INTEGRAL VOICES:
EXAMINING MATH EXPERIENCES OF UNDERREPRESENTED STUDENTS

By Elisha Smith Arrillaga, Shakiyya Bland,
Katrina Goto, and Marcelo Almora Rios

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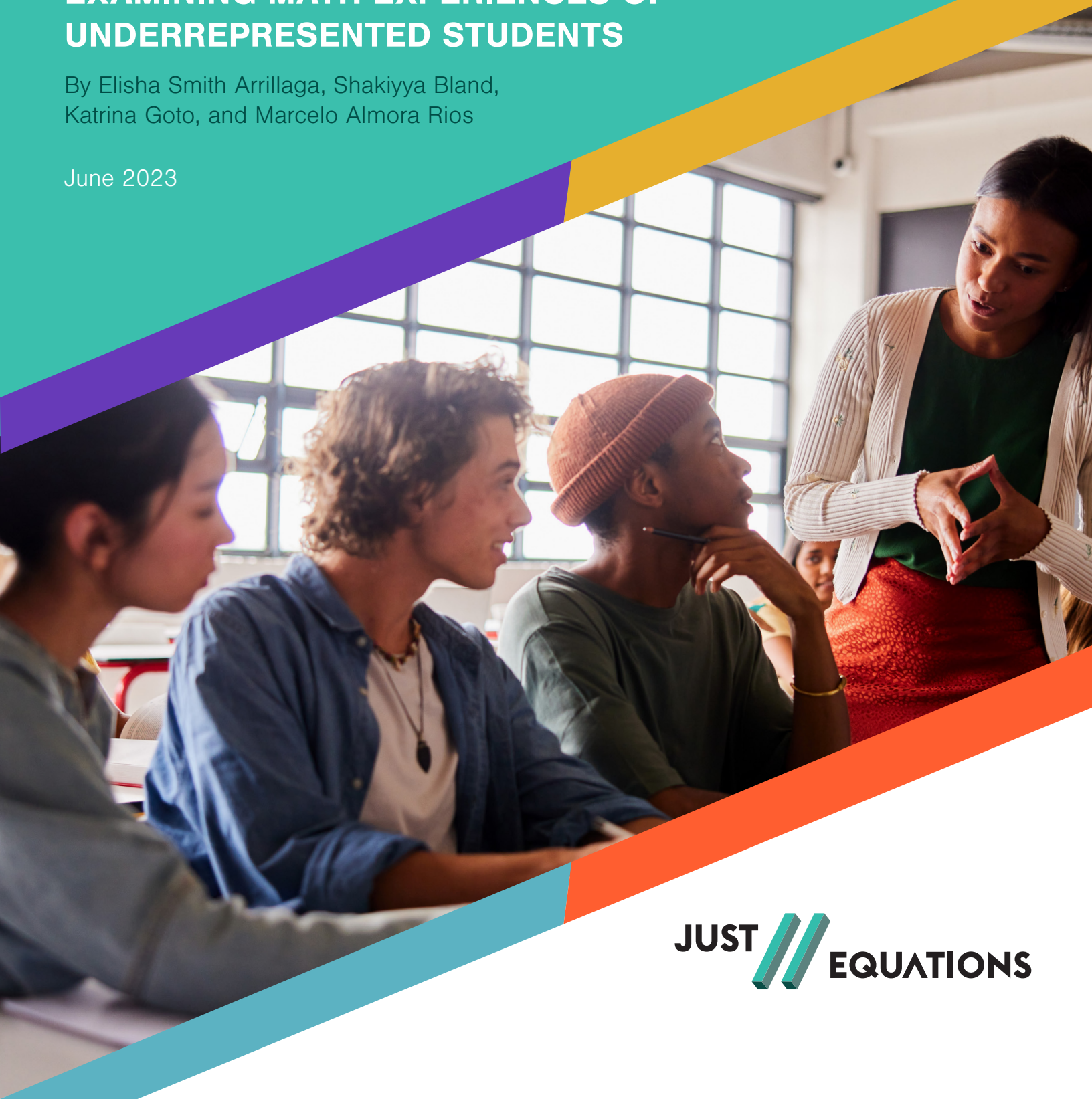

JUST // EQUATIONS

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ABOUT JUST EQUATIONS

Just Equations reconceptualizes the role of mathematics in ensuring education equity for students. An independent resource on the equity dimensions of math education in the transition from high school to college, Just Equations advances evidence-based strategies to ensure that math policies give all students the quantitative foundation they need to succeed in college and beyond. Just Equations' work is supported by College Futures Foundation, the Bill & Melinda Gates Foundation, and Valhalla Foundation.

ABOUT THE AUTHORS

Elisha Smith Arrillaga, a faculty member at the College of Education at the University of Texas at Austin, has served in numerous leadership roles to increase education and workforce opportunities for students of color. Most recently, as the managing director of the Charles A. Dana Center at UT Austin, she led work to change K–12 and postsecondary math education policy in more than 35 states. She oversaw several statewide research and advocacy initiatives as the executive director of the Education Trust–West. Smith Arrillaga holds a B.A. in mathematics from Smith College, an M.S. in survey methodology from the University of Maryland at College Park, and a Ph.D. from the Princeton School of Public and International Affairs. She has taught at both the K–12 and postsecondary levels.

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Katrina Goto, a program associate at Just Equations, graduated from the University of California, Berkeley with high distinction and highest honors in 2022. Goto was a finalist for the Political Science Departmental Citation, a William K. (Sandy) Muir Jr. Leadership Award nominee, a University Medal nominee, and a Phi Beta Kappa inductee. During her senior year, Goto was accepted into UC Berkeley's Political Science Department Honors Program. Her thesis examined support for holistic college admissions among Asian Americans.

Marcelo Almora Rios, a research fellow at Just Equations, recently completed an M.A. in the Department of Mathematics at the University of Montana. He has supported students in mathematics in many roles, including as a graduate student instructor. Almora Rios' research interests lie at the intersection of math education, psychology, and philosophy. A Peruvian immigrant and first-generation college student, Almora Rios is the recipient of a 2023 National Science Foundation Graduate Research Fellowship and a 2020 Latinos in Technology scholarship.

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EXECUTIVE SUMMARY

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High school and college students make a multitude of academic choices that are consequential to their postsecondary education and career trajectories. Among those choices, selecting which mathematics courses to take in high school has significant implications for a student's opportunity to attend college, as well as to pursue a STEM major. For students applying to college, access to accurate information about the college admissions process is a critical determinant of their math course choices.

Although many new careers and college majors require preparation in areas of mathematics such as data science and statistics, calculus still dominates as a signal of academic rigor. Leading math associations have challenged this messaging. They argue that pressure to rush through the math curriculum to reach calculus can undermine development of foundational math skills and increase educational stratification. However, when it comes to college admissions, some students receive the message that they need to take AP Calculus—as one student said, "just so colleges would see that you're competitive."

Mixed messages concerning colleges' math expectations can create a confusing landscape for students and families to navigate. As prior Just Equations reports have shown, the lack of clear signals from admissions offices may disproportionately create barriers for Black, Latinx, and other underrepresented students, reinforcing inequitable access to the most selective institutions. This report examines the perspectives of underrepresented students on the role of high school math in college admissions to shed light on the processes, policies, and strategies that help or hinder students in preparing for college success.

ABOUT THIS REPORT

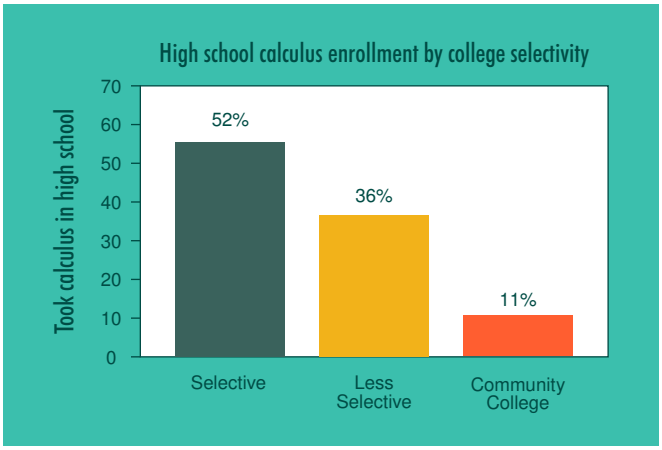
The first two reports in this series examined the perspectives of admissions officers and high school counselors. This report provides insight into how students interpret the advice and information they receive from high school teachers, counselors, and college admissions officers about the role of mathematics in college planning. Its focus is on students who are historically underrepresented in higher education, particularly Black and Latinx students, and those who are low income or in the first generation of their family to attend college.

