Preparatory Pathways and STEM Calculus Completion under AB 1705: An Aggregate Look at College-Level Reports

NOVEMBER 2024

Introduction

Assembly Bill 1705 (AB 1705) aims to improve calculus completion for students in Science, Technology, Engineering, and Math (STEM) programs across the California Community Colleges (CCC). The law sets new standards for placement and first math enrollment to ensure STEM students begin in transferable, college coursework that best positions them to complete calculus requirements for their programs (see sidebar). Each college must validate its local placement practices and enrollment patterns and make changes as necessary to achieve this goal.

To support this validation process, the California Community Colleges Chancellor's Office (CCCCO) partnered with The RP Group's Multiple Measures Assessment Project (MMAP) to provide each college with a short report that examined their students' persistence to and completion of calculus from various starting points in the STEM Calculus Pathway.[1] Colleges had the option of acting on the provided report or submitting additional data to validate their current practices.

This brief offers an aggregate look at these 115 college reports, following up on an earlier statewide analysis of more than 37,000 student records that applied the same validation standards.[2] College-level analyses provide an opportunity to verify statewide findings based on a more recent timeframe, a different set of criteria for grouping students based on high school

AB 1705 STEM Calculus Pathway Standards

For programs requiring STEM calculus, students start in calculus unless the college shows that all of the following are true:

- The student is highly unlikely to succeed in the first STEM calculus course without 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.

See California Education Code 78213 sections (c), (f), and (i).

[1] Sample college report

[2] Find a summary of the statewide descriptive analysis in *Preparatory Pathways and STEM Calculus Completion: Implications of the AB 1705 Standards*. The technical appendices also provide statewide statistical analysis with controls for some student and college characteristics.

accomplishments, and student information obtained through the centralized community college application (CCCApply), instead of high school transcripts.

Methodology

Each college report used data provided by the college to the Chancellor's Office Management Information System (COMIS) as well as data obtained from CCCApply. The analysis excluded students who did not report high school GPA or highest math course completed in CCCApply since they could not be assigned a placement profile.

The cohort for each local report included students at the college whose first California Community Colleges (CCC) math course was a transfer-level course in the STEM Calculus Pathway (i.e., College Algebra, Trigonometry, Precalculus, Calculus 1) in the academic years 2019-2020, 2020-2021 or fall 2021. The cohort excluded those who started in the summer term, were dually enrolled in high school, or who took preparatory work for calculus at a college elsewhere in the system.

Each local college report also examined students who declared a STEM major as a subset of the full cohort. Consistent with the statewide report, we identified STEM majors requiring STEM calculus using Common Course Identification System (C-ID) Transfer Model Curricula[3] and the following STEM-related Taxonomy of Programs (TOP) Codes: 1905.00, 0706.00, 0707.00, 0707.10, 0901.00, 1914.00, 1701.00, 1902.00, 0401.00, 4902.00.[4] The focus of this brief is STEM majors within each college report. The appendices contain parallel analyses for the full cohort.

Key Terms

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

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

Preparatory Courses: Transfer-level prerequisites to calculus, (e.g., College Algebra, Trigonometry, Precalculus).

STEM Calculus Pathway: Calculus 1 and its prerequisite transfer-level preparatory courses.

Calculus Throughput Rate: Also referred to as Calculus Completion Rate; the percentage of students who successfully complete (C or better) Calculus 1 or 2 within a given timeframe out of the count who started in a specified course in the calculus pathway.

The local college reports grouped students by the STEM Calculus Pathway placement levels defined by the CCCCO in February 2024.[5] Students with a higher placement profile had a high school grade point average (HSGPA) of 2.6 or greater and had passed high school precalculus or trigonometry with a grade of C or higher. The lower placement profile included everyone else, i.e., students with a HSGPA less than 2.6 and/or who did not pass high school precalculus or trigonometry.

[3] Common Course Identification System.

[4] California Community Colleges 2023 Taxonomy of Programs Manual.

[5] CCCCO memorandum on STEM Calculus Pathway validation under AB 1705. Local reports informed this guidance.

Each local college report provided cohort enrollment counts and Calculus 1 and 2 completion rates (throughput) for each course in the college's STEM Calculus Pathway by placement level, with students tracked for two years to determine Calculus 1 completion and three years to determine Calculus 2 completion, anywhere within the CCC. Biology majors were removed from the Calculus 2 throughput calculation because the Transfer Model Curricula for Biology requires only Calculus 1.

