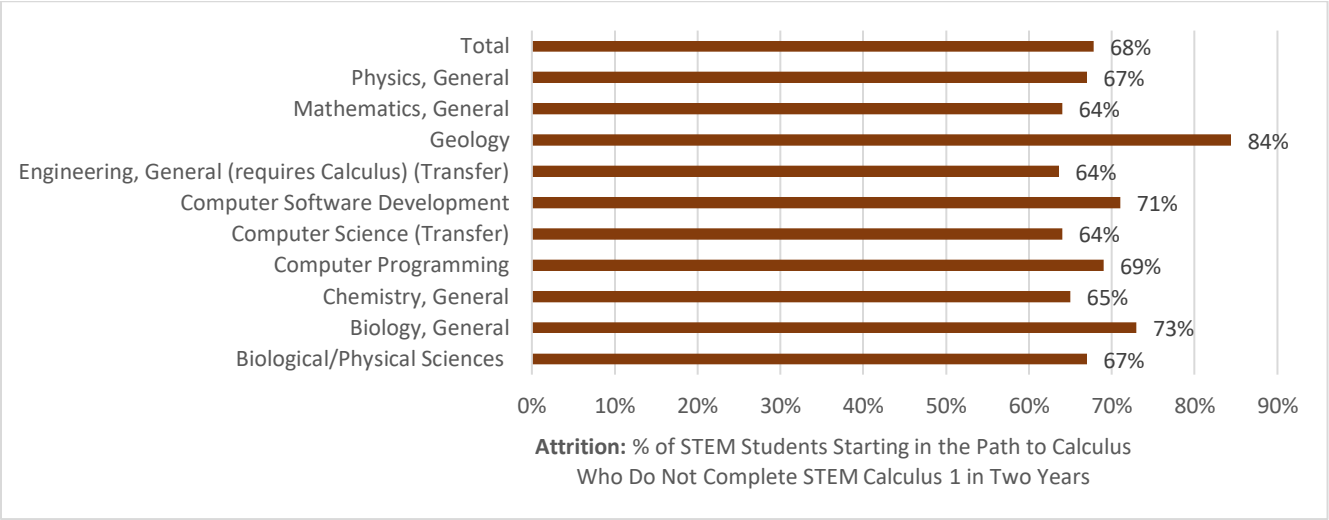
This analysis suggests that restricting access to Calculus as a strategy for improving calculus completion was associated with small to modest gains at best. The potential limitations of this approach are high rates of attrition that may negatively impact enrollments in STEM programs.

Attrition in the Path to Calculus and STEM Programs

Key Finding: *Attrition in the path to STEM Calculus may contribute to attrition in STEM and to the loss of STEM potential.*

The loss of students in the path to STEM Calculus has a large impact on STEM programs in California's community colleges. If students do not complete STEM Calculus, they are stymied in achieving STEM transfer status. Between 2012 and 2019, 73% of biology majors, 64% of engineering majors, 64% of computer science majors, and 64% of math majors did not complete the first STEM Calculus course within two years of starting in a transfer-level preparatory course in the path to Calculus (Figure 7).

Figure 7. Attrition in the Path to Calculus by STEM Major



Note: First CCC math enrollment in 2012-2013 through 2019-2020. See Appendix G for cohort counts.

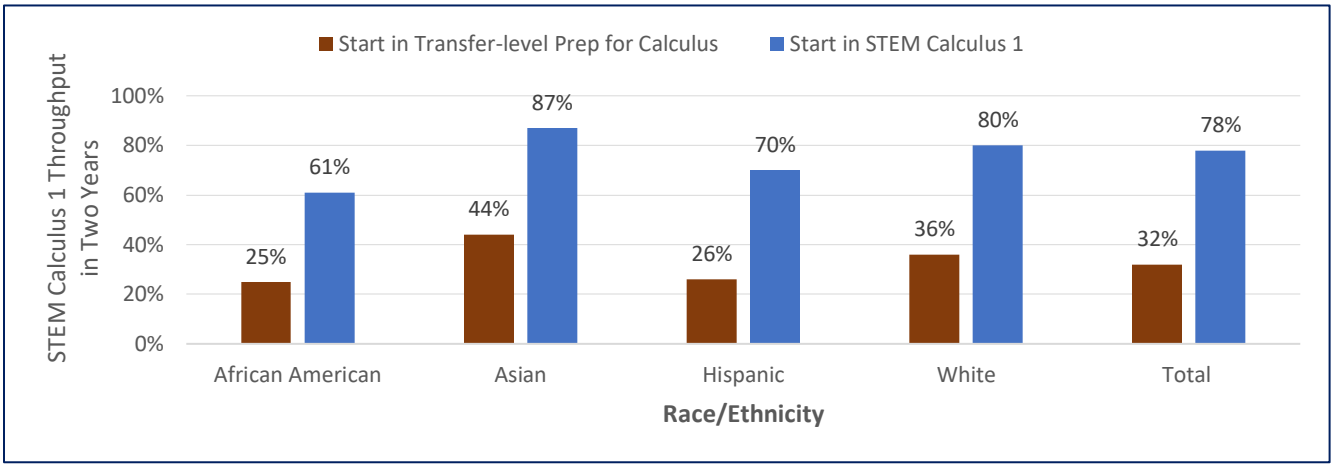
Overall, **for STEM students who began math in calculus preparation, attrition was 68% statewide, due in part to the loss of students who chose not to persist despite initial success.** Over half of students earning an A or B in College Algebra and nearly one-third with an A or a B in Trigonometry did not enroll in the STEM Calculus 1 within two years.[14]

Attrition in the Path to Calculus and STEM Equity

Key Finding: *Pathways to STEM Calculus and inequitable access to Calculus may contribute to inequity in calculus completion and ultimately to less diverse STEM programs.*

As noted earlier, STEM students who began in a preparatory course below STEM Calculus 1 had much lower Calculus 1 throughput in two years (32%) when compared to students who began in Calculus 1 (78%), even when disaggregated by high school math preparation and high school GPA. When the data are further disaggregated by race and ethnicity, the patterns previously observed continue to appear (Figure 8). Furthermore, in our regression analysis, across all demographic groups, there was no evidence that transfer-level preparatory coursework prior to STEM Calculus 1 was associated with higher Calculus 1 throughput rates, even for students with the lowest level of high school math preparation.