For this report, Just Equations partnered with the Southern California College Attainment Network through its Let's Go to College California project and with the National Association for College Admission Counseling. A survey and set of focus groups conducted with Let's Go to College California allow a deep dive into students' decision-making, and a NACAC survey adds a national perspective. The vast majority of students in the Let's Go to College California sample met our definition of underrepresented and/or first generation. About three-quarters were Latinx, and a similar proportion said their parents don't have college degrees. The students were predominantly enrolled in California public institutions, and 47 percent reported plans to major in STEM.

ACCESS TO HIGH SCHOOL MATH COURSES

Calculus in high school is an important stepping stone to STEM fields. And some selective colleges expect it even for non-STEM students. However, **high school calculus enrollment is limited to a small number of students**, correlating starkly with socioeconomic status and race.

When students attend a high school that offers calculus and they plan to attend college, do they take calculus? In the NACAC poll, nearly 75 percent of students report that calculus was offered at their high school. However, just 45 percent of students report having taken the course. In the Let's Go to College California sample, with its higher proportion of underrepresented students, 84 percent of students report that calculus was offered by their high school, but only 37 percent report taking the course. Students who currently attend the most selective colleges were more likely to say they took calculus in high school.



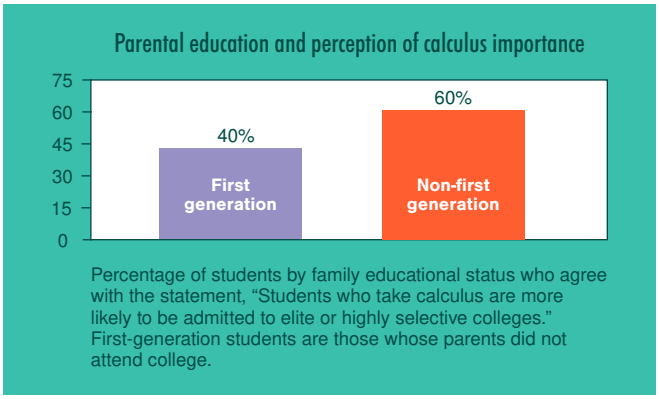
Tracking, in which students are sorted into low- and high-level classes, often based on a perception of student ability, influences whether students make it to calculus. Many students in the sample were not on track to take calculus in their senior year because they started ninth grade taking algebra or pre-algebra. Others said they had difficulty taking calculus because their high schools didn't offer it or had limited sections.

STUDENT BELIEFS ABOUT COLLEGE EXPECTATIONS

Gaps in access to information about college preparation and the admissions process are correlated with traditional barriers to college, namely low socioeconomic status, first-generation status, and membership in racial or ethnic groups historically underrepresented in higher education. Compared to public high schools, private high schools allocate more resources to assist students in the college selection and application process. And, even among public schools, students in higher-income communities have better access to such services than those in lower-income ones. Such disparities diminish the ability of students to base decisions on the best possible information. **Students who do not know that colleges may prioritize calculus could be at a disadvantage in the admissions process.**

When students were asked which math courses are most important to colleges, the majority (67 percent) chose calculus. Statistics ranked second at 40 percent. Students majoring in STEM were more likely to choose calculus than other students.

Nearly half of students (45 percent) said they believed that students who take calculus are more likely to be admitted to highly selective colleges. STEM majors (49 percent) were more likely than non-STEM majors (41 percent) to agree that a calculus course enhances a student's chance of being admitted to college. Unlike students whose parents attended college, the majority of first-generation students did not believe that students who take calculus are more likely to be admitted to highly selective colleges.



Percentage of students by family educational status who agree with the statement, "Students who take calculus are more likely to be admitted to elite or highly selective colleges." First-generation students are those whose parents did not attend college.

In focus group discussions, many students exposed the information disconnects that may have disadvantaged them during the college admissions process. Some students said they received coursetaking information too late for it to be helpful for college planning, or that they were not given input on decisions about which courses to take. "I did not even know I could choose or change my classes until senior year of high school," one student said. In some cases, students felt pressure to take math classes over the summer in order to get to calculus. "There was like this major rush to get into AP Calculus like your junior year," one student recalled.

STUDENT PERCEPTIONS OF COUNSELORS' ADVICE

About half the students said their high school counselors recommended they take calculus. Fifty-three percent said that one reason they chose their high school math coursetaking was that they believed it would help them get into college.

However, **there is clear stratification by racial group in math coursetaking recommendations**. Asian American respondents report receiving recommendations to take calculus courses at a higher rate than other racial groups—61 percent, compared to 41 percent of Black respondents, 50 percent of White respondents, and 52 percent of Latinx respondents. A similar pattern emerged in the NACAC poll: 54 percent of Asian American respondents said they were recommended to take calculus, compared to 45 percent of Hispanic, 42 percent of White and 36 percent of Black students.

Furthermore, more than one-third of Black respondents (38 percent) and more than one-quarter of Latinx respondents (27 percent) report not receiving recommendations to take any advanced math course by their high school counselor, while only 21 percent of Asian American respondents and 18 percent of White respondents report no math course recommendation.

Such patterns may reflect racial differences in students' prior math preparation, but they also raise questions about the consistency of the advice provided by counselors. Discrepancies in which students are advised to take calculus or other advanced math courses may have significant repercussions for equitable college access.

STUDENT PERCEPTIONS OF THE ADMISSIONS PROCESS

Students express concern about colleges emphasizing a course that isn't universally accessible. In the NACAC survey, 76 percent of surveyed students agreed, "It is unfair for colleges to prioritize courses not offered in many high schools." But colleges that do prioritize calculus are not always transparent about it, which is also unfair. When colleges tell students to take the most rigorous courses available, do they mean calculus? Though many colleges say they evaluate students' transcripts in the context of courses available to them, a lack of clear information appears to loom large for students. In our survey, students, particularly Latinx students, ranked lack of "access to information about college admissions" as the biggest hurdle in the college application process.

LOOKING AHEAD

The absence of clearly identified math expectations may serve to reinforce inequities in who is represented at the most competitive institutions, with fewer Black, Latinx, and first-generation students enrolling. It also has repercussions for the math sequences high schools offer.

New policies and practices are needed to ensure that students, their families, and their counselors have the information necessary to make good decisions about math coursetaking in high school and for college access. The student perspectives described in this report point to the following recommendations.

Adopt broader, more transparent math requirements for admission. Colleges and universities should broaden the range of math courses they accept for admission and communicate those policies transparently. Institutions should also review any requirements they have for a specific high school course, such as calculus, to determine whether they are essential for success at the college or in particular majors. Furthermore, students' records should be considered in the context of the courses available to them, so that they aren't penalized for not having access to specific courses.

Increase access to counseling and support. States, districts, and other funders should invest more in school counseling, particularly in lower-resourced schools that serve students of color, first-generation students, and students from low-income backgrounds. To ensure students receive the support needed to promote college access, the number of counselors should be increased to meet the American School Counselor Association's minimum recommended student-to-counselor ratio of 250-to-1.

Engage college-access organizations. State education departments, districts, and other funders should support college-access organizations to help ensure that all students are receiving appropriate information about their math coursetaking options and alignment with college admissions. Students in our survey frequently mentioned college-access organizations, which often work with students in lower-resourced schools, as trusted sources of information concerning college admissions.

Adopt more equitable K–12 course-enrollment policies. So that students don't reach high school off track for college preparation, states, districts, departments, and schools should enact more equitable course-placement policies. The National Council of Teachers of Mathematics has also promoted the principle of "appropriate acceleration," to de-emphasize the practice of rushing students through math sequences regardless of whether they've mastered foundational concepts.

INTEGRAL VOICES:
EXAMINING MATH EXPERIENCES OF UNDERREPRESENTED STUDENTS

High school and college students make a multitude of academic choices that are consequential to their postsecondary education and career trajectories. Among those choices, selecting which mathematics courses to take in high school has significant implications for a student's opportunity to attend college, as well as to pursue a STEM major (Guo et al., 2015; Jiang et al., 2020; Maltese & Tai, 2011). For students applying to college, access to accurate information about the college admissions process is a critical determinant of their math course choices. Such decisions are influenced by students' personal circumstances, their interests and aspirations, and the course options available to them, which can vary widely. To make these course-planning decisions with far-reaching implications, students and their families rely on information from high school teachers, school counselors, admissions officers, and other college-access professionals.