As part of the AB 1705 STEM Calculus Pathway validation process, colleges could submit their own analysis using a CCCCO template.[6] Colleges had the opportunity to define a local cohort by choosing a different timeframe (post fall 2019), identifying a subset of TOP codes relevant to their calculus-based STEM programs, restricting the analysis to declared STEM majors instead of all students enrolled in the STEM Calculus Pathway, or using local information not reported to COMIS to identify students' placement profiles (e.g., results of local prerequisite challenge or prerequisite equivalency processes). Four colleges submitted these alternative data, which were reviewed by the CCCCO. These additional data did not affect the analysis for this brief. All other colleges chose to act on the local college report provided by the CCCCO.

For the aggregate analysis presented in this brief, we give a descriptive summary of college-level results for STEM majors using the information provided in the college reports. Each local college report was tailored to the courses in the local STEM Calculus Pathway. Since these courses differ across colleges, for simplicity, we collapsed all preparatory courses into one category. We used the same two placement profiles used in the local college reports, which may not correspond to placement policies at the college. For each college, we calculated the following:

1. percentage of STEM majors by placement profile that began in Calculus 1 versus a preparatory course,
2. the two-year Calculus 1 throughput by starting level (Calculus 1 or preparatory course) for each placement profile and the difference in throughput rates, and
3. the three-year Calculus 2 throughput by starting level (Calculus 1 or preparatory course) for each placement profile and the difference in throughput rates.

To examine the degree to which colleges varied, for each placement profile and starting level, we ordered colleges from smallest value to largest and divided the list into quartiles. We made tables and box-and-whisker plots based on the minimum, the maximum, and quartile marks (25th percentile, 50th percentile, and 75th percentile).

[6] Data submission form for STEM Calculus Pathway validation

Key Findings from the College Reports

Calculus access (as measured by first math course attempted) varies widely across colleges for STEM majors with the same placement profile (Table 1 and Figure 1).

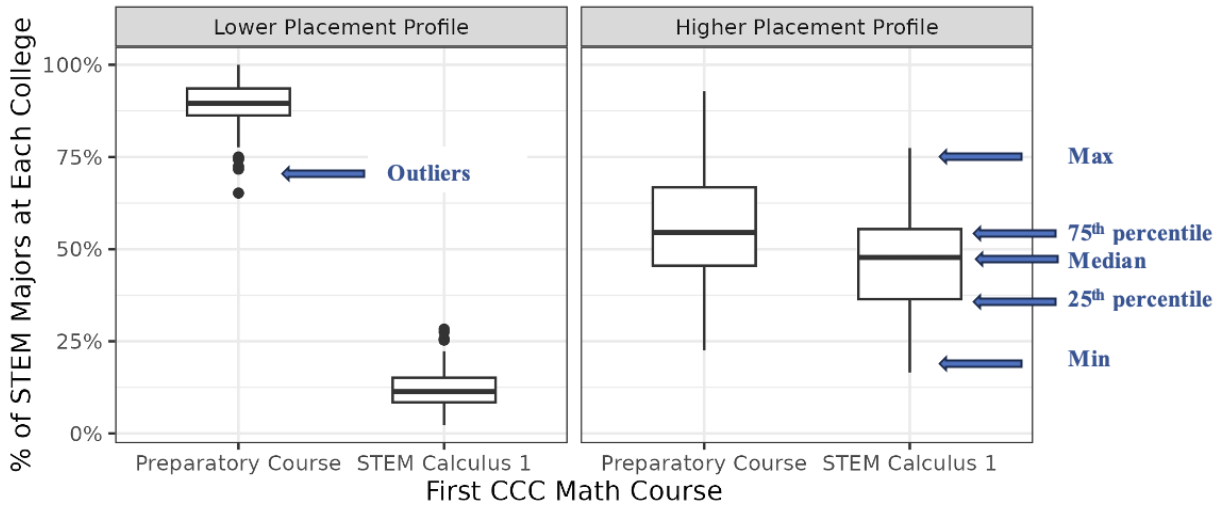
STEM majors with the same placement profile may or may not have started in Calculus 1, depending on the college they attended. To see how widely calculus access varied, for each placement profile, we ordered colleges based on the percentage of STEM majors starting in Calculus 1 and divided the colleges into quartiles. For example, the last row of the table gives the quartile marks for the percentage of STEM majors with a higher placement profile that started in Calculus 1 across 98 colleges. Between 17% and 36% of students with a higher placement profile started in Calculus 1 at the 25% of colleges in the first quartile (below the 25th percentile.) For the 25% of colleges in the fourth quartile (above the 75th percentile), between 55% and 77% of higher placement profile students started in Calculus 1.