Figure 8. STEM Calculus 1 Two-Year Throughput, STEM Students Disaggregated by Starting Level and Race/Ethnicity



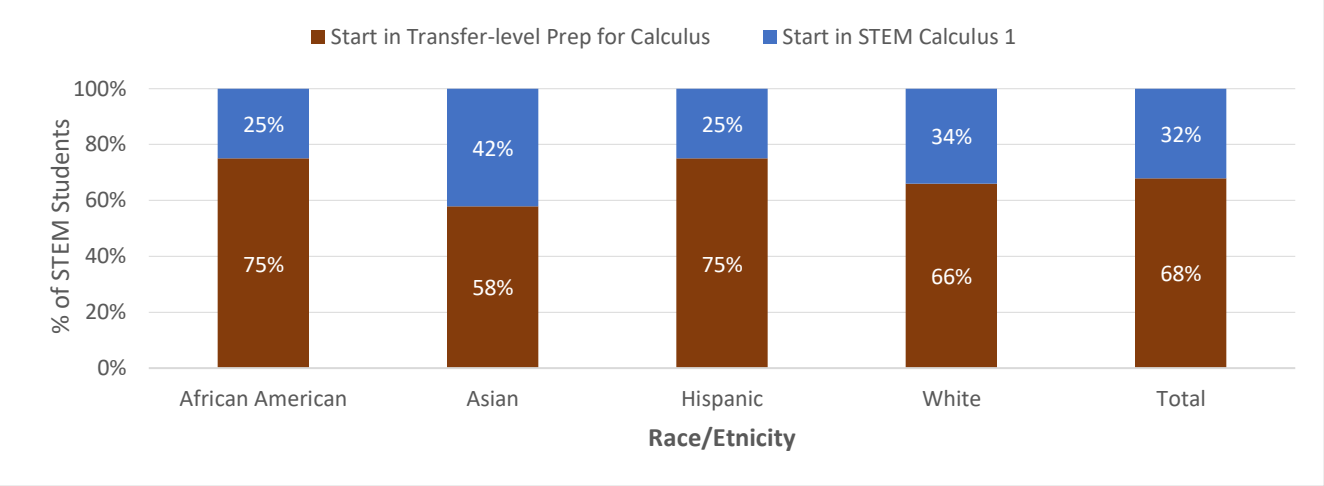
Note: First CCC math enrollment in 2012-2013 through 2019-2020. See Appendix H for additional race/ethnicity categories and data.

The high rate of attrition in the STEM Calculus path may be contributing to inequity in calculus completion when students of color disproportionately begin math, by choice or requirement, in a course below Calculus. In the academic years 2012-2013 through 2019-2020, 75% of African American and 75% of Hispanic STEM students who started in a transfer-level math course in the

[14] See Appendix F, Table F3

STEM Calculus pathway began in a preparatory course, compared to 58% of Asian and 66% of White students (Figure 9).

Figure 9. Starting Level by Race/Ethnicity for STEM Students



Note: First CCC math enrollment in 2012-2013 through 2019-2020. See Appendix H for additional race/ethnicity categories and data.

African American and Hispanic STEM students were less likely to have received the traditional math preparation for calculus in high school, which is consistent with their lower rates of direct enrollment in Calculus. A larger proportion of African American and Hispanic students had a high school GPA at or below 2.6, and did not complete Trigonometry, Precalculus, or Calculus in high school (Appendix E). **However, this overrepresentation in preparatory coursework is also present for African American and Hispanic STEM students who completed advanced high school math.** For example, African American and Hispanic high school calculus completers were more likely to begin in a preparatory college course below Calculus compared to their Asian and White counterparts (African American: 25%, Hispanic: 26%, Asian: 15%, White: 16%). In a similar vein, the percentage of high school precalculus completers who enrolled in Calculus as their first college math course was lower for African American and Hispanic STEM students (African American: 14%, Hispanic: 14%, Asian: 25%, White: 22%).

This inequity in calculus access for well-prepared students may be due to restrictive local placement policies that barred access to Calculus at colleges serving a large proportion of the state's African American and Hispanic students. This inequity may also arise from well-prepared students of color disproportionately choosing to enroll in preparatory courses, a choice that may be influenced by implicit racial bias in institutional STEM cultures or approaches to advising and messaging that exacerbate imposter syndrome. Whether by student choice or college requirement, the disproportionately large enrollment of African American and Hispanic STEM students in preparatory courses below Calculus – a path with high rates of attrition – may be contributing to inequity in calculus completion and the resulting loss of students of color in STEM because if students do not complete STEM Calculus, they are not able to progress in their pursuit of a STEM degree. **Given the**

state's demographics, the continuing loss of students of color in the STEM Calculus path is likely to have a lasting effect on STEM programs in California's community colleges in the future.

Conclusion

At its heart, AB 1705 contributes to a broader effort to increase equitable completion outcomes across the California community colleges so more students achieve economic mobility. This research shows that, at present, placement policies and curricular paths to STEM Calculus are associated with STEM attrition and may be contributing to inequity in STEM.

These analyses demonstrate that transfer-level preparatory courses prior to STEM Calculus 1 do not meet AB 1705 standards at the statewide level for any student group examined. Across all levels of high school math preparation and across placement levels based on high school GPA, STEM students had higher STEM Calculus completion rates if they began in Calculus. Preparatory courses prior to STEM Calculus 1 were associated with high levels of attrition for every group. The findings suggest that current pathways to Calculus are not effectively supporting STEM students and STEM programs and could be contributing to the loss of capable STEM students who are not permitted to, or who choose not to, enroll directly in Calculus.

This evidence suggests that more students could make progress toward a STEM degree if they began directly in STEM Calculus 1. Broadening access to Calculus combined with the implementation of evidence-based instructional practices and holistic support offer the next horizon for the effort to improve calculus completion. Concurrent support– delivered either as a corequisite to STEM Calculus 1 or integrated into an "enhanced" Calculus course – presents a valuable opportunity for supporting students and ameliorating the attrition seen in current pathways to Calculus.

Appendix A Methodology

The analyses in this report follow methods used in prior placement validation studies commissioned by the California Community Colleges Chancellor's Office and conducted by the Multiple Measures Assessment Project. An accompanying technical report contains more detail about the methodology and includes multivariate logistic regression models and confirmatory decision tree analysis.[15]

The cohort is California Community College (CCC) STEM majors whose first college math enrollment was in a transfer-level calculus pathway course (College Algebra, Trigonometry, Precalculus, or STEM Calculus 1) at any point in the academic years between 2012-2013 and 2019-2020, excluding students who started a calculus pathway course while in high school or during a summer term. The study also does not include students who began in developmental education because they were the subject of previous validation studies[16] and are not the focus of the section of AB 1705 that sets standards for placement into the first STEM Calculus course (Ed. Code 78213, section (f)).

The cohort is students with a STEM major as reported by each college to the COMIS upon matriculation and completion of an educational plan (SMO2). If SM02 was missing, STEM majors were also identified using the SS02 element (Student Credit Course of Study). STEM majors were identified using the C-ID Transfer Model Curricula[17] as programs that require completion of at least a first-level STEM Calculus course, which includes biology, chemistry, computer science, engineering, geology, math, and physics. In the examination of Calculus 2 completion, the cohort was restricted to STEM majors in programs that require a second semester of Calculus, according to the C-ID Transfer Model Curricula, which removed biology from the list of STEM majors for this part of the analysis.