Although many new careers and college majors require preparation in areas of mathematics such as data science and statistics, calculus still dominates as a signal of academic rigor (Anderson & Burdman, 2022). Leading math associations have challenged this messaging. They argue that pressure to rush through the math curriculum to reach calculus can undermine development of foundational math skills and increase educational stratification (Mathematical Association of America & National Council of Teachers of Mathematics, 2022; National Council of Teachers of Mathematics, 2018; National Research Council, 2013). The vast majority of students who take high school calculus either repeat calculus when they get to college, enroll in a lower-level course, or take a course such as statistics that doesn't require them to know calculus (Bressoud, 2017, p. 5). The Mathematical Association of America and National Council of Teachers of Mathematics noted in a 2022 statement,

> *A high school calculus course should not be the singular end goal of the PK–12 mathematics curriculum at the expense of providing a broad spectrum of mathematical preparation.*

However, as Just Equations learned in a set of focus groups, when it comes to college admissions, some students receive an altogether different message. As one student said,

> *It was like an unstated rule. … If you wanted to go to a good college later on, you would have had to take AP Calculus early on, just so colleges would see that you're competitive.*

Mixed messages concerning colleges' math expectations can create a confusing landscape for students and families to navigate. As prior Just Equations reports have shown, the lack of clear signals from admissions offices may disproportionately create barriers for Black, Latinx, and other underrepresented students, reinforcing inequitable access to the most selective institutions. Few institutions treat calculus as an outright requirement, but many admissions officers say they favor students who have taken the course (Anderson & Burdman, 2022). For students wishing to attend selective institutions, high school counselors say they overwhelmingly advise taking four years of high school math courses, including a year of calculus (Burdman & Anderson, 2022). High school counselors are more likely than admissions officers to emphasize calculus. In surveys, 93 percent of high school counselors said calculus gives students an edge in admissions, but only 53 percent of admissions officers said the same (Burdman & Anderson, 2022, p. 17).

Though some admissions offices have broadened the range of math courses they accept, most high schools still emphasize the traditional math curriculum. Not all students have access to rigorous high school math courses aligned with their interests, which further complicates any analysis of why students take the courses they do. Because of practices like tracking, in which students are sorted into low- and high-level classes, often based on a perception of student ability, advanced math courses may be unavailable to some students, particularly underrepresented students (Lawyers' Committee for Civil Rights of the San Francisco Bay Area, 2013; National Council of Teachers of Mathematics, 2018). Studies have found that tracking exacerbates educational inequity (Francis & Darity, 2021; Irizarry, 2021; National Council of Teachers of Mathematics, 2018; Patrick et al., 2020).

Such disparities influence students' readiness for college. Thirty-eight percent of colleges and universities require applicants to have four years of math, and all but 12 percent require at least three years of math (Anderson & Burdman, 2022, p. 7). Certain majors require specific preparation, and, as of 2015–16, only 38 percent of high schools with high Black and Latinx student enrollment offered the mathematics content required for admission into most STEM disciplines (U.S. Department of Education, Office for Civil Rights, 2018, p. 5). Students at the remaining high schools could not access the necessary courses without enrolling in a college course. While many admissions offices use a holistic process that considers the courses available to applicants, such reduced access could nevertheless diminish a student's chances of attending a selective institution.

ABOUT THIS REPORT

This is the third in a series of reports by Just Equations that examine the role of math in college admissions. The first report, *A New Calculus for College Admissions*, explores four-year college and university admissions policies and unwritten practices concerning high school math coursetaking based on a survey and a set of interviews with admissions professionals. The second, *Calculating the Odds*, analyzes high school counselors' interpretations of these expectations and their coursetaking recommendations to students, also through a survey and interviews. This report looks at the student experience, providing insight into how students, especially underrepresented students, interpret the advice and information they receive from high school teachers, counselors, and college admissions officers about the role of mathematics in college planning.

Specifically, this report explores college-bound students' awareness of the range of math courses available, how those students make decisions regarding high school math course enrollment, and the implications of those choices for college admissions. Its focus is on students who are historically underrepresented in higher education, particularly Black and Latinx students, and those who are low income or in the first generation of their family to attend college. The goal is to shed light on the processes, policies, and strategies that help or hinder students in selecting math courses that prepare them for success in college, including the high school counseling practices that can support equitable preparation and college access.

For this report, Just Equations partnered with the Southern California College Attainment Network (SoCal CAN), an alliance of 118 college-access organizations supporting students in the Los Angeles region through its Let's Go to College California project, a student-led virtual hub of college resources, and with the National Association for College Admission Counseling, an organization of professionals guiding students in the transition from secondary to postsecondary education. A survey and set of focus groups conducted with Let's Go to College California allow a deep dive into how counseling practices support the decision-making of first-generation and other underrepresented students, and a NACAC survey adds perspectives from a national sample of students.

The report advocates for college admissions offices to broaden their math expectations to allow for relevant, mathematically rigorous courses such as statistics, not just calculus, and to publish more transparent requirements and preferences. At the same time, the report calls for increasing access to advanced math courses, including calculus, data science, and statistics, and thereby access to STEM, for historically underrepresented students.

METHODOLOGY

A 29-item Google Forms survey was conducted via a link on Let's Go to College CA's Instagram page, yielding 290 valid responses from current college students ages 18–23.

The responses were collected over the span of three weeks in January and February 2023. They were then used in a multivariate analysis, performed primarily using the pandas Python library. Students affiliated with Let's Go to College CA were invited to participate in one of four 50-minute virtual focus groups. Participation was not contingent upon completing the survey. Sixty-three students participated in the focus groups, which were facilitated by Just Equations researchers. These conversations provided more contextual information about how students access college counseling information and on their perspectives about the role of mathematics in college admissions. All audio recordings were transcribed and a thematics analysis was performed using the transcripts.

To center student perspectives, current college students led data-collection efforts. The student-driven model afforded students autonomy to organize, manage, and communicate with peers. Student-led research positions students as change agents and leaders in developing and increasing the use of data to inform policymakers (Anderson & Arango, 2019).

In addition, a 15-minute survey was administered by NACAC to a national sample of 1,010 participants ages 16–22 from February 17 to March 9, 2023. Students were asked about their future education plans and their perceptions of the college admissions process. Data collection was conducted by the Harris Poll.

Unless otherwise noted, all quotations in this report are from survey responses and focus group discussions. Participants were advised that their names would not be used.

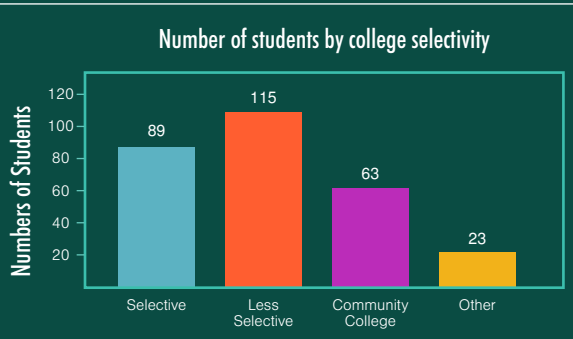
DEMOGRAPHICS

The vast majority of students in the Let's Go to College CA sample met our definition of underrepresented and/or first generation. Respondents self-selected one or more racial/ethnic category. Most (75.2 percent) of the survey sample identified as Latinx. The next three largest groups represented were African American/Black (11 percent), Asian (10 percent), and White (9.7 percent). These demographics largely reflect those of Los Angeles,[1] where Let's Go to College California is based, but are not representative of all high schools or higher-ed institutions within California.

The majority of students in our sample also come from lower socioeconomic strata. Around 77 percent of students reported having parents who do not have a college degree; the majority of students' parents (65 percent) have a high school/GED diploma or less. About two-thirds said financial aid was a factor in their college selection.

Nearly 77 percent of our sample identified as women, a little over 16 percent identified as men, and a small percentage (5.5 percent) identified as genderqueer or nonbinary. About 66 percent of respondents graduated from a non-charter or -magnet public high school, 27 percent graduated from a charter or magnet high school, and about 7 percent graduated from a private high school or were homeschooled.

Students were predominantly enrolled in California public institutions (78 percent were enrolled at a University of California campus, a California State University campus, or one of the California Community Colleges), and 47 percent reported plans to major in STEM. The majority of students identified as first- or second-year college students (65 percent) and as first-generation college students (72 percent). Students were also distributed across selective institutions (31 percent), less-selective institutions (40 percent), and community colleges (22 percent) (see *Number of students by college selectivity, p. 7*).



Selective institutions were defined as those with an acceptance rate of 40 percent or lower. A small number of survey respondents, 23, were either enrolled in institutions with no public acceptance rate info or did not report a post–high school enrollment.