Table 1. Percentage of STEM Majors by College by First CCC Math Attempted and Placement Profile (Table for Figure 1)

Placement Profile	First CCC Math Course	Number of Colleges	Percentage of STEM Students by College				
			Min	25th Percentile	Median	75th Percentile	Max
Lower Placement Profile	Preparatory Course	107	65%	86%	90%	94%	100%
	Calculus 1	69	2%	8%	11%	15%	28%
Higher Placement Profile	Preparatory Course	103	23%	46%	55%	67%	93%
	Calculus 1	98	17%	36%	48%	55%	77%

Cohort: California community colleges, fall 2019-fall 2021. Higher placement profile: HSGPA at least 2.6 and passed high school precalculus or trigonometry with a C or better. Lower placement profile: Everyone else. For each placement level, colleges with fewer than 10 STEM majors starting in a preparatory course or in Calculus 1 are omitted.

Figure 1. Percentage of STEM Majors by College by First CCC Math Attempted and Placement Profile



Calculus access varied widely across colleges for STEM majors with a higher placement profile. The percentage who began in Calculus I ranged from 17% to 77% across 98 colleges. At a typical college, represented by the median, less than half (48%) of higher placement profile students began in Calculus 1. Students with a higher placement profile who began in preparatory courses were repeating coursework that they successfully completed in high school, and this was common to varying degrees across 103 colleges, ranging from 23% to 93%, with a median of 55%.

Colleges were more consistent in their initial enrollment patterns for STEM majors with a lower placement profile. The percentage who began in preparatory work ranged from 65% to 100%, with a median of 90%. Yet, at 69 colleges, some STEM majors with a lower placement profile directly enrolled in calculus. At these colleges, between 2% and 28% started in calculus with a median of 11%.

Two-year Calculus 1 throughput rates varied substantially across colleges for STEM majors with the same placement profile and starting level (Table 2 and Figure 2).

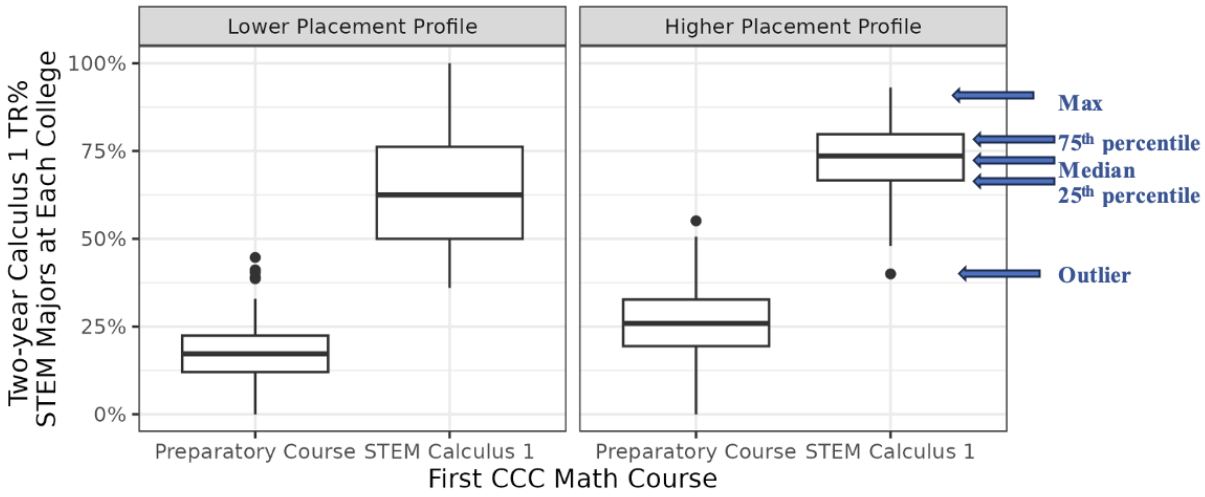
To see how much college outcomes varied, for each placement profile and each starting level (preparatory course or Calculus 1), we ordered colleges based on their two-year Calculus 1 throughput for STEM majors and divided the colleges into quartiles. For example, in the first row of the table, for students with a lower placement profile who begin in a preparatory course, 0% to 12% completed calculus within two years at colleges in bottom quartile (the 25% of colleges with the lowest throughput for this group).

