Crossing Signals:

What College Websites Tell Students About Taking Mathematics

By Pamela Burdman and Rogéair D. Purnell

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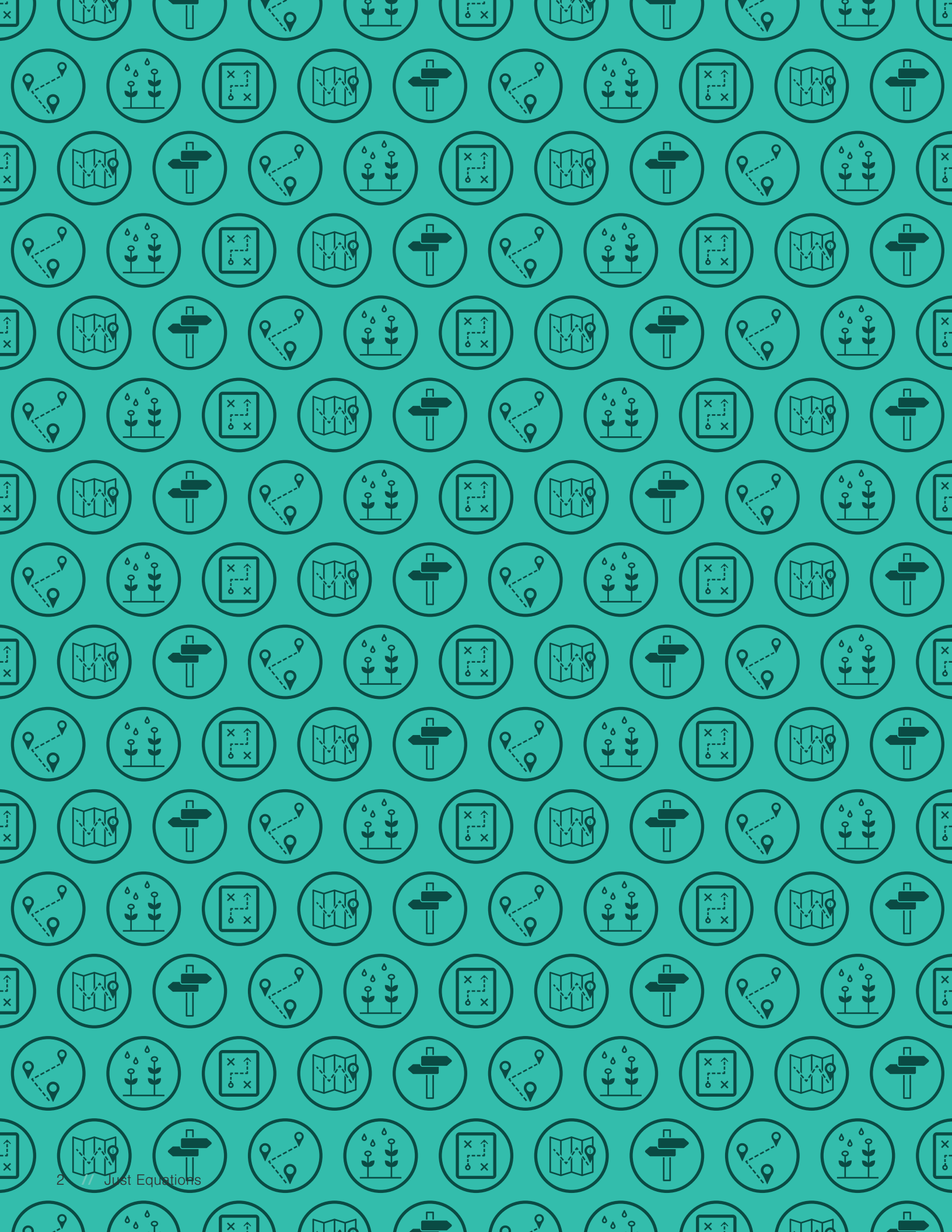
JUST EQUATIONS



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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' founding partners are the Opportunity Institute, the Education Trust-West, the Campaign for College Opportunity, LearningWorks, and Policy Analysis for California Education.

ABOUT THE AUTHORS

Pamela Burdman, executive director of Just Equations, is a policy analyst and strategist on equitable college access, readiness, and success, with a particular focus on the role of mathematics. She works at the intersection of education research, policy, and practice to synthesize knowledge from the field to define problems and advance strategies to support student success. She began her career as a reporter for the San Francisco Chronicle more than 20 years ago and first focused on math opportunity as a program officer at the William and Flora Hewlett Foundation.

Rogéair D. Purnell, Ph.D., is a researcher, evaluator, and facilitator and the president and founder of RDP Consulting. Over the course of her career, she has led a number of education-related studies and projects focused on transfer, student support services, guided pathways, and dual enrollment, with special attention to community college student success. As a funder, facilitator, and administrator, she has supported programs working to improve high school completion rates and postsecondary