The NACAC survey's sample more closely represents national population demographics: 51 percent of respondents self-identified as White, 25 percent as Hispanic, 14 percent as African American/Black, and 5 percent as Asian. Nearly 48 percent of the sample identified as female, 47 percent as male, and 4 percent as nonbinary or gender nonconforming. Respondents were in the 16-22 age range, but the majority were age 18 or older (69 percent). Thirty-six percent of students reported having parents who did not attend college.

[1] According to a recent report, 11th graders in the Los Angeles Unified School District during the 2015–16 and 2016–17 school years were 76 percent Latinx, 5 percent Asian American, 8 percent African American, and 8 percent White (Wainstein et al., 2023).

ACCESS TO HIGH SCHOOL MATH COURSES

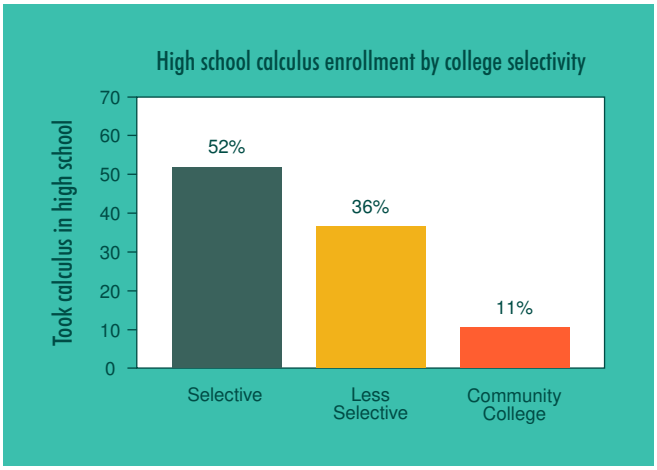
For students interested in STEM fields, calculus in high school is an important stepping stone to college. And some selective colleges expect it even for non-STEM students. However, despite the emphasis on calculus in college admissions, high school calculus enrollment is limited to a small number of students. In 2019, only 16 percent of high school grads—roughly half a million students—had calculus on their transcripts, and 17 percent had statistics (National Center for Education Statistics, 2022, Figure 1).

Not only do the majority of students not take calculus, many do not even have access to the course as high school students, either because their school doesn't offer it or because slots in the course are limited. In 2018, only 53 percent of U.S. high schools offered a calculus course (Hayes, 2019, p. 18, Table 23). Though those schools represent 82 percent of students, course offerings do not guarantee access. Access to calculus varies starkly by socioeconomic status and race. While 46 percent of Asian American students completed calculus, only 18 percent of White students, 6 percent of Black students and 9 percent of Latinx students did so (NCES, 2022, Figure 2). Students from the highest-income quartile of schools were nearly three times as likely to take calculus as students from the two lowest-income quartiles (NCES, 2022, Figure 5).

Because the pathway from Algebra I to calculus consists of five courses, middle school math placement plays an outsized role in determining what math students can access during high school and, by default, in college. Many students don't get to access calculus simply because they didn't have the opportunity to take Algebra I in middle school (Bressoud, 2020; Galanti et al., 2021). These students are more likely to be Black and Latinx students (Charles A. Dana Center et al., 2022; Patrick et al., 2020). Others may be winnowed out based on the limited number of sections at their high school. The Let's Go to College CA sample in this study illustrates such systemic barriers. About two-thirds of the students in the sample took Algebra I or pre-algebra as their first high school math course, so didn't have the benefit of middle school acceleration.

When students attend a high school that offers calculus and they plan to attend college, do they take calculus? In the NACAC poll, nearly 75 percent of students report that calculus was offered at their high school. However, just 45 percent of students report having taken the course.[2] In the Let's Go to College CA sample, with its higher proportion of underrepresented students, 84 percent of students report that calculus was offered by their high school. But only 37 percent of students in the sample report taking calculus or AP Calculus in high school.

When examined by college selectivity in the Let's Go to College CA sample, the results show that students who currently attend the most selective colleges took calculus at higher rates in high school.



In 2018, in California, 75 percent of high school seniors were enrolled in a math class (Reed et al., 2023, p. 2). Sixty-seven percent of students in our sample reported taking four or more years of math. It is likely that most of those students took a math class in their senior year, though some told us they took two courses in one year, or an extra course over the summer, to avoid taking math their senior year. Students in this study who currently attend the most selective colleges were also the most likely to have taken four years of math in high school (see *Math coursetaking and college selectivity, p. 9*). Public universities in California require three years of math for admission, though four years are recommended.

HIGH SCHOOL MATH REQUIREMENTS MATTER

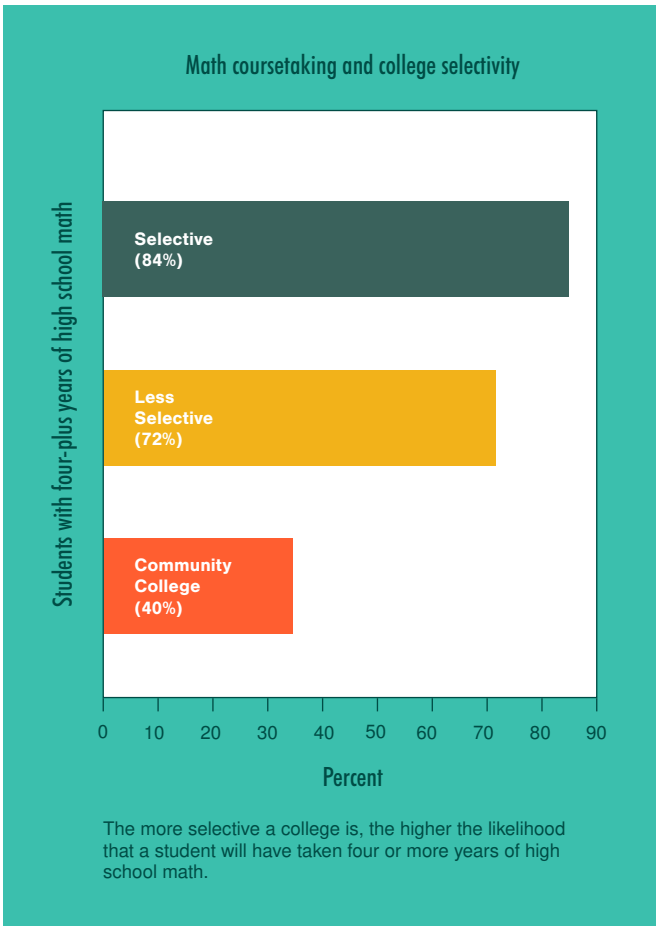
Only 17 states require four years of math for high school graduation. Twenty-seven more require three years of math. The remaining states either require two years or don't specify (Charles A. Dana Center et al., 2022, p. 19). This range is problematic for equitable college access because students who seek to attend selective colleges but live in states with more minimal requirements may not know that they need to take more math than their school requires. And even though colleges rarely require calculus for incoming students, many selective colleges still prefer students to have the course on their transcripts (Anderson & Burdman, 2022), significantly raising the stakes for students' high school math enrollment decisions.

[2] The NACAC survey respondents are as young as 16; because the sample includes high school students, some may still intend to take calculus during high school.

Some students' comments underscore the difficulty of taking a calculus course at their high school.

> *So, when I was applying for college, it felt that schools were only looking for AP scores. I mean AP math classes. But my school that I went to didn't have those.*
>
> *Unfortunately, my high school did not offer AP classes, so I had to do dual enrollment, which made high school a bit challenging.*
>
> *My school only offered up to Calculus AB, and it was only one class for the whole school, so it was pretty competitive to get in, and I know a couple students who ended up taking the AP Calc BC exam even though there wasn't a course. So they just resorted to studying the textbook themselves and teaching it themselves. But I couldn't do that. … It was scary.*

While some students' ability to take calculus was constrained by limited access, awareness of college expectations also played a role in students' math coursetaking decisions.



The more selective a college is, the higher the likelihood that a student will have taken four or more years of high school math.