Table 2. Two-Year Calculus 1 Throughput Rate (TR) by College, First CCC Math Attempted, and Placement Profile (Table for Figure 2)

Placement Profile	First CCC Math Course	Number of Colleges	Two-Year Calculus 1 Throughput Rate (TR) by College				
			Min	25th Percentile	Median	75th Percentile	Max
Lower Placement Profile	Preparatory Course	107	0%	12%	17%	22%	45%
	Calculus 1	69	36%	50%	63%	76%	100%
Higher Placement Profile	Preparatory Course	103	0%	19%	26%	33%	55%
	Calculus 1	98	40%	67%	74%	80%	93%

Cohort: California community colleges, fall 2019-fall 2021. Higher placement profile: HSGPA at least 2.6 and passed high school precalculus or trigonometry with a C or better. Lower placement profile: Everyone else. For each placement level, colleges with fewer than 10 STEM majors starting in a preparatory course or in Calculus 1 are omitted.

Figure 2. Two-Year Calculus 1 Throughput Rate (TR) by College by First CCC Math Attempted and Placement Profile



For STEM majors beginning in Calculus 1 with a higher placement profile, two-year completion rates across colleges varied widely, from 40% to 93%, with a median of 73%. **At colleges where some STEM majors with the lower placement profile started in Calculus 1, at no college was this subset of students highly unlikely to succeed when given two years,**[7] an observation that is relevant to the first AB 1705 standard governing calculus access. Two-year Calculus 1 throughput for calculus starters with a lower placement profile ranged from 36% to 100%, with a median of 63%.

Despite the variability in completion rates for calculus starters across colleges, preparatory coursework produced worse outcomes. For students with a higher placement profile who began in a course below calculus — the starting point for most students, calculus throughput averaged 26% (median) across colleges, with a range of 0% to 55%. In fact, at all but one college (102 of 103), the throughput rate for preparatory course starters with a higher placement profile was at most 50%, a rate exceeded by calculus starters with a lower placement profile at most colleges (52 of 69). These data suggest that for these better prepared students, repeating the preparatory coursework had a hindering effect on calculus completion.

Preparatory coursework was also a poor conduit to and through Calculus 1 for students with a lower placement profile. Two-year calculus completion rates ranged from 0 to 45%, with a median of 17%. These data suggest that current pathways are not effective in achieving their intended purpose of broadening access to and success in calculus for students with weaker high school preparation. If community colleges are to provide a true avenue into STEM for all students, colleges need to seek an alternative approach to fostering calculus-readiness that motivates students to persist and gives them the skills to succeed.

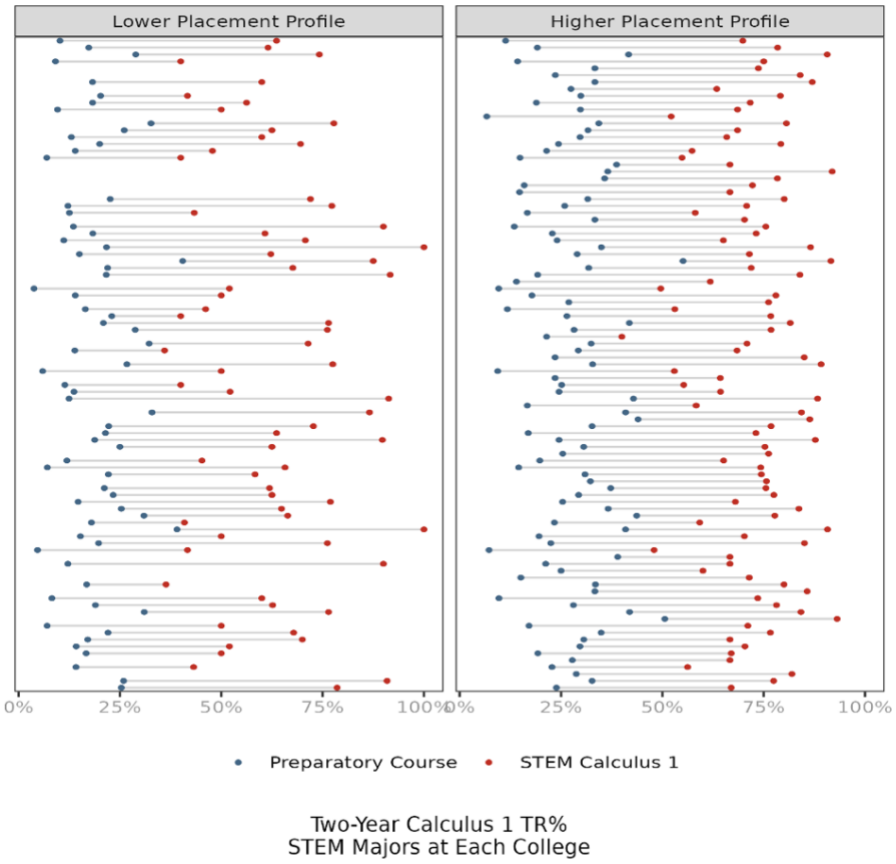
[7] For the first AB 1705 standard, the CCCCO has set a benchmark of a 15% as an operational definition of "highly unlikely to succeed."

