A Focus on Biology: An Extension of the Report *Preparatory Pathways and STEM Calculus Completion: Implications of the AB 1705 Standards*

Introduction

Research conducted by The RP Group's Multiple Measures Assessment Project (MMAP) and summarized in Preparatory Pathways and STEM Calculus Completion: Implications of the AB 1705 Standards found high rates of attrition along the path to calculus for students pursuing programs in Science, Technology, Engineering and Math (STEM). In this study of over 37,000 STEM students in the California Community Colleges (CCC), 70% began in a transferable, college math course below calculus, yet only 32% of those starting in one of these preparatory courses completed STEM Calculus 1 within two years.

The aforementioned report offered insights to help colleges respond to legislative mandates calling for data-based placement policies designed to improve calculus completion rates. These legal standards now require colleges to provide evidence that their STEM students begin in the math coursework that best positions them to complete the calculus requirements for their programs of study.

Since California law also requires community colleges to use high school transcript data as the primary means of placement, the analyses examined STEM Calculus throughput from various starting points in the college curriculum and grouped STEM students by high school grade point average (GPA) and level of math preparation. Within each group, a consistent pattern emerged: STEM Calculus 1 throughput was highest for students who directly enroll in Calculus 1 and progressively lower for students starting in Precalculus, Trigonometry, and College Algebra.

Key Terms

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

Direct Enrollment: student's first math enrollment in the California community college system, not necessarily in the freshman year.

STEM Calculus 1 Two-Year Throughput: proportion of the cohort starting in a specified course in the calculus pathway (College Algebra, Trigonometry, Precalculus, or STEM Calculus 1) who successfully completed, with a C or better, STEM Calculus within two years.

Preparatory Course: A transfer-level math course required in the path to STEM Calculus 1 that may include College Algebra, Trigonometry, or Precalculus.

This brief provides a follow-up to the initial report with a particular focus on students in biology majors. Our goal is to determine if the original report underestimated calculus completion rates for certain biology majors because their programs of study allowed for a different form of calculus. For example, even though STEM Calculus is the gateway requirement for most STEM majors, some California State University (CSU) biology programs allow for applied calculus courses, and a few permit precalculus to satisfy biology degree requirements.[1]

This brief provides a short overview of additions to the original methodology, followed by key findings that address questions about the applicability of the original research when we examine biology majors separate from other STEM majors.

Methodology

MMAP disaggregated the cohort used in the statewide analysis of all STEM majors in the original research, separating biology majors and non-biology majors. We identified biology majors by TOP codes 0401.00 (General Biology) and 4902.00 (Biological and Physical Sciences and Mathematics). As an additional check, we re-examined TOP codes related to biology excluded from the original analyses, using the TOP Code Handbook, the Chancellor's Office DataMart, Chancellor's Office Curriculum Inventory (COCI), and college catalogs. Our review confirmed that some colleges used biology-related TOP codes other than 0401.00 and 4902.00 to describe local certificate or associate degree programs with math requirements other than courses in the calculus pathway. For more information on the original methodology, see the report for an overview, and the technical appendices for more details.

We also reran the regression analysis developed for the main report adding a variable to identify biology majors. The models included controls such as (1) first CCC math course enrolled; (2) highest high school math completed; (3) high school GPA; (4) years between high school and community college enrollment; (5) first math enrollment pre- and post-AB 705; (6) student demographics (i.e., race/ethnicity, gender); and (7) EOPS status. For a discussion of the regression models, see the technical appendices.

[1] Using ASSIST.org, we examined lower division math requirements for all general biology BA and BS degrees and all biology-related concentrations offered in the CSU. Of the 65 programs examined, 57 required some form of calculus, five had requirements that students could meet with a preparatory course in the calculus pathway, and three required only statistics.

Key Findings

When we examine outcomes for biology students separately from other STEM students, the STEM Calculus 1 throughput patterns align with the original analysis for all STEM students.

Two-year throughput for STEM Calculus 1 is highest with direct enrollment into Calculus and progressively lower for biology majors starting in Precalculus, Trigonometry, and College Algebra (Table 1).