STUDENT BELIEFS ABOUT COLLEGE EXPECTATIONS

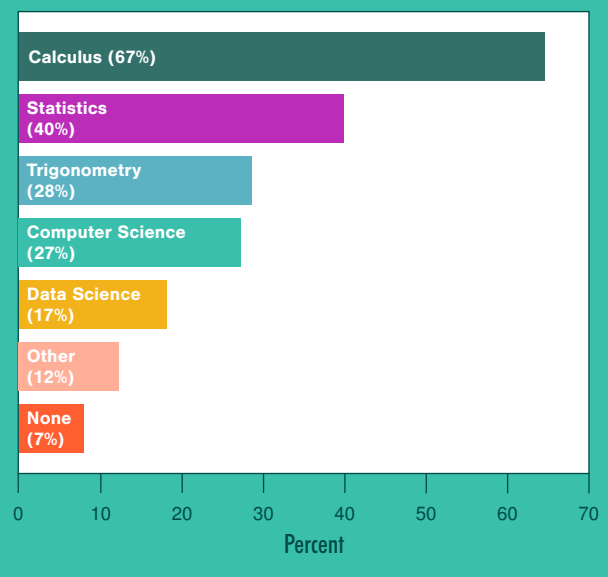
The college admissions process has grown in complexity in recent decades, and **information failures constitute an ever-increasing barrier to college access** (Dynarski et al., 2023), especially given the abundance of often-conflicting information today's students face. One possible result is postsecondary "undermatch," in which high-achieving, low-income students matriculate at institutions below their academic ability (Dynarski et al., 2023; Hoxby & Avery, 2012; Ross et al., 2013). Another is nonattendance, which includes failure to apply to postsecondary institutions, failure to apply to a sufficient range of postsecondary institutions, and failure to matriculate after acceptance (Dynarski et al., 2023; Hoxby & Avery, 2012; Pallais, 2015; Ross et al., 2013).

Information failures have serious equity implications. A substantial body of literature finds that gaps in access to information about college preparation and the admissions process are correlated with traditional barriers to college, namely low socioeconomic status, first-generation status, and membership in racial or ethnic groups historically underrepresented in higher education. These deficits in information and counseling are associated with lower college enrollment rates (Choy et al., 2000; Horn & Chen, 1998; Venezia & Kirst, 2005). Information about math and college access is no exception.

Compared to public high schools, private high schools allocate more resources to assist students in the college selection and application process. Private schools are twice as likely to have college counselors (Clinedinst & Patel, 2018, p. 4). Public schools in the United States have an average student-to-counselor ratio of 470-to-1, almost double the ratio recommended by the American School Counselor Association (Patel & Clinedinst, 2019, p.ii). However, even among public schools, students in higher-income communities have better access to such services than those in lower-income ones (Radford et al., 2016).

Multiple factors influence students' enrollment decisions. For a student interested in statistics and social sciences, for example, not taking calculus may be a good decision. For other students, taking calculus may not even be an option, due to lack of access or middle school placement practices that disproportionately limit opportunity for students of color or low-income students. Nevertheless, students' decisions should be based on the best possible information. Students who do not know that colleges may prioritize calculus could be at a disadvantage in admissions.

When students in the Let's Go to College CA survey were provided a list of math courses and asked which are most important to colleges when making admissions decisions, the majority of students (67 percent) chose calculus (*see Math courses by perceived importance, p. 10*). Statistics ranked second at 40 percent. Students majoring in STEM were more likely to choose calculus than other students (see *STEM students value calculus, p. 11)*.



Students in the Let's Go to College CA survey were given a list of math courses and asked which ones colleges value most when making admissions decisions. Students could check as many courses as they wanted.

Nearly half of students (45 percent) said they believed that students who take calculus are more likely to be admitted to highly selective colleges. For example, one student noted:

> *I feel as though colleges are really looking for students who took AP Calculus specifically, and then, if they took other AP classes, that would also be beneficial. But I feel like calculus is like a main determinant.*

STEM majors (49 percent) were more likely than non-STEM majors (41 percent) to agree that a calculus course enhances a student's chance of being admitted to college. These sentiments echo those of admissions officers and especially high school counselors, as reported in prior Just Equations reports, which highlight the priority placed on calculus in the admissions process at selective universities. As the dean of admissions at a private university stated, "Calculus is the gold standard that people in this business use as a shortcut" (Anderson & Burdman, 2022, p. 10).

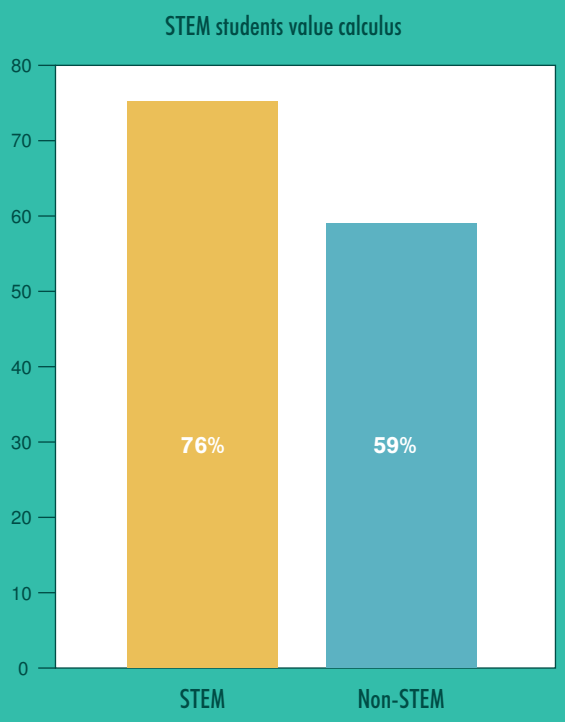
Perceptions about calculus coursetaking also varied by students' first-generation status (*see Parental education and perception of calculus importance, p. 11*). Unlike students whose parents attended college, the majority of first-generation college students did not agree that students who take calculus are more likely to be admitted to highly selective colleges.

In focus group discussions, many students exposed the information disconnects that may have disadvantaged them during the college admissions process. Some students highlighted the untimely nature of the coursetaking advice they received. One reported that she did not have access to information on which courses she needed to take in order to pursue her intended major until it was time to apply. By the time she realized she would have benefited from continuing in math, it was too late:

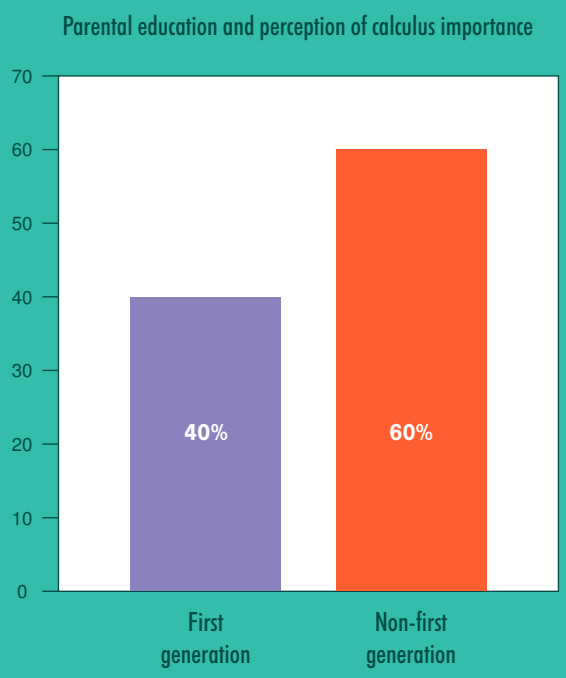
> *We're required to do three years of math, but the fourth year is recommended. So many people like my peers and I, we did like geometry over summer and then just do two years throughout high school so that we can have extra room for other classes or not having to go to classes during our last year.*

Another said:

> *My counselors always placed me in courses they thought fit best. I did not even know I could choose or change my classes until senior year of high school.*



Percentage of STEM and non-STEM majors who chose calculus when asked which math courses are most important to colleges.



Percentage of students by family educational status who agree with the statement, "Students who take calculus are more likely to be admitted to elite or highly selective colleges." First-generation students are those whose parents did not attend college.

Another student described a rush to calculus in high school, based on student assumptions about what colleges want to see on transcripts, regardless of whether calculus aligns with their interests.