Consistent with prior AB 705 and AB 1705 validation studies, the analyses used throughput as an outcome metric, specifically STEM Calculus 1 and STEM Calculus 2 throughput. Calculus throughput is a rate that calculates successful calculus completions based on the number of students who start in a specified course in the calculus pathway (College Algebra, Trigonometry, Precalculus, STEM Calculus 1). For example, if 200 students start in Precalculus, and 60 progress to Calculus, and 50 pass Calculus, the throughput is 25% (50 out of 200). Since throughput connects calculus completion to math placement and initial course enrollment, it measures the efficacy of the placement system and associated curricular structures in supporting calculus completion. All STEM students whose first math enrollment is in STEM Calculus 1 or a transfer-level preparatory course prior to STEM

[15] See the technical report.
[16] Maximizing Calculus Completion for Students Seeking the Business Administration Degree and Preparatory Pathways and STEM Calculus Completion: Implications of the AB 1705 Standards, Technical Appendices
[17] The Course Identification Numbering System's Transfer Model Curriculum Information page

Calculus 1 are included in the calculation. Throughput is lowered by students not passing a course (earning a D, F, NP, EW, or W)[18] in the calculus pathway or not persisting after a course success.

Throughput in this study includes the successful completion of Calculus 1, within two years or Calculus 2, within three years from the student's initial math enrollment in a transfer-level course in the calculus pathway. For example, if the first math enrollment was in Fall 2019, students would be tracked through Summer 2021 for Calculus 1 completion and through Summer 2022 for Calculus 2 completion. Completion is tracked anywhere in the CCC system. AB 1705 specifies that placement must maximize gateway math course completion within one year of first math course enrollment.[19] However, we use a two-year timeframe to accommodate the longer calculus pathways at many colleges. This approach allows us to examine the full potential of a longer path to improve calculus completion.

STEM Calculus 1 is defined as the first Calculus course required for STEM majors and excludes Business Calculus and other forms of applied calculus. All colleges have a STEM Calculus 1 course equivalent to C-ID Math 210 Single Variable Calculus 1 Early Transcendentals, Math 211 Single Variable Calculus 1 Late Transcendentals, or the first half of a Math 900S Single Variable Calculus Sequence. STEM Calculus 2 is a course certified by the C-ID as equivalent to Math 220 Single Variable Calculus 2 Early Transcendentals, Math 221 Single Variable Calculus 1 Late Transcendentals, or the second half of a Math 900S Single Variable Calculus Sequence.[20]

Students' high school preparation is disaggregated in two ways: (1) by highest high school (HS) math course completed with a C or better and by (2) placement levels based on default STEM placement rules for precalculus:[21]

Default STEM Placement Groups for Our Analysis	
Level 1: Highest level	GPA >= 3.4
Level 2	2.6 < GPA < 3.4 and Passed Trig, Precalc or Calc in High School
Level 3	2.6 < GPA < 3.4 and did NOT pass Trig, Precalc or Calc in High School
Level 4: Lowest level	GPA <=2.6

In addition to the descriptive analyses, we ran a series of multivariate regression analyses to identify variables that influenced throughput and to explore factors such as time between high school and college, pre- and post-AB 705 changes in the placement process, student demographics, and institutional characteristics. The primary analysis used logistic regression predicting throughput in

[18] Excuse withdrawals (EW) count as a valid enrollment and are considered an unsuccessful attempt. The full list of unsuccessful attempts include D+, D, D-, F, F+, EW, FW, ID+, ID, ID-, IF, INP, NP, W.
[19] California Educational Code 78213 section (c)(1)
[20] The Course Identification Numbering System's Final Descriptors page
[21] The default STEM placement rules are based on MMAP's decision tree analysis that operationalized earlier placement reforms mandated by AB 1705's sister legislation, AB 705 (Irwin, 2017). These placement rules were widely adopted across the California community college system. See Multiple Measures Assessment Project (MMAP) Summary of Methodology for English and Math Phase II Rule Sets and AB 705 Adjustments.

STEM Calculus 1 in two years. An accompanying technical report includes a full discussion of the methodology, the regression models, and findings from them.[22]

Also included in this report is a descriptive analysis of conditional throughput. Conditional throughput excludes all STEM students who started in a course in the path to STEM Calculus 1 but never attempted STEM Calculus 1, which is nearly 40% of STEM aspirants in this study. For example, if 100 students start in Precalculus, and 60 progress to Calculus, and 30 pass Calculus, the conditional throughput is 50% (30 out of 60). We included the conditional throughput analysis because it is like a success rate calculation, which is a calculation that is more familiar than throughput. However, it is important to note that "conditional throughput" does not meet the validation requirements of AB 1705 because it does not measure the overall impact of a college's placement policies and initial course enrollment patterns on STEM students' completion of the gateway calculus course for their program.

Data were provided by EdResults Partnerships, California Partnership for Achieving Student Success (CalPASS Plus), which included data for all California Community Colleges, as provided by the colleges to the Chancellor's Office Management Information System (COMIS), as well as high school transcript data, when available. High school data came from two sources, CalPASS Plus's data system, which provides high school transcript data from participating high schools, and self-reported high school transcript information from the community college's Open CCCApply application. Data were sourced initially from CCCApply, and when not available, from CalPASS Plus. When using transcripts, only students with at least 11th or 12th grade data available were included. A subset of these transcripts had cumulative GPA but lacked information about highest school math completed. These students were retained in the sample as "missing some high school math data." Cal-Pass Plus encrypts student-level data and adheres to strict legal standards on student identification.

[22] See technical report.

Appendix B Cohort Description

The cohort is California Community College STEM students who started in a transfer-level calculus pathway course (College Algebra, Trigonometry, Precalculus, STEM Calculus 1) in the academic years from 2012-2013 to 2019-2020, excluding students who started a calculus pathway course while in high school or during a summer term.