Now we turn from looking at variability in outcomes across colleges to comparing throughput rates within each college for STEM students with the same placement profile who do or don't start in Calculus 1.

STEM students who started in STEM Calculus 1 were more likely to complete calculus after two years than those with the same placement profile who started in preparatory coursework at all colleges with samples of sufficient size for analysis, an observation that addresses the second AB 1705 Calculus Pathway placement standard (Figure 3, Table 4 and Figure 4).

In Figure 3, each line segment represents a college. With a blue dot at the two-year calculus throughput rate for students beginning in a preparatory course, and a red dot for the two-year calculus throughput rate for students beginning in Calculus 1. The length of the line segment shows the difference in throughput rates based on starting course. At every college, the two-year calculus throughput rate was lower for students starting in a preparatory course relative to students starting in Calculus 1, regardless of placement profile (lower or higher.)

Figure 3. Two-Year Calculus 1 Throughput Rates by College, Placement Profile, and Starting Level



Cohort: California community colleges, fall 2019-fall 2021. Higher placement profile: HSGPA at least 2.6 and passed high school precalculus or trigonometry with a C or better. Lower placement profile: Everyone else. For each placement level, colleges with fewer than 10 STEM majors starting in a preparatory course or in Calculus 1 are omitted.

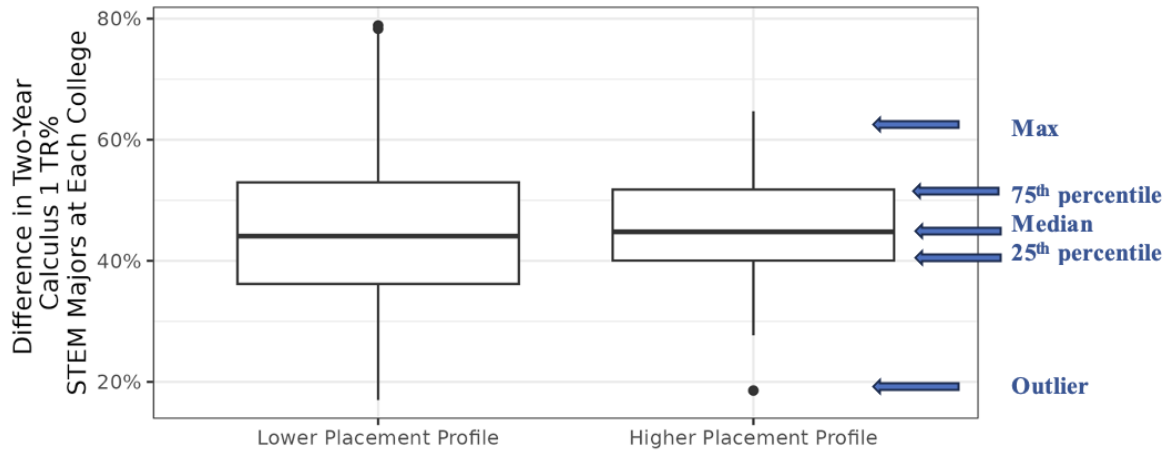
Table 4 and Figure 4 use the information from Figure 3. For each placement profile, we ordered colleges by the difference in two-year calculus completion rates (calculus starters minus prep course starters) and divided them into quartiles. Positive differences represent higher completion rates for students starting in Calculus 1. For example, for students with a higher placement profile, if a college had a two-year calculus completion rate of 50% for those starting in Calculus 1 and a 15% for those starting in a course below calculus, the difference is 35 percentage points. This college would be in the first quartile of the bottom row in the table (i.e., between min = 19% and 25th percentile = 40%).