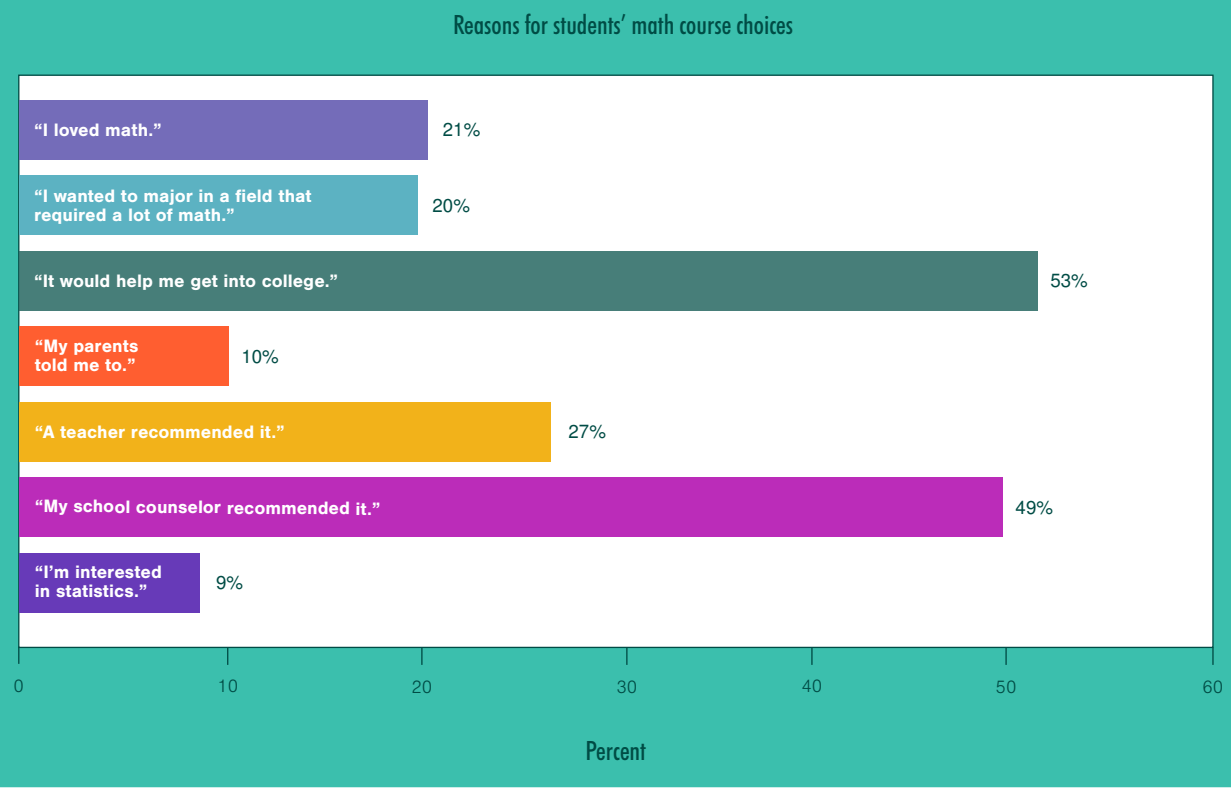
> *There was like this major rush to get into AP Calculus like your junior year. So in order to do that people were taking a lot of math classes over the summer. Personally, I took geometry and Algebra II in just one summer to hopefully catch up to meet that goal.*

Among the information sources shaping students' attitudes about math coursetaking and college, counselors play a primary role.

STUDENT PERCEPTIONS OF COUNSELORS' ADVICE

For most high school counselors, calculus is a default recommendation for students seeking to attend selective colleges, according to *Calculating the Odds*. Many believe such colleges expect calculus, whether colleges say so explicitly or not. Though some counselors believe that calculus is not academically necessary for all students, many say pressure to accelerate to calculus is driven by admissions (Burdman & Anderson, 2022).

An examination of the survey data shows that there is a considerable proportion of students whose high school counselors recommended they take calculus. In fact, when presented with a list of options and asked, "Thinking about the math you took in high school, **why did you choose to take those courses**," 49 percent of students chose, "Because my school counselor recommended it." Fifty-three percent of surveyed students stated that one reason they chose their high school math courses was that they believed it would help them get into college (see *Reasons for students' math course choices, p. 12*).



However, there is clear stratification by racial group in math coursetaking recommendations. When the same sample was asked, "**Which of the following mathematics courses were recommended** to you by your high school counselor," 52 percent named calculus. Asian American respondents report being recommended for calculus courses at a higher rate than other racial groups—61 percent, compared to 41 percent of Black respondents, 50 percent of White respondents, and 52 percent of Latinx respondents. A similar pattern emerged in the NACAC poll: 54 percent of Asian American respondents said they were recommended to take calculus, compared to 45 percent of Hispanic, 42 percent of White and 36 percent of Black students.

Furthermore, 31 percent of students said no one recommended that they take an advanced math course at all. More than one-third of Black respondents (38 percent) and more than one-quarter of Latinx respondents (27 percent) report not receiving recommendations to take any math course by their high school counselor, while only 21 percent of Asian American respondents and 18 percent of White respondents report no math course recommendation. These findings regarding calculus recommendations are consistent with literature that points to racial bias in counselors' math course recommendations (Francis et al., 2019).

Such patterns may reflect racial differences in students' prior math preparation, but they also raise questions about the consistency of the advice provided by counselors. Discrepancies in which students are advised to take calculus or other advanced math courses may have significant repercussions for equitable college access.

Surveyed students noted that parents and counselors were helpful sources of information, but different students received different types of information:

> *My parents and my counselor really influenced my courses I took in high school. They pushed me to take the hardest classes possible in order to appear as appealing as possible to colleges.*
>
> *My high school mostly chose our courses, and I chose my own courses that I was able to based on what I was interested in and sometimes talking to friends.*
>
> *I would say that my decisions were influenced by my high school counselor and myself. … I just wanted to take courses in succession by difficulty then just be comfortable with whatever courses I have. I wish I knew that AP courses were almost not even worth the choice, honestly, and not to rush the process of choosing colleges.*

Many students emphasized getting information about math and college admissions from sources outside their school, including community-based college-access and success programs, due to disappointment with their school counselors—or a lack of counselors. For some, having a counselor of color was preferable.

My school was very like underfunded. We didn't have a counselor, so I just did my own personal research on how to apply to colleges.

I feel like it was YouTube that kind of led me to select all my, like, courses because, yeah, again my guidance counselor, she was really no help and, yeah, it was just me who chose my courses.

My high school counselor, she was White, but she was also overwhelmed with a lot of students in my high school. … So I sought out a college-access program [that] happens nationwide, and, once you're in, they assign you college-access managers. So they were my co–college counselors and they were people of color.

Some focus group participants who expressed a belief that calculus is preferred in the college selection process felt that calculus is a main determinant in college admissions decisions because it represents college readiness. Several students said they believed that taking AP Calculus was necessary if you wanted to appear competitive to a selective college. Some participants expressed pressure to get to the highest level of rigorous mathematics—Calculus AB or Calculus BC if offered at their school—prior to applying to a highly selective university, even if calculus did not align with their chosen major.

I was told to double up on math courses in my sophomore year so I could take AP Calc in my senior year, even though that wasn't something I was interested in or even related to my major.

STUDENT PERCEPTIONS OF THE ADMISSIONS PROCESS

Many high school counselors criticize colleges for preferring applicants who have taken calculus, a practice they say puts undue pressure on students to race through the math curriculum or take math courses that don't align with their academic interests, according to *Calculating the Odds*. The practice also disadvantages students who don't have easy access to the course (Burdman & Anderson, 2022). Students seem to share the concern about emphasizing a course that isn't universally accessible. In the NACAC survey, 76 percent of surveyed students agreed "It is unfair for colleges to prioritize courses not offered in many high schools." The predicament around math coursetaking decisions is complicated by a lack of transparency: Few colleges list calculus as an outright requirement, instead telling students to take the most "rigorous" courses available to them. This message leaves much up to interpretation, so that even when calculus is not required, counselors often assume that it is a covert requirement (Burdman & Anderson, 2022).

How does this mix of messages influence students? Centering student voices helps us understand how students interpret information on math coursetaking shared with them by high school counselors and college admissions personnel. A lack of clear information appears to loom large. In our survey, students ranked "access to information about college admissions" as the biggest hurdle in the process of applying to college, with more than a third of students identifying it as the "greatest barrier." Latinx students (40 percent) were more than twice as likely as White respondents (18 percent) to select "access to information" as their greatest barrier, along with 28 percent of Asian respondents and 31 percent of Black respondents.

Focus group comments reveal that, though students are not fully clear about what is required by admissions offices, many—like counselors—hold a default assumption that calculus, especially AP Calculus, is important for admission to selective colleges.

I'm not sure this is necessarily what the admissions is looking for, but it's sort of, at my school, taking AP Calculus in high school would put you at a significant advantage when you end up at the university because most of the popular majors like economics and statistics and computer science require you to have taken these introductory calculus classes. So if you had taken AP Calculus in high school, right, you would not have to take the introductory Calculus I and II classes. … If you were a student who came in with credit for those classes already, you were at a fairly substantial advantage compared to those who had not taken those classes in high school.