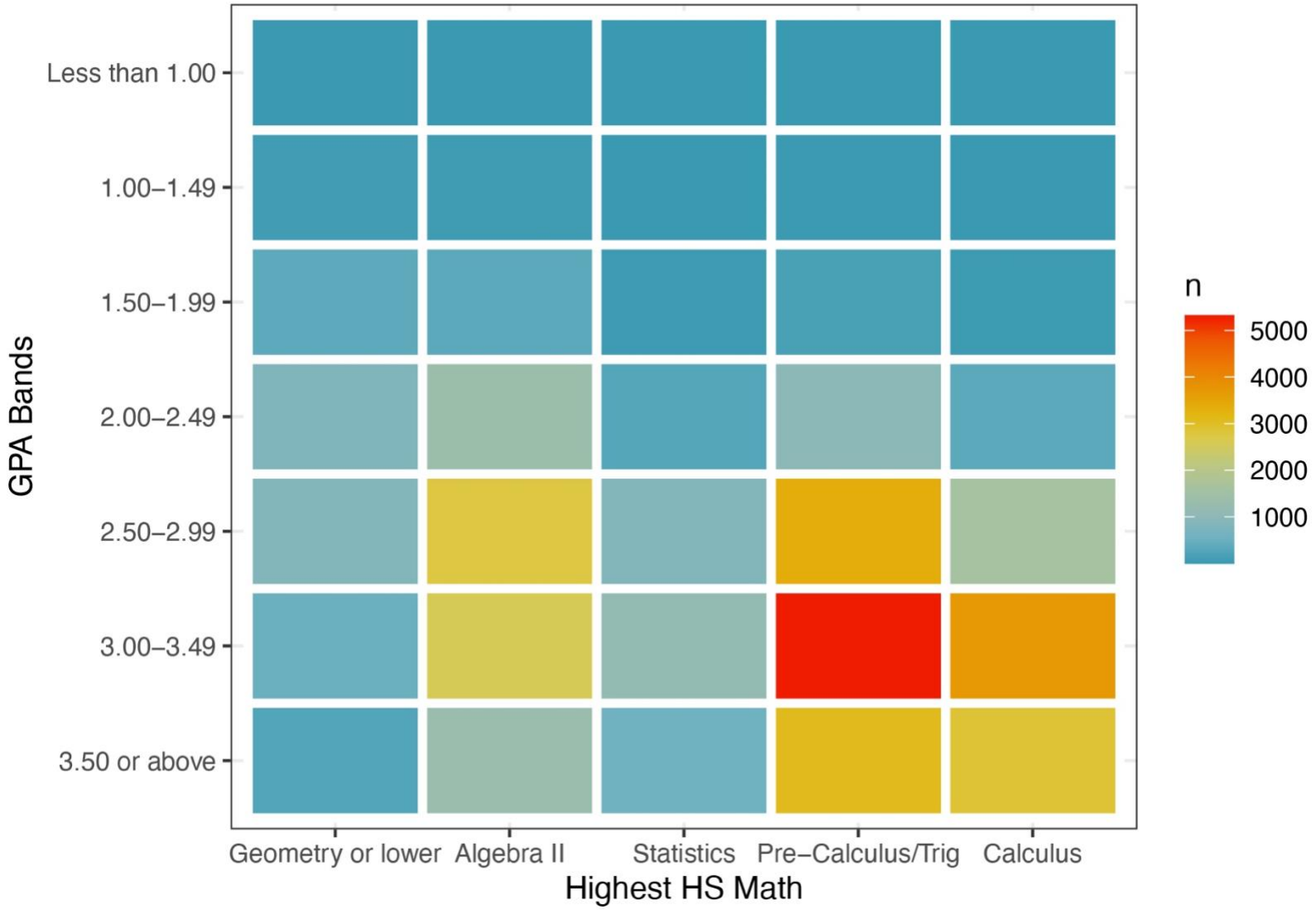
Table B1. Distribution of STEM Students Starting in Calculus Pathway by High School Math Preparation

Highest High School Math Completed (C or better)	Count	Percent
Geometry or lower	2,868	7.7%
Algebra 2	8,379	22.5%
Statistics	2,903	7.8%
Trigonometry or Precalculus	12,935	34.7%
Calculus	8,578	23.0%
Missing Some HS Math Data	1,569	4.2%
Total	37,232	100%

Table B2. Distribution of STEM Students Starting in Calculus Pathway by Default STEM Placement Rules

High School Preparation	Count	Percent
GPA <= 2.6	7,043	18.9%
2.6 < GPA < 3.4 Did not pass Trig, Precalc or Calc	7,247	19.5%
2.6 < GPA < 3.4 Passed Trig, Precalc or Calc	11,505	30.9%
GPA >= 3.4	10,954	29.4%
Missing Some HS Math Data	483	1.3%
Total	37,232	100%

Figure B1. Heat Map of STEM Students Starting in Calculus Pathway by High School GPA and Highest High School Math Completed



Appendix C. STEM Calculus 1 Throughput

For the calculation of STEM Calculus throughput in two years, the cohort is California Community College (CCC) STEM students who started in a transfer-level calculus pathway course (College Algebra, Trigonometry, Precalculus, STEM Calculus 1) in the academic years from 2012-2013 to 2019-2020, excluding students who started a college calculus pathway course while in high school or during a summer term. Students were tracked for two years across the system from initial math enrollment.

Example calculation of throughput: If 100 students started in College Algebra, and 40 progressed to STEM Calculus 1, and 20 passed STEM Calculus 1, the throughput is 20% (20 out of 100).

We also include in Appendix C (Table C4) information about the number of attempts until Calculus 1 completion for STEM students enrolling directly into STEM Calculus 1 when tracked for two years.

In addition, Appendix C (Tables C5 and C6) includes the one-year throughput for STEM Calculus 1 by first CCC math course, disaggregated by level of high school math preparation. We include the one-year throughput for comparison and also because AB 1705 stipulates that placement must maximize the probability that a student completes transfer-level math coursework that satisfies a requirement of their degree program or major within a year of their first math enrollment (Education Code 78213 (c)). For this report, we used two-year Calculus throughput to examine the full potential of preparatory sequences consisting of two courses prior to Calculus 1.

Table C1. STEM Calculus 1 Throughput (%) in Two Years by First CCC Math Course

First CCC Math Course	Successful in STEM Calculus 1	Cohort	Throughput %
College Algebra	997	5,428	18.4%
Trigonometry	2,767	9,489	29.2%
Precalculus	4,479	10,667	42.0%
STEM Calculus I	9,100	11,648	78.1%
Total	17,343	37,232	46.6%

Table C2. STEM Calculus 1 Throughput Rate (TR) in Two Years by First CCC Math Course and Highest High School Math Completed

		First CCC Math Course									
		College Algebra		Trigonometry		Precalculus		STEM Calculus 1		TOTAL	
		Cohort	TR (%)	Cohort	TR (%)	Cohort	TR (%)	Cohort	TR (%)	Cohort	TR (%)
Highest High School Math Completed	HS Geometry or lower	823	9.7%	1,015	15.3%	800	29.1%	230	61.7%	2,868	21.3%
	HS Algebra 2	1,789	14.6%	2,981	23.8%	2,626	37.0%	983	68.6%	8,379	31.2%
	HS Statistics	573	20.8%	1,009	30.1%	900	41.9%	421	73.6%	2,903	38.2%
	HS Trigonometry or Precalculus	1,401	25.1%	2,922	34.3%	4,109	43.7%	4,503	73.3%	12,935	49.9%
	HS Calculus	508	27.4%	1,094	45.0%	1,738	52.8%	5,238	85.6%	8,578	70.3%
	Missing Some HS Math Data	334	13.8%	468	22.4%	494	37.0%	273	68.1%	1,569	33.1%
	Total	5,428	18.4%	9,489	29.2%	10,667	42.0%	11,648	78.1%	37,232	46.6%

Table C3. STEM Calculus 1 Throughput Rate (TR) in Two Years by First CCC Math and Default STEM Placement Rules

		First CCC Math Course									
		College Algebra		Trigonometry		Precalculus		STEM Calculus 1		Total	
		Cohort	TR %	Cohort	TR %	Cohort	TR %	Cohort	TR %	Cohort	TR %
High School Preparation by Default STEM Placement Rules	HSGPA < =2.6	1,549	8.0%	2,417	15.3%	2,136	24.7%	941	57.1%	7,043	22.1%
	2.6 < HSGPA < 3.4 Did not pass Trig, Precalc or Calc	1,611	15.6%	2,659	24.4%	2,187	34.9%	790	64.9%	7,247	30.0%
	2.6 < HSGPA < 3.4 Passed Trig, Precalc or Calc	1,128	24.0%	2,335	34.7%	3,372	43.4%	4,670	74.3%	11,505	52.3%
	HSGPA >= 3.4	1,050	32.0%	1,912	46.4%	2,827	59.0%	5,165	87.7%	10,954	67.8%
	Missing Some HS Math Data	90	15.6%	166	30.1%	145	41.4%	82	61.0%	483	36.0%
	Total	5,428	18.4%	9,489	29.2%	10,667	42.0%	11,648	78.1%	37,232	46.6%