Table 4. Difference in Two-Year Calculus 1 Throughput Rates (Calc 1 Starters minus Prep Starters) for STEM Majors by College and Placement Profile (Table for Figure 4)

Placement Profile	Number of Colleges	Difference in Two-Year Calculus 1 Throughput Rates (Calc Starters minus Prep Starters)				
		Min	25th Percentile	Median	75th Percentile	Max
Lower Placement Profile	69	17%	36%	44%	53%	79%
Higher Placement Profile	95	19%	40%	45%	52%	65%

Cohort: California community colleges, fall 2019-fall 2021. Higher placement profile: HSGPA at least 2.6 and passed high school precalculus or trigonometry with a C or better. Lower placement profile: Everyone else. For each placement level, colleges with fewer than 10 STEM majors starting in Calculus 1 are omitted.

Figure 4. Difference in Two-Year Calculus 1 Throughput Rate (Calculus 1 Starters minus Prep Starters), STEM Majors by College and Placement Profile



STEM majors who began in Calculus 1, regardless of placement profile, were much more likely to complete calculus at every college included in the analysis. On average, two-year calculus completion gains were large for calculus starters relative to students with the same placement profile who started in a course below Calculus 1. The median gain was for 45 percentage points (higher placement profile) and 44 percentage points (lower placement profile.) The gains seen at individual colleges varied widely but were substantial at every college in the analysis, ranging from 19 to 65 percentage points for students with a higher placement profile and 17 to 79 percentage points for students with the lower placement profile.

For each placement profile, Calculus 2 completion in three years was higher for STEM majors who started in Calculus 1 compared to those who started in preparatory coursework, an observation that addresses the third AB 1705 Calculus Pathway placement standard (Table 5 and Figure 5).

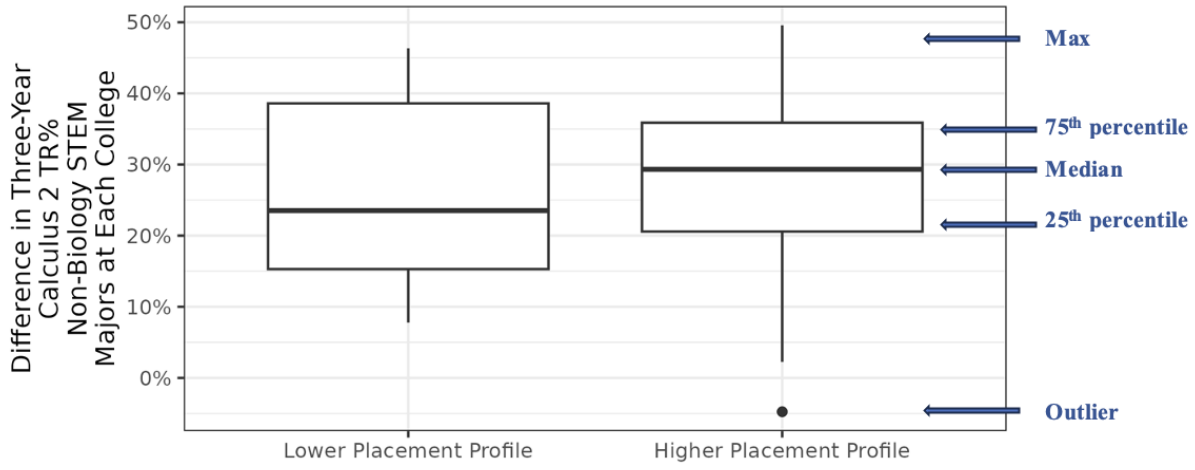
In Table 5 and Figure 5, positive differences represent higher three-year Calculus 2 completion rates for students starting in Calculus 1 relative to those starting in a preparatory course at the college. For example, for students with a higher placement profile, if a college had a three-year Calculus 2 completion rate of 30% for those starting in Calculus 1 and a 10% Calculus 2 completion rate for those starting in a course below calculus, the difference is 20 percentage points. This college would be in the first quartile of bottom row in the table (between min = –5% and 25th percentile = 21%).