I wasn't really told what kinds of math courses colleges were looking for, but I assume that any high-level math courses such as AP courses were important to them. I also think calculus was the main math course they were looking for.

The advice to take calculus, however, put some students at a disadvantage with respect to their majors. One student noted,

> *I took and passed AP Calculus, but my college did not accept it because I believe it is different from statistics. I did not have any statistics classes in my high school, so I was at a disadvantage.*

However, other students were given the impression that statistics is on par with calculus with respect to AP classes.

> *For the math portion, I think that they would look at how many advanced honors and AP math classes you're able to take, specifically like calculus and statistics, because they also require those in college.*
>
> *When it comes to math, colleges, I believe, are looking for advanced courses, AP courses, statistics, and calculus, and seeing that you succeeded in those courses.*
>
> *For advanced math courses, I'd say probably things like AP Calc or AP Stats were probably things that admission counselors would look for.*

The UC system is on record that calculus is not prioritized in admission. Since our student sample was centered in California, it is possible that some students' comfort with taking statistics was influenced by this policy position, but that cannot be determined from this study (see *The University of California de-emphasizes calculus, p. 14*).

What is clear is the responsibility of school counselors to support students in making pivotal decisions about higher education. Ensuring that counselors have clear and consistent information about math coursetaking as it relates to admissions is essential, particularly when admissions policies are being updated or revised.

The survey results support the idea that well-aligned messages about math coursetaking increase a student's likelihood of taking a specific math course. For instance, the Let's Go to College CA survey found that students are far more likely to enroll in calculus if they perceive calculus as important to college admissions committees and if their high school counselors recommend it. Students are unlikely to enroll in the course if they don't perceive calculus as important and/or do not receive a recommendation from their counselor to take calculus.

THE UNIVERSITY OF CALIFORNIA DE-EMPHASIZES CALCULUS

Because the students in our sample were primarily from California, it is important to point out that the state's public universities have been more explicit than most higher education systems that they accept courses from outside the calculus pathway in the admissions process. In a 2016 statement, the University of California's admissions board clarified that calculus generally does not have special weight in UC admissions decisions. And, in 2020, the system changed its policies to explicitly allow additional advanced math courses, such as statistics, probability, data science, discrete mathematics, and some computer science courses (Johnson, 2020).

Our sample suggests that, true to its stated policy, the UC system does admit students who don't have calculus on their transcripts, including to its most selective campuses. Of the UC students in our sample, 41 percent had taken calculus in high school. Among those attending the five most selective UC campuses, 47 percent had taken calculus. This pattern also appears consistent with UC's practice of "holistic review," in which students are evaluated in the context of the opportunities available to them. Based on the courses they took in ninth grade, the majority of students in the survey—as well as the majority of students attending UC—were not on accelerated pathways that would have led them to calculus by their senior year.

LOOKING AHEAD

Insights from first-generation and underrepresented college students reveal the challenges they face in accessing advanced math courses and receiving accurate guidance about which courses will best prepare them for college, especially for admission to selective universities. The absence of clearly identified math expectations may serve to reinforce inequities in who is represented at the most competitive institutions, with fewer Black, Latinx, and first-generation students enrolling. It also has repercussions for the math sequences high schools offer.

New policies and practices are needed to ensure that students, their families, and their counselors have the information necessary to make good decisions about math coursetaking in high school and for college access. The student perspectives described in this report point to the following recommendations.

Adopt broader, more transparent math requirements for admission. Colleges and universities should broaden the range of math courses they accept for admission and communicate those policies Colleges and universities should broaden the range of math courses they accept for admission and be transparent about those policies. Institutions should also review any requirements they have for a specific high school course, such as calculus, to determine whether they are essential for success at the college or in particular majors. Furthermore, students' records should be considered in the context of the courses available to them, so that they aren't penalized for not having access to specific courses. The UC and CSU systems require three years of high school math (and recommend four years), with math course options including computer science, data science, and statistics, in addition to courses in the traditional algebra-to-calculus-sequence. Both Harvard College and the University of Chicago explicitly state that calculus is not required for admission. NACAC is also promoting greater clarity in admissions policies with respect to math, so that high school counselors, students, and families have accurate information about colleges' math expectations.

Increase access to counseling and support. States, districts, and other funders should invest more in school counseling, particularly in lower-resourced schools that serve students of color, students whose parents did not attend college, and students from low-income backgrounds. To ensure students receive the support needed to promote college access, the number of counselors should be increased to meet the American School Counselor Association's minimum recommended student-to-counselor ratio of 250-to-1. Counselors also need support to prioritize reaching out to students of color and first-generation and low-income students with accurate, timely information about math coursetaking. Organizations such the National College Attainment Network and the American School Counselor Association can point to tools (such as ASCA's resource list) that support eliminating individual bias from 1-to-1 counseling.

Engage college-access organizations. State education departments, districts, and other funders should support college-access organizations to help ensure that all students are receiving appropriate information about their math coursetaking options and alignment with college admissions. Students in our survey frequently mentioned college-access organizations, which often work with students in lower-resourced schools, as trusted sources of information concerning college admissions. Collaboration between schools and college-access organizations is also essential. Through such organizations, education systems can also invest in supporting families, especially those of first-generation college students of color, to expand the support network for students as they choose courses and careers.

Adopt more equitable K–12 course-enrollment policies. So that students don't reach high school off track for college preparation, states, districts, departments, and schools should enact more equitable course-placement policies. To ensure that students master math concepts without skipping foundational content, the National Council of Teachers of Mathematics has promoted the principle of "appropriate acceleration" (National Council of Teachers of Mathematics, 2018). In middle school and high school, multiple measures can help identify students for advanced math coursework opportunities, including student interest, exam scores, grades in relevant prerequisite courses, and standardized test scores. Automatic enrollment in advanced coursework for any student identified through one or more measures is recommended. Districts should also monitor progress to ensure that implementation of such policies expands opportunities for historically underserved students.

REFERENCES

Anderson, K., & Arango, K. (2019). Student-led advocacy guide: Resources for organizations seeking to engage students in policy & advocacy work. The Scholarship Foundation of St. Louis. https://sfstl.org/wp-content/uploads/2019/11/SLA_Guide.pdf

Anderson, V., & Burdman, P. (2022). A new calculus for college admissions: How policy, practice, and perceptions of high school math education limit equitable access to college. Just Equations. https://justequations.org/resource/a-new-calculus-for-college-admissions-how-policy-practice-and-perceptions-of-high-school-math-education-limit-equitable-access-to-college

Asim, M., Kurlaender, M., & Reed, S. (2019). 12th grade course-taking and the distribution of opportunity for college readiness in mathematics. Policy Analysis for California Education. https://edpolicyinca.org/publications/12th-grade-course-taking-and-distribution-opportunity-college-readiness-mathematics

Bressoud, D. M. (Ed.). (2017). *The role of calculus in the transition from high school to college mathematics.* MAA Press. https://www.maa.org/sites/default/files/RoleOfCalc_rev.pdf

Bressoud, D. M. (2020). The strange role of calculus in the United States. *ZDM Mathematics Education, 53*(3), 521–533. http://doi.org/10.1007/s11858-020-01188-0

Bryan, J., Kim, J., & Liu, C. (2022). School counseling college-going culture: Counselors' influence on students' college-going decisions. *Journal of Counseling & Development, 100*(1), 39–55. https://doi.org/10.1002/jcad.12408

Burdman, P., & Anderson, V. (2022). Calculating the odds: Counselor views on math coursetaking and college admissions. Just Equations & National Association for College Admission Counseling. https://justequations.org/resource/calculating-the-odds-counselor-views-on-math-coursetaking-and-college-admissions

Charles A. Dana Center, Student Achievement Partners, & Education Strategy Group. (2022). Re-envisioning mathematics pathways to expand opportunities: The landscape of high school to postsecondary course sequences. https://edstrategy.org/wp-content/uploads/2022/07/Re-Envisioning-Mathematics-Pathways-to-Expand-Opportunities_FINAL.pdf

Choy, S. P., Horn, L. J., Nunez, A., & Chen, X. (2000). Transition to college: What helps at-risk students and students whose parents did not attend college. *New Directions for Institutional Research, 27*(3), 45–63. https://eric.ed.gov/?id=EJ621638

Clinedinst, M., & Patel, P. (2018). 2018 state of college admission. National Association for College Admission Counseling. https://chaowu.org/wp-content/uploads/2019/03/soca18.pdf

Dynarski, S., Nurshatayeva, A., Page, L. C., & Scott-Clayton, J. (2023). Addressing non-financial barriers to college access and success: Evidence and policy implications (NBER Working Paper No. 30054). National Bureau of Economic Research. http://www.nber.org/papers/w30054