Table C4. Number of Attempts Until STEM Calculus 1 Completion for Students Starting Directly in STEM Calculus 1, Tracked for Two Years by Highest High School Math Completed

STEM Students Starting in STEM Calculus 1		Number of Attempts Until STEM Calculus 1 Completion in Two Years				
		1	2	3	4	5+
Highest High School Math Completed	HS Geometry or lower	103	28	10	1	
	HS Algebra 2	468	161	40	5	
	HS Statistics	254	43	12	1	
	HS Trigonometry or Precalculus	2,457	670	155	18	2
	HS Calculus	3,856	529	92	8	1
	Missing Some High School Math Data	148	31	6	1	

Tables C5 and C6 have the **one-year** Calculus 1 throughput calculations. Since students were tracked for one year instead of two years, we were able to include an additional cohort year. The cohort is California Community College (CCC) STEM students who started in a transfer-level calculus pathway course (College Algebra, Trigonometry, Precalculus, STEM Calculus 1) in the academic years from 2012-2013 to 2020-2021, excluding students who started a calculus pathway course while in high school or during a summer term. Students were tracked for **one year** across the system from initial math enrollment.

Table C5. STEM Calculus 1 Throughput (%) in One Year by First CCC Math Course

First CCC Math Course	Successful in STEM Calculus 1	Cohort	Throughput %
College Algebra	277	7,244	3.8%
Trigonometry	1,093	11,927	9.2%
Precalculus	3,470	13,089	26.5%
STEM Calculus I	10,531	14,450	72.9%
Total	15,371	46,710	32.9%

Table C6. STEM Calculus 1 Throughput Rate (TR) in One Year by First CCC Math Course and Highest High School Math

First CCC Math Course											
		College Algebra		Trigonometry		Precalculus		STEM Calculus 1		TOTAL	
		Cohort	TR (%)	Cohort	TR (%)	Cohort	TR (%)	Cohort	TR (%)	Cohort	TR (%)
Highest High School Math Completed	HS Geometry or lower	1,239	1.6%	1,394	3.9%	1,057	15.8%	266	54.1%	3,956	9.8%
	HS Algebra 2	2,427	2.8%	3,832	6.6%	3,331	22.8%	1,210	60.3%	10,800	16.8%
	HS Statistics	808	5.0%	1,385	8.3%	1,183	26.3%	529	69.9%	3,905	21.4%
	HS Trigonometry or Precalculus	1,749	5.2%	3,498	11.9%	4,986	27.7%	5,696	66.7%	15,929	35.7%
	HS Calculus	615	8.1%	1,263	17.7%	1,964	37.3%	6,450	82.1%	10,292	61.2%
	Missing Some HS Math Data	406	2.0%	555	5.8%	568	20.8%	299	63.5%	1,828	19.0%
	Total	7,244	3.8%	11,927	9.2%	13,089	26.5%	14,450	72.9%	46,710	32.9%

Appendix D. Impact of Calculus Pathway Length on STEM Calculus 1 Throughput in Two Years

Cohort is California Community College (CCC) STEM students who started in a transfer-level calculus pathway course (College Algebra, Trigonometry, Precalculus, STEM Calculus 1) in the academic years from **2018-2019 to 2019-2020**. Students were tracked for two years, excluding students who started a calculus pathway course while in high school or during a summer term. Pathway length is the number of transfer-level math courses in the path to STEM Calculus 1. Since pathway length is a feature of the design of calculus preparation at a college, only students who started and completed their sequence at the same college were included. The courses within pathways of the same length may be different across colleges. For example, a two-course pathway may consist of College Algebra and Trigonometry at one college but Trigonometry and Precalculus at another college. Students who began in the second course of a two-course path or the third course in a three-course path were counted in the One-Course Path. Students who began in the second course of a three-course path were counted in the Two-Course Path.

Table D1. Calculus 1 Throughput in Two Years by Number of Preparatory Courses in Calculus Pathway

Pathway Length	Count of STEM Students Starting in Calculus Pathway	Calculus I Throughput in Two Years
Start in STEM Calculus 1	4,995	76.9%
One-Course Path to Calculus	3,021	41.7%
Two-Course Path to Calculus	7,480	23.9%
Three-Course Path to Calculus	513	13.6%
Total	16,009	43.5%

Table D2. Calculus 1 Throughput Rate (TR) in Two Years by Pathway Length and Highest High School Math

		Calculus Pathway Length							
		Three-Course Path		Two-Course Path		One-Course Path		Start in STEM Calculus 1	
		Cohort	TR %	Cohort	TR %	Cohort	TR %	Cohort	TR %
Highest High School Math Completed	HS Geometry or lower	116	5.2%	1,168	12.3%	210	28.1%	72	68.1%
	HS Algebra 2	148	6.9%	2,549	20.9%	820	38.9%	373	65.4%
	HS Statistics	60	13.3%	945	25.8%	289	44.3%	157	73.2%
	HS Trigonometry or Precalculus	118	22.0%	1,875	32.1%	1,200	43.9%	1,963	71.7%
	HS Calculus	42	44.2%	572	37.3%	406	46.2%	2,368	83.7%
	Missing Some HS Math Data	30	3.3%	373	14.7%	100	41.0%	65	70.8%

Appendix E. STEM Calculus 2 Throughput in Three Years

The cohort is California Community College (CCC) STEM students in majors that require Calculus 1 and 2 who started in a transfer-level calculus pathway course (College Algebra, Trigonometry, Precalculus, STEM Calculus 1) in the academic years between **2012-2013 and 2018-2019**, excluding students who started a calculus pathway course while in high school or during a summer term. Students were tracked for three years from initial math enrollment across the system. This analysis excluded biology majors because the Transfer Model Curriculum for Biology does not require Calculus 2. This analysis also excluded the 2019-2020 cohort to allow three years for completion.

Example calculation of Calculus 2 throughput: If 100 students started in College Algebra, and 40 both progressed to STEM Calculus 1 and passed, and 20 both progressed to and passed Calculus 2, the Calculus 2 throughput is 20% (20 out of 100).