Table 5: Difference in Three-Year Calculus 2 Throughput Rates (Calculus 1 Start minus Prep Start) for Non-Biology STEM Majors by College and Placement Profile (Table for Figure 5)

Placement Profile	Number of Colleges	Difference in Three-Year Calculus 2 Throughput Rates (Calculus 1 Starters minus Prep Starters)				
		Min	25th Percentile	Median	75th Percentile	Max
Lower Placement Profile	69	8%	15%	24%	39%	46%
Higher Placement Profile	95	-5%	21%	29%	36%	50%

Cohort: California community colleges, fall 2019-fall 2021. Biology majors excluded because the Transfer Model Curricula for Biology does not include Calculus 2. Higher placement profile: HSGPA at least 2.6 and passed high school precalculus or trigonometry with a C or better. Lower placement profile: Everyone else. For each placement level, colleges with fewer than 10 STEM students starting in Calculus 1 are omitted.

Figure 5. Difference in Three-Year Calculus 2 Throughput Rate (Calculus Start minus Prep Start) for Non-Biology STEM Majors by College and Placement Level



Local college reports showed Calculus 2 throughput rates were higher for students enrolled directly in Calculus 1 across placement profiles, with one exception (for students with a higher placement profile at one college, which was an outlier.) The median throughput gain across colleges was 29 percentage points for students with a higher placement profile and 24 percentage points for

students with a lower placement profile when compared to peers with the same placement profiles who began in preparatory coursework at the college.

Conclusion

AB 1705 contributes to a broader effort to improve STEM outcomes for California's community college students. **An aggregate look at college-level reports shows, at present, local curricular paths to STEM calculus are not optimal for calculus completion and therefore no college is currently meeting AB 1705 standards.**

These findings are consistent with the statewide analysis that used an earlier timeframe, different criteria for grouping students by high school achievement, and high school transcripts instead of data from the system's centralized college application. **Taken together, these analyses suggest that more students could make progress toward a STEM degree if they began directly in STEM Calculus 1, regardless of a lower or higher placement profile.** For students who want or need additional support, a shift from preparatory courses to targeted support concurrent with calculus enrollment addresses the high rates of attrition in the STEM Calculus Pathway and may make prerequisite skill development more relevant, and thus more interesting, to students.

As a final note, improvement in calculus outcomes will likely require a comprehensive approach. Colleges will need to pair AB 1705's focus on access and curricular structures with other efforts to redesign STEM students' math experiences inside and outside the classroom.

In the classroom, teaching matters, and research conducted on California community colleges suggests that in transfer-level math, it matters more than a student's academic preparation (Dadgar et al., 2023). Completion gains anticipated by the approach to calculus placement and support facilitated by AB 1705 can be amplified by faculty implementation of evidence-based teaching practices (Kim et al., 2024; Kramer et al., 2023, Watson et al., 2023, Kroeper et al., 2022).

Positive messaging, asset and strengths-based counseling, and wrap-around services will also play a vital role in realizing the promise of AB 1705 to improve STEM students' calculus outcomes. It will indeed take a village to ensure STEM students reach their highest potential.

Appendix A: All STEM Calculus Pathway Students

Local college reports also analyzed outcomes for all students whose first math enrollment was in the STEM Calculus Pathway, of which STEM majors were a subset. Tables in this appendix summarize college-level outcomes for all such students.

Cohort is California community colleges between fall 2019-fall 2021. When a disaggregated college cohort was fewer than 10 students, the college was removed from that part of the analysis. STEM Calculus 2 analysis was not done because it is not possible to identify students in the "all students" group who were in programs that require Calculus 2.

Higher placement profile: Students with HSGPA of 2.6 or greater who also passed HS precalculus or trigonometry with a C or better. Lower placement profile: Everyone else, i.e., students with HSGPA less than 2.6 and/or who did not pass HS precalculus or trigonometry with a C or better.

For each college, we calculated the following:

1. percentage of all students by placement profile that began in Calculus 1 versus a preparatory course,
2. the two-year Calculus 1 throughput by starting level (Calculus 1 or preparatory course) for each placement profile and the difference in throughput rates.