Francis, D. V., & Darity, W. A., Jr. (2021). Separate and unequal under one roof: How the legacy of racialized tracking perpetuates within-school segregation. *The Russell Sage Foundation Journal of the Social Sciences, 7*(1), 187–202. https://doi.org/10.7758/RSF.2021.7.1.11

Francis, D. V., de Oliveira, A. C. M., & Dimmitt, C. (2019). Do school counselors exhibit bias in recommending students for advanced coursework? *The B.E. Journal of Economic Analysis & Policy, 19*(4), 1–17. https://www.degruyter.com/document/doi/10.1515/bejeap-2018-0189/html

Galanti, T. M., Frank, T. J., & Baker, C. K. (2021). Hyper-acceleration of Algebra I: Diminishing opportunities to learn in secondary mathematics. *Journal of Mathematics Education at Teachers College, 12*(1), 43–50. https://journals.library.columbia.edu/index.php/jmetc/article/view/7379

Guo, J., Parker, P. D., Marsh, H. W., & Morin, A. J. S. (2015). Achievement, motivation, and educational choices: A longitudinal study of expectancy and value using a multiplicative perspective. *Developmental Psychology, 51*(8), 1163–1176. http://dx.doi.org/10.1037/a0039440

REFERENCES CONTINUED

Hayes, M. L. (2019). 2018 NSSME+: Status of high school mathematics. Horizon Research Inc. http://horizon-research.com/NSSME/wp-content/uploads/2019/05/2018-NSSME-Status-of-High-School-Math.pdf

Hicks, T. (2003). First-generation and non-first-generation pre-college students' expectations and perceptions about attending college. *Journal of College Orientation Transition and Retention, 11*(1), 5–17. https://www.researchgate.net/publication/36725986_First-Generation_and_Non-First-Generation_Pre-College_Students'_Expectations_and_Perceptions_About_Attending_College

Horn, L. J., & Chen, X. (1998). Toward resiliency: At-risk students who make it to college. U.S. Department of Education, Office of Educational Research and Improvement. https://files.eric.ed.gov/fulltext/ED419463.pdf

Hoxby, C. M., & Avery, C. (2012). The missing "one-offs": The hidden supply of high-achieving, low income students (NBER Working Paper No. 18586). National Bureau of Economic Research. http://dx.doi.org/10.3386/w18586

Irizarry, Y. (2021). On track or derailed? Race, advanced math, and the transition to high school. *Socius: Sociological Research for a Dynamic World, 7*, 1–21. https://journals.sagepub.com/doi/pdf/10.1177/2378023120980293

Jiang, S., Simpkins, S. D., & Eccles, J. S. (2020). Individuals' math and science motivation and their subsequent STEM choices and achievement in high school and college: A longitudinal study of gender and college generation status differences. *Developmental Psychology, 56*(11), 2137–2151. http://dx.doi.org/10.1037/dev0001110

Johnson, S. (2020, November 9). University of California expands list of courses that meet math requirement for admission. *EdSource.* https://edsource.org/2020/university-of-california-expands-list-of-courses-that-meet-math-requirement-for-admission/643173

Lawyers' Committee for Civil Rights of the San Francisco Bay Area. (2013). Held back: Addressing misplacement of 9th grade students in Bay Area school math classes. https://lccrsf.org/wp-content/uploads/HELD-BACK-9th-Grade-Math-Misplacement.pdf

Maltese, A. V., & Tai, R. H. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students. *Science Education, 95*(5), 877–907. https://onlinelibrary.wiley.com/doi/10.1002/sce.20441

Martin, D. B. (2009). Researching race in mathematics education. *Teachers College Record, 111*(2), 295–338. https://eric.ed.gov/?id=EJ829114

Mathematical Association of America, & National Council of Teachers of Mathematics. (2022). A joint position statement of the Mathematical Association of America and the National Council of Teachers of Mathematics. https://www.maa.org/sites/default/files/Calculus%20Position%20Statement_0.pdf

National Center for Education Statistics. (2022). High school mathematics and science course completion. *Condition of Education.* U.S. Department of Education, Institute of Education Sciences. https://nces.ed.gov/programs/coe/indicator/sod/high-school-courses

National Council of Teachers of Mathematics. (2018). *Catalyzing change in high school mathematics: Initiating critical conversations.* National Council of Teachers of Mathematics. https://www.nctm.org/Store/Products/Catalyzing-Change-in-High-School-Mathematics-(Download)

National Research Council. (2013). *The Mathematical Sciences in 2025.* The National Academies Press. https://nap.nationalacademies.org/catalog/15269/the-mathematical-sciences-in-2025

Pallais, A. (2015). Small differences that matter: Mistakes in applying to college. *Journal of Labor Economics, 33*(2), 493–520. https://laeri.luskin.ucla.edu/wp-content/uploads/sites/22/2022/12/LAERITwelfthGradeMathandCollegeAccessReport121522.pdf

REFERENCES CONTINUED

Patel, P., & Clinedinst, M. (2019). State-by-state student-to-counselor ratio maps by school district. National Association for College Admission Counseling. https://files.eric.ed.gov/fulltext/ED615227.pdf

Patrick, K., Socol, A., & Morgan, I. (2020). Inequities in advanced coursework: What's driving them and what leaders can do. The Education Trust. https://edtrust.org/wp-content/uploads/2014/09/Inequities-in-Advanced-Coursework-Whats-Driving-Them-and-What-Leaders-Can-Do-January-2019.pdf

Radford, A. W., Ifill, N., & Lew, T. (2016). A national look at the high school counseling office: What is it doing and what role can it play in facilitating students' paths to college? National Association for College Admission Counseling. https://eric.ed.gov/?q=Radford+The+High+School+Counseling+Office&id=ED578183

Reardon, S. F. (2011). The widening academic achievement gap between the rich and the poor: New evidence and possible explanations. In G. J. Duncan & R. J. Murnane (Eds.), *Whither opportunity? Rising inequality, schools, and children's life chances* (pp. 91–116). Russell Sage Foundation. https://www.russellsage.org/publications/whither-opportunity

Reed, S., Merritt, C., & Kurlaender, M. (2023). 12th grade math: An updated look at high school math course-taking in California. Policy Analysis for California Education. https://edpolicyinca.org/sites/default/files/2023-02/ig_reed-dec2022.pdf

Roderick, M., Nagaoka, J., Coca, V., & Moeller, E., with Roddie, K., Gilliam, J., & Patton, D. (2008). From high school to the future: Potholes on the road to college. Consortium on Chicago School Research at the University of Chicago. https://consortium.uchicago.edu/sites/default/files/2018-10/CCSR_Potholes_Report.pdf

Rotermund, S., & Burke, A. (2021). Science and engineering indicators: Elementary and secondary STEM education. National Science Board, National Science Foundation, & National Center for Science and Engineering Statistics. https://ncses.nsf.gov/pubs/nsb20211/

Ross, R., White, S., Wright, J., & Knapp, L. (2013). Using behavioral economics for postsecondary success. Ideas42. https://www.ideas42.org/wp-content/uploads/2015/05/Using-Behavioral-Economics-for-Postsecondary-Success_ideas42_2013.pdf

Ross, T., Kena, G., Rathbun, A., KewalRamani, A., Zhang, J., Kristapovich, P., and Manning, E. (2012). Higher education: Gaps in access and persistence study (NCES 2012-046). U.S. Department of Education, National Center for Education Statistics. https://nces.ed.gov/pubs2012/2012046.pdf

Teague, D. (2017). The song remains the same, but the singers have changed. In D. M. Bressoud (Ed.), *The role of calculus in the transition from high school to college mathematics* (pp. 41–45). MAA Press. https://www.maa.org/sites/default/files/RoleOfCalc_rev.pdf

U.S. Department of Education, Office for Civil Rights. (2018). 2015–16 civil rights data collection: STEM course taking. https://ocrdata.ed.gov/assets/downloads/stem-course-taking.pdf

Venezia, A., & Kirst, M. W. (2005). Inequitable opportunities: How current education systems and policies undermine the chances for student persistence and success in college. *Educational Policy, 19*(2), 283–307. https://doi.org/10.1177/0895904804274054

Wainstein, L., Miller, C. E., Phillips, M., Yamashiro, K., & Melguizo, T. (2023). Twelfth grade math and college access. Los Angeles Education Research Institute. https://laeri.luskin.ucla.edu/wp-content/uploads/sites/22/2022/12/LAERITwelfthGradeMathandCollegeAccessReport121522.pdf

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