Table E1. STEM Calculus 2 Throughput Rate (TR) in Three Years by First Community College Math Course

First CCC Math Course	Cohort	TR %
College Algebra	1,547	20.0%
Trigonometry	3,590	27.4%
Precalculus	4,297	37.3%
STEM Calculus I	5,370	60.5%
Total	14,804	41.5%

Table E2. STEM Calculus 2 Throughput Rate (TR) in Three Years by First CCC Math Course and Highest High School Math

		First CCC Math Course									
		College Algebra		Trigonometry		Precalculus		STEM Calculus 1		TOTAL	
		Cohort	TR %	Cohort	TR %	Cohort	TR %	Cohort	TR %	Cohort	TR %
Highest High School Math Completed	HS Geometry or lower	142	14.8%	313	18.5%	250	26.0%	122	36.1%	827	45.2%
	HS Algebra 2	512	12.1%	1,081	21.7%	945	34.9%	468	52.4%	3,006	29.0%
	HS Statistics	142	21.1%	313	29.4%	315	37.1%	184	59.2%	954	36.5%
	HS Trigonometry or Precalculus	474	25.3%	1,199	29.7%	1,700	36.1%	1,991	56.3%	5,364	41.2%
	HS Calculus	180	31.7%	488	41.2%	857	46.9%	2,460	67.2%	3,985	58.0%
	Missing Some HS Math Data	97	19.6%	196	20.9%	230	32.6%	145	53.1%	668	31.7%

Table E3. STEM Calculus 2 Throughput Rate (TR) in Three Years by First CCC Math Course and Default STEM Placement Rules

		First CCC Math Course									
		College Algebra		Trigonometry		Precalculus		STEM Calculus		Total	
		Cohort	TR %	Cohort	TR %	Cohort	TR %	Cohort	TR %	Cohort	TR %
High School Preparation by Default STEM Placement Rules	GPA < 2.6	412	9.2%	986	15.5%	913	23.2%	573	36.3%	2,884	21.2%
	2.6 <= GPA < 3.4 Did not pass Trig, Precalc or Calc	429	13.8%	913	24.0%	756	33.3%	369	50.7%	2,467	29.1%
	2.6 <= GPA < 3.4 Passed Trig, Precalc or Calc	391	25.8%	965	30.8%	1,574	36.6%	2,274	56.8%	5,204	43.5%
	GPA >= 3.4	282	37.2%	646	45.4%	995	54.4%	2,115	72.8%	4,038	61.4%
	Missing Some HS Math Data	33	18.2%	80	26.3%	59	37.3%	39	59.0%	211	34.1%

Appendix F. Conditional STEM Calculus 1 Throughput and Attrition

For Table F1, the cohort is restricted to California Community College STEM students who enrolled in STEM Calculus 1 within two-years of their first math enrollment in the academic years from 2012-2013 to 2019-2020, excluding students who started a calculus pathway course while in high school or during a summer term.

Example calculation of conditional throughput: If 100 students started in College Algebra, and 40 progressed to STEM Calculus 1, and 20 passed STEM Calculus 1, the conditional throughput is 50% (20 out of 40).

Table F1. Conditional Throughput Rate (CTR) to STEM Calculus 1 in Two Years

		First CCC Math Course															
		College Algebra				Trigonometry				Precalculus				STEM Calculus			
		Starting Cohort	Calc 1 success	Attempt Calc 1	CTR %	Starting Cohort	Calc 1 success	Attempt Calc 1	CTR %	Starting Cohort	Calc 1 success	Attempt Calc 1	CTR %	Starting Cohort	Calc 1 success	Attempt Calc 1	CTR %
Highest High School Math Completed	HS Geometry or lower	823	90	109	82.6%	1,015	168	226	74.3%	800	248	309	80.3%	230	142	230	61.7%
	HS Algebra 2	1,789	296	389	76.1%	2,981	790	1,003	78.8%	2,626	1,025	1,315	77.9%	983	674	983	68.6%
	HS Statistics	573	128	153	83.7%	1,009	325	387	84.0%	900	395	492	80.3%	421	310	421	73.6%
	HS Trig or Precalculus	1,401	376	475	79.2%	2,922	1,095	1,319	83.0%	4,109	1,896	2,464	76.9%	4,503	3,302	4,503	73.3%
	HS Calculus	508	154	189	81.5%	1,094	519	591	87.8%	1,738	945	1,132	83.5%	5,238	4,486	5,238	85.6%
	Missing Some HS Data	334	50	63	79.4%	468	119	145	82.1%	494	193	238	81.1%	273	186	273	68.1%

For Table F2 and Table F3, the cohort is California Community College STEM students who started in a preparatory transfer-level course in the calculus pathway (College Algebra, Trigonometry, Precalculus) in the academic years from 2012-2013 to 2019-2020, excluding students who started a calculus pathway course while in high school or during a summer term. Students were tracked for two years across the system from initial math enrollment.

Table F2. Attrition in the Path to STEM Calculus 1 for STEM Majors by Highest High School Math Completed

Highest High School Math Completed	Start in Transfer-level Calculus Prep	No STEM Calculus 1 Attempt	% Attrition
HS Geometry or lower	2,638	1,994	75.6%
HS Algebra 2	7,396	4,689	63.4%
HS Statistics	2,482	1,450	58.4%
HS Trig or Precalculus	8,432	4,174	49.5%
HS Calculus	3,340	1,428	42.8%
Missing Some HS Math Data	1,296	850	65.6%
TOTAL	25,584	14,585	57.0%

Table F3. Attrition in the Path to STEM Calculus 1 by First CCC Math for STEM Majors Earning an A or B in First CCC Math

First CCC Math Course	Cohort	Earned an A or B in First CCC Math	% with A or B in First CCC Math	No STEM Calculus Attempt	% with A or B in First CCC Math and No STEM Calculus Attempt
College Algebra	5,428	1,891	34.8%	988	52.2%
Trigonometry	9,489	3,445	36.8%	1112	32.3%
Precalculus	10,667	4,130	38.7%	722	17.5%
Total	25,584	9,466	37.0%	2,822	29.8%

Appendix G. Attrition in Calculus Pathway by STEM Major

The cohort is California Community College STEM students who started in a transfer-level calculus pathway course (College Algebra, Trigonometry, Precalculus, STEM Calculus 1) in the academic years from 2012-2013 to 2019-2020, excluding students who started a calculus pathway course while in high school or during a summer term. Students were tracked for two years from initial math enrollment across the system.

Table G1. Distribution of STEM Students by Major

STEM Major[23]	TOP Code	Count	%
Biological and Physical Sciences and Mathematics	4902.00	4,376	11.1%
Biology, General	0401.00	13,404	34.1%
Chemistry	1905.00	1,263	3.2%
Computer Programming	0707.10	2,852	7.3%
Computer Science (Transfer)	0706.00	4,675	11.9%
Computer Software Development	0707.00	175	0.4%
Engineering, General (Transfer)	0901.00	9,114	23.2%
Geology	1914.00	112	0.3%
Mathematics, General	1701.00	2,720	6.9%
Physics, General	1902.00	643	1.6%
Total		39,334	100.0%

[23] The categories of STEM majors are based on TOP codes with titles from the TOP-CIP Crosswalk provided by WestEd and the Center for Educational Excellence to the Chancellor's Office.

Table G2. Attrition in the Path to Calculus by Major

STEM Major	Start in Transfer-level Calculus Prep	Did Not Complete STEM Calculus I within Two Years	
		n	%
Biological and Physical Sciences and Mathematics	3,354	2,247	67.0%
Biology, General	9,840	7,200	73.2%
Chemistry, General	852	554	65.0%
Computer Programming	1,933	1,328	68.7%
Computer Science (Transfer)	3,114	2,001	64.3%
Computer Software Development	121	86	71.1%
Engineering, General (Transfer)	5,971	3,840	64.3%
Geology	83	70	84.3%
Mathematics, General	1,709	1,085	63.5%
Physics, General	398	267	67.1%
Total	27,375	18,678	68.2%

Appendix H. Race/Ethnicity

Cohort is California Community College STEM students who started in a transfer-level calculus pathway course (College Algebra, Trigonometry, Precalculus, STEM Calculus 1) in the academic years from 2012-2013 to 2019-2020. Dual enrollment students and students taking their first community college math course in a summer term were excluded. Students were tracked for two years from initial math enrollment across the system. Race/ethnicity titles reflect those used in statewide reporting to the Chancellor's Office Management Information System (COMIS).