Table 1. STEM Calculus 1 Two-Year Throughput Rates (TR%) for Biology vs Other STEM Majors by First College Math Course Attempted

First CCC Math	Biology Majors			Other STEM Majors		
	Completed	Cohort	TR%	Completed	Cohort	TR%
College Algebra	451	2,921	15.4%	546	2,507	21.8%
Trigonometry	1,140	4,408	25.9%	1,627	5,081	32.0%
Precalculus	1,827	4,810	38.0%	2,652	5,857	45.3%
STEM Calculus 1	3,431	4,470	76.8%	5,669	7,178	79.0%
Total	6,849	16,609	41.2%	10,494	20,623	50.9%

Cohort: Students with initial math enrollment in 2012-2013 through 2019-2020, excluding students whose first math enrollment was in summer, tracked for two years.

The same STEM Calculus 1 throughput pattern occurs across the levels of high school math preparation for biology students and for other STEM students. For both groups, the two-year throughput for STEM Calculus 1 is highest with direct enrollment into STEM Calculus 1 and progressively lower for students starting college math in Precalculus, Trigonometry, and College Algebra (Table 2).[2]

Table 2. STEM Calculus 1 Two-Year Throughput Rates (TR%) for Biology vs. Other STEM Majors, Disaggregated by High School Math Preparation and First College Math Course

Highest HS Math	First College Math Course Attempted															
	College Algebra				Trigonometry				Precalculus				STEM Calculus 1			
	Biology Majors		Other STEM Majors		Biology Majors		Other STEM Majors		Biology Majors		Other STEM Majors		Biology Majors		Other STEM Majors	
	Cohort	TR%	Cohort	TR%	Cohort	TR%	Cohort	TR%	Cohort	TR%	Cohort	TR%	Cohort	TR%	Cohort	TR%
Geometry or lower	487	7.4%	336	13.1%	453	11.9%	562	18.0%	361	27.7%	439	30.3%	87	**67.8%**	143	**58.0%**
Algebra 2	944	12.5%	845	16.9%	1,370	20.4%	1,611	26.7%	1,216	33.2%	1,410	40.3%	367	**69.8%**	616	**67.9%**
Statistics	297	16.8%	276	25.0%	527	26.6%	482	34.0%	433	35.6%	467	47.8%	175	**68.0%**	246	**77.6%**
Precalculus/Trig	752	22.5%	649	28.2%	1345	30.9%	1,577	37.2%	1,851	40.4%	2,258	46.5%	1,813	**71.4%**	2,690	**74.6%**
Calculus	264	23.5%	244	31.6%	511	40.3%	583	49.1%	739	47.5%	999	56.7%	1,925	**84.9%**	3,313	**86.1%**
Missing Some HS Math Data	177	9.0%	157	19.1%	202	22.3%	266	22.6%	210	33.8%	284	39.4%	103	**66.0%**	170	**69.4%**
Total	2,921	15.4%	2,507	21.8%	4,408	25.9%	5,081	32.0%	4,810	38.0%	5,857	45.3%	4,470	**76.8%**	7,178	**79.0%**

Cohort: Students with initial math enrollment in 2012-2013 through 2019-2020, excluding students whose first math enrollment was in summer, tracked for two years.

[2] 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). See Appendix I in the June 2024 update of the main report for an overview of math placement and calculus access policies across the 115 California community colleges and across the cohort years for this analysis.

With regression controls, the typical Biology student has better odds of completing STEM Calculus in two years if the student begins in that course.

For both the typical STEM student majoring in biology or in a non-biology program, preparatory courses are associated with lower predicted probabilities of STEM Calculus completion across the different levels of high school math preparation.

Figures 1A and 1B show the typical STEM student's predicted probability of completing STEM Calculus in two years with regression controls. The typical STEM student is a Hispanic male with a high school GPA of 3.1.[3] Figure 1A estimates throughput for the typical STEM student who is a biology major. Figure 1B estimates throughput for the typical STEM student who is in a non-biology STEM major.

Figure 1. Predicted Two-Year Throughput for STEM Calculus 1 for a Typical STEM Student (Hispanic Male with a 3.1 High School GPA), Disaggregated by High School Math Preparation and First College Math Course, with Regression Controls.