To examine the degree to which colleges varied, for each placement profile and starting level, we ordered colleges from smallest value to largest and divided the list into quartiles. We made tables based on the minimum, the maximum, and quartile marks (25th percentile, 50th percentile, and 75th percentile).

Table A1: Percentage of All Students Starting CCC Math in the STEM Calculus Pathway Students by College, Level of First CCC Math Attempted, and Placement Profile

Placement Profile	First CCC Math Course	Number of Colleges	Percentage of All Students Starting CCC Math in the STEM Calculus Pathway by College				
			Min	25th Percentile	Median	75th Percentile	Max
Lower Placement Profile	Preparatory Course	114	75%	89%	92%	95%	100%
	Calculus 1	110	1%	5%	8%	11%	25%
Higher Placement Profile	Preparatory Course	113	24%	51%	61%	73%	100%
	Calculus 1	112	9%	28%	39%	49%	76%

Interpreting Table A1: For example, in the last row of the table, between 9% and 28% of students with a higher placement profile started in Calculus 1 at colleges in the first quartile (the 25% of colleges with the smallest percentages of direct Calculus 1 enrollment for student with the higher placement profile.)

Table A2: Two-Year Calculus 1 Throughput Rates for All Students Starting Math in the STEM Calculus Pathway Students by College, Level of First CCC Math Attempted, and Placement Profile

Placement Profile	First CCC Math Course	Number of Colleges	Two-Year Calculus 1 Throughput Rate (TR) by College				
			Min	25th Percentile	Median	75th Percentile	Max
Lower Placement Profile	Preparatory Course	114	0%	8%	12%	17%	36%
	Calculus 1	89	30%	53%	63%	72%	100%
Higher Placement Profile	Preparatory Course	112	0%	13%	21%	26%	50%
	Calculus 1	105	36%	65%	71%	78%	91%

Interpreting Table A2: For example, in the first row of the table, for students with a lower placement profile who begin in a preparatory course, 0% to 8% completed calculus within two years at colleges in first quartile (the 25% of colleges with the lowest throughput for this group).

Table A3. Difference in Two-Year Calculus 1 Throughput Rates (Calc 1 Start minus Prep Start) for All Calculus Pathway Students by College and Placement Profile

Placement Profile	Number of Colleges	Difference in Two-Year Calculus 1 Throughput Rates (Calc Starters minus Prep Starters)				
		Min	25th Percentile	Median	75th Percentile	Max
Lower Placement Profile	89	26%	39%	49%	57%	82%
Higher Placement Profile	105	24%	44%	49%	56%	74%

Interpreting Table A3: For example, for students with a higher placement profile, if a college had a two-year calculus completion rate of 50% for those starting in Calculus 1 and a 15% for those starting in a course below calculus, the difference is 35 percentage points. This college would be in the first quartile of the bottom row in the table (i.e., between min = 24% and 25th percentile = 44%).

References

Dadgar, M., Riggs, S., Hodara, M., & Buck, D. (2023). *Counting on math faculty: Examining the role of faculty and instructional practices in students' gateway math success.* Education Equity Solutions. https://www.edequitysolutions.com/_files/ugd/7c1f86_ba5a5b4ad77b485396ab67079301d266.pdf

Kramer, L., Fuller, E., Watson, C.N., Castillo, A., Duran Oliva, P., & Potvin, G. (2023). Establishing a new standard of care for calculus using trials with randomized student allocation. *Science*. *381(*6661), 995-998. https://www.science.org/doi/10.1126/science.ade9803

Watson, C. N., Duran, P., Castillo, A., Fuller, E., Potvin, G., & Kramer, L. (2023). The supportive role of active learning in a calculus course on low precalculus proficiency students. *International Journal of Mathematical Education in Science and Technology*, 1–22. https://doi.org/10.1080/0020739X.2023.2255189

Kim, M. H., Han, J., Buford, K. N., Osterhage, J. L., & Usher, E. (2024). Undergraduate student perceptions of instructor mindset and academic performance: A motivational climate theory perspective. *Contemporary Educational Psychology, 77*, 102280. https://doi.org/10.1016/j.cedpsych.2024.102280

Kroeper, K. M., Muenks, K., Canning, E., & Murphy, M.C. (2022). An exploratory study of the behaviors that communicate perceived instructor mindset beliefs in college STEM classrooms. *Teaching and Teacher Education. 114*(5). https://doi.org/10.1016/j.tate.2022.103717