Table H1. Highest High School Math Completed by Race/Ethnicity for STEM Majors Starting in the Calculus Pathway

		Race/Ethnicity																	
		African American		Asian		Hispanic		Native American		Pacific Islander		Two or More Races		Unknown		White		Total	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Highest High School Math Completed	HS Geometry or lower	85	9.2%	461	5.6%	1,427	8.9%	7	8.9%	6	5.6%	143	7.7%	49	8.4%	690	7.4%	2,868	7.7%
	HS Algebra 2	240	26.1%	1,607	19.4%	3,828	23.8%	27	34.2%	25	23.4%	387	20.8%	138	23.5%	2,127	22.7%	8,379	22.5%
	HS Statistics	81	8.8%	651	7.9%	1,186	7.4%	5	6.3%	10	9.3%	163	8.8%	58	9.9%	749	8.0%	2,903	7.8%
	HS Trig or Precalculus	307	33.4%	2,857	34.5%	5,567	34.7%	19	24.1%	40	37.4%	631	33.9%	215	36.7%	3,299	35.3%	12,935	34.7%
	HS Calculus	156	17.0%	2,376	28.7%	3,467	21.6%	14	17.7%	21	19.6%	434	23.3%	106	18.1%	2,004	21.4%	8,578	23.0%
	Missing Some HS Math Data	50	5.4%	320	3.9%	580	3.6%	7	8.9%	5	4.7%	101	5.4%	20	3.4%	486	5.2%	1,569	4.2%
	Total	919	100%	8,272	100%	16,055	100%	79	100%	107	100%	1,859	100%	586	100%	9,355	100%	37,232	100%

Table H2. Default STEM Placement by Race/Ethnicity for STEM Majors Starting in the Calculus Pathway

		Race/Ethnicity																	
		African American		Asian		Hispanic		Native American		Pacific Islander		Two or More Races		Unknown		White		Total	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
High School Preparation by Default STEM Placement Rules	GPA < 2.6	253	27.5%	1,150	13.9%	3,763	23.4%	16	20.3%	23	21.5%	345	18.6%	106	18.1%	1,387	14.8%	7,043	18.9%
	2.6 <= GPA < 3.4 Did not pass Trig, Precalc or Calc	201	21.9%	1,382	16.7%	3,279	20.4%	26	32.9%	22	20.6%	340	18.3%	132	22.5%	1,865	19.9%	7,247	19.5%
	2.6 <= GPA < 3.4 Passed Trig, Precalc or Calc	261	28.4%	2,743	33.2%	5,105	31.8%	19	24.1%	34	31.8%	548	29.5%	167	28.5%	2,628	28.1%	11,505	30.9%
	GPA >= 3.4	193	21.0%	2,886	34.9%	3,751	23.4%	14	17.7%	25	23.4%	590	31.7%	175	29.9%	3,320	35.5%	10,954	29.4%
	Missing Some HS Math Data	11	1.2%	111	1.3%	157	1.0%	4	5.1%	3	2.8%	36	1.9%	6	1.0%	155	1.7%	483	1.3%
	Total	919	100%	8,272	100%	16,055	100%	79	100%	107	100%	1,859	100%	586	100%	9,355	100%	37,232	100%

Table H3. First CCC Math Course by Race/Ethnicity for STEM Majors Starting in the Calculus Pathway

		Race/Ethnicity																	
		African American		Asian		Hispanic		Native American		Pacific Islander		Two or More Races		Unknown		White		Total	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
First CCC Math Course	College Algebra	142	15.5%	704	8.5%	2,854	17.8%	19	24.1%	17	15.9%	242	13.0%	97	16.6%	1,353	14.5%	5,428	14.6%
	Trigonometry	283	30.8%	1,773	21.4%	4,577	28.5%	28	35.4%	30	28.0%	427	23.0%	154	26.3%	2,217	23.7%	9,489	25.5%
	Precalculus	267	29.1%	2,364	28.6%	4,652	29.0%	19	24.1%	31	29.0%	557	30.0%	150	25.6%	2,627	28.1%	10,667	28.7%
	STEM Calculus 1	227	24.7%	3,431	41.5%	3,972	24.7%	13	16.5%	29	27.1%	633	34.1%	185	31.6%	3,158	33.8%	11,648	31.3%
	Total	919	100%	8,272	100%	16,055	100%	79	100%	107	100%	1,859	100%	586	100%	9,355	100%	37,232	100%

Table H4. Distribution of First CCC Math by Race/Ethnicity for STEM Majors Who Completed Calculus in High School

		Race/Ethnicity								
		African American (n=308)	Asian (n=4,955)	Hispanic (n=6,317)	Native American (n=24)	Pacific Islander (n=40)	Two or More Races (n=890)	Unknown (n=249)	White (n=4,167)	Total (n=16,950)
First CCC Math	Transfer-level Calculus Prep	25.3%	15.1%	26.3%	37.5%	12.5%	16.5%	16.9%	15.6%	19.7%
	STEM Calculus 1	25.3%	32.8%	28.6%	20.8%	40.0%	32.2%	25.7%	32.5%	30.9%
	Higher Math	14.0%	30.0%	16.5%	12.5%	17.5%	28.1%	33.7%	30.2%	24.6%
	Non-STEM Calculus	1.0%	1.7%	1.9%	0.0%	2.5%	2.8%	3.2%	3.1%	2.2%
	Other Math	34.4%	20.3%	26.7%	29.2%	27.5%	20.3%	20.5%	18.6%	22.6%

Note in Tables H4 and H5: Students whose first math course at the CCC was Calculus II, Calculus III, Linear Algebra, or Differential Equations were categorized as starting in "Higher Math." Those who began in a Business Calculus or other applied calculus courses were classified as beginning in "Non-STEM Calculus." The "Other Math" category includes students who started in transfer-level Statistics or Liberal Arts Math courses or below transfer-level courses.