Figure 1A. Biology Student

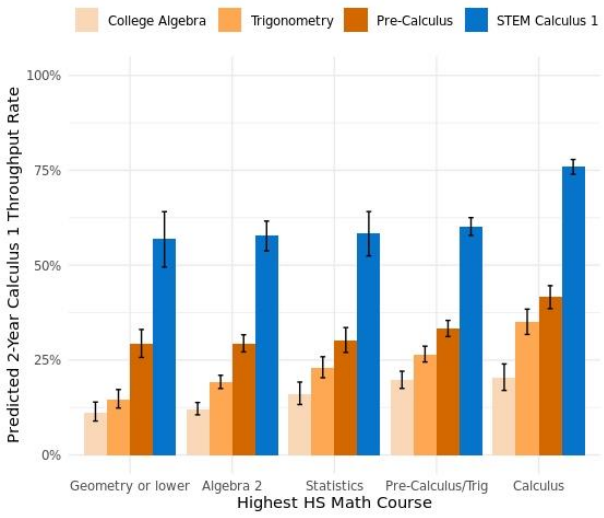
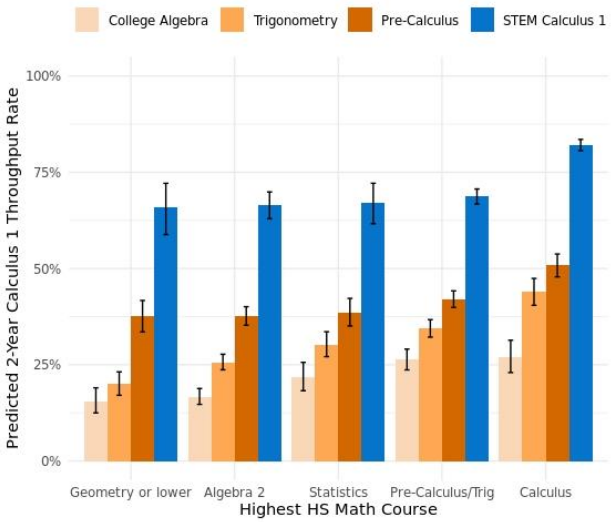


Figure 1B. Non-Biology STEM Student



Note: Vertical lines represent the 95% confidence interval for the predicted throughput. When holding all else constant, the typical biology student is predicted to have slightly lower two-year STEM Calculus throughput rates (significant at $p < 0.05$) than the typical non-biology STEM student.

[3] The regression models predict two-year STEM Calculus throughput by race and gender. This approach is used by Bahr et al. (2008). Does mathematics remediation work?: A comparative analysis of academic attainment among community college students. *Research in Higher Education*, *49*, 420-450. In our cohort, the largest racial/ethnic group is Hispanic, and males are more prevalent than females. The average high school GPA for the cohort was 3.1.

When two-year throughput includes all forms of calculus (STEM and applied), throughput rates increase by a few percentage points for biology students, but the patterns remain consistent with the original findings for all STEM students (Table 3).

Table 3. Two-Year Throughput Rates (TR%) for All Forms of Calculus 1 (Applied Calculus 1 and STEM Calculus 1) among Biology Majors by First College Math Course Attempted

First CCC Math	Completed Applied or STEM Calculus in 2 Years	Cohort	TP %
College Algebra	542	2,921	18.6%
Trigonometry	1,222	4,408	27.7%
Precalculus	1,902	4,810	39.5%
Applied Calculus	386	536	72.0%
STEM Calculus 1	3,459	4,470	77.4%
Total	7,511	17,145	43.8%

Cohort: Students with initial math enrollment in 2012-2013 through 2019-2020, excluding students whose first math enrollment was in summer, tracked for two years.

Conclusion

In California's community colleges, biology students experience low calculus completion rates when starting in preparatory coursework in the calculus pathway. Across all levels of high school math preparation, Calculus throughput was highest for biology students who directly enrolled in Calculus and progressively lower for students starting in Precalculus, Trigonometry, and College Algebra. This trend mirrors the findings from the original analysis for all STEM students. The consistency in this pattern suggests that the **structure of a college's preparatory pathways influences Calculus throughput for biology majors** as well as other STEM majors. STEM students who need or desire additional preparatory skill development **may be better served by directly enrolling in Calculus with concurrent, corequisite support**.