Table H5. Distribution of First CCC Math by Race/Ethnicity for STEM Majors Who Completed Precalculus or Trigonometry in High School

		Race/Ethnicity								
		African American (n=308)	Asian (n=4,955)	Hispanic (n=6,317)	Native American (n=24)	Pacific Islander (n=40)	Two or More Races (n=890)	Unknown (n=249)	White (n=4,167)	Total (n=16,950)
First CCC Math	Transfer-level Calculus Prep	29.0%	32.2%	34.5%	34.8%	36.0%	34.2%	35.5%	35.5%	34.1%
	STEM Calculus 1	14.4%	24.8%	13.7%	6.5%	10.5%	20.6%	24.6%	21.5%	18.2%
	Higher Math	2.3%	5.3%	2.0%	4.3%	0.0%	4.4%	5.0%	4.4%	3.4%
	Non-STEM Calculus	0.6%	1.6%	0.9%	0.0%	0.0%	1.8%	2.0%	1.3%	1.2%
	Other Math	53.7%	36.2%	48.8%	54.3%	53.5%	39.0%	33.0%	37.2%	43.0%

Table H6. STEM Calculus 1 Throughput in Two Years by Race/Ethnicity and Starting Level for STEM Majors in the Calculus Pathway

		Race/Ethnicity																	
		African American		Asian		Hispanic		Native American		Pacific Islander		Two or More Races		Unknown		White		Total	
		n	TP%	n	TP%	n	TP%	n	TP%	n	TP%	n	TP%	n	TP%	n	TP%	n	TP%
Starting Level	Transfer-level Calculus Prep	692	25.1%	4,841	43.8%	12,083	26.1%	66	18.2%	78	19.2%	1,226	35.2%	401	32.7%	6,197	35.6%	25,584	32.2%
	STEM Calculus 1	227	61.2%	3,431	86.7%	3,972	69.9%	13	61.5%	29	69.0%	633	78.8%	185	79.5%	3,158	80.3%	11,648	78.1%
	Total	919	100%	8,272	100%	16,055	100%	79	100%	107	100%	1,859	100%	586	100%	9,355	100%	37,232	100%

Appendix I. Math Placement Policies and Practices in the California Community Colleges

Appendix I was added to the report in June 2024.

Overview of the Changing Landscape of Math Placement in California Community Colleges

Within the window of this study, math placement policies and practices in the California community colleges shifted over time in response to changes in California Education Code. While adhering to statewide regulation, colleges maintain local control over decisions involving math placement. Local placement criteria are not reported to the state Chancellor's Office and often this information is not publicly available on college websites. However, periodic survey-based studies have documented statewide trends and also significant differences in approaches to math placement across colleges (PPIC 2016, PPIC 2018).

Here are some highlights:

2012-2014: Passage of the 2012 Student Success Act motivated the Student Transcript-Enhanced Placement Study (STEPS). A joint project of the state's Chancellor's Office, Cal-PASS and The RP Group, STEPS worked with eleven colleges to implement and study the use of high school transcript data as a multiple measure in placement (The RP Group 2014).

2014-2015: Placement testing was prevalent. Different tests were in use across the system. For colleges using the same test, cut scores varied widely. Some colleges also used high school grade point average (HSGPA) as a multiple measure in math placement, allowing a student with a low test score but strong HSGPA to access higher levels of math (PPIC 2016).

2016-2017: The Multiple Measures Assessment Project (MMAP) developed math placement rules from an extensive decision tree analysis that identified measures predicting 70% course success. The rules for placement into STEM Calculus 1 included disjunctive use of HSGPA criteria, e.g., 11th grade HSGPA greater than 3.6 or (disjunctive) HSGPA of at least 3.2 with a C or better in high school Precalculus (MMAP 2016). These placement rules were part of the Common Assessment Initiative, a joint effort with the state Chancellor's Office, the Academic Senate of California Community Colleges, and The RP Group.

2018-2019: Assembly Bill 705 goes into effect. The law prioritized the use of high school transcript data as a multiple measure in placement, with students receiving the highest placement afforded by any one measure. Colleges are required to use self-reported academic records and guided self-placement when high school transcripts are unavailable. Placement must maximize the probability that a student completes transfer-level math within a year of first math attempt (AB 705).

2019-2020: AB 705 implemented systemwide. Placement testing discontinued (CCCCO 2019).

2023-2024: The 2022 passage of AB 1705 clarifies colleges' obligations to ensure that students begin math in transfer-level coursework that satisfies a requirement for their degree or transfer program, with well-defined exceptions. Preparatory courses that do not count toward degree or transfer requirements are an option for students who are highly unlikely to succeed if colleges can demonstrate that the delay improves students' chances of completing math requirements for their program (AB 1705). This report, in addition to local analyses provided by MMAP and the state Chancellor's Office to each college, is part of AB 1705 placement validation processes.

Access to STEM Calculus

During the timeframe of this study, students could have accessed STEM Calculus 1 as their first college math course in one or more of the following ways depending on a college's local practice and the cohort year.

- Placement testing (phased out systemwide by Fall 2019)
- Verification of precalculus completion with a transcript or self-reported
- Calculus placement based on high school GPA
- A guided self-placement process allowing access to STEM Calculus 1
- Concurrent enrollment in a corequisite to STEM Calculus 1 instead of a prerequisite
- A prerequisite challenge (in effect statewide 2012 – present): The criteria used in the evaluation of prerequisite challenges are set by Title 5 Section 55003(p), including an option for students to provide evidence that they have "the knowledge or ability to succeed in the course or program despite not meeting the prerequisite or corequisite." Implementation across colleges varies. For example, one college might only clear a prerequisite with an AP test score or prior college math coursework, while another college may interview students or consider factors other than math coursework, such as work experience or a student's own belief in her ability to succeed.

For this study, it was not feasible to examine math placement policies across colleges and across time to ascertain how students, particularly those with lower levels of high school math preparation, gained access to STEM Calculus as their first college math course in the California community college system. We also were not able to gather more detailed local placement records, if they existed, because student-level data was encrypted by our third-party data provider. We did not have social security numbers or college IDs. It is possible that a student participated in a prerequisite challenge process or other local mechanism to provide evidence of calculus readiness that was recognized by the college, e.g. the student completed additional math coursework after high school outside of the California community college (CCC) system before enrolling in Calculus at a CCC. It is also possible that the college's placement rules for Calculus included multiple measures, such as high school GPA, that permitted students with lower levels of math on their high school transcript to start in Calculus.

Two-Case Studies of Recent STEM Calculus Access at Colleges with Differing Approaches

After the culmination of this study, we gained direct access to CCCApply data for a later timeframe (2019-2020, 2020-2021, and Fall 2021). CCCApply is the application form for the California Community College system. Students self-report HSGPA and information about their high school math course-taking in CCCApply. We engaged two colleges willing to devote time to an investigation of additional local records pertinent to calculus placement during this period.

At the one college, the STEM Calculus 1 placement rule was a HSGPA of at least 3.3 or completion of precalculus/trigonometry with at least a C. A student meeting either criterion had access to STEM Calculus. This college also allowed students access to STEM Calculus 1 through a guided self-placement process. For this college, we identified a total of 227 students during the timeframe who started in STEM Calculus 1 without high school Precalculus or Trigonometry according to CCCApply. An institutional researcher at the college determined that the college cleared STEM Calculus enrollment for 159 (70%) based on HSGPA and for 30 (13%) through the guided self-placement process. The college could not locate further placement information for the remaining 38 students.

At another college, access to STEM Calculus required verification of completion of Precalculus or Calculus with a transcript, AP/IB test score, or self-reported high school information. For this college, we identified a total of 30 students who started in STEM Calculus without high school Precalculus or Trigonometry according to CCCApply. An institutional researcher at the college verified that all 30 students were cleared for Calculus enrollment by some mechanism offered by the college. Written records existed for only 8 of the 30 – seven with additional non-CCC math coursework and one with a qualifying IB test score. The rest, 22 of the 30, were probably cleared based on the e-form that gave students another opportunity to self-report their high school math.

Both colleges were following their local placement policies and practices. Both approaches were aligned with California Education Code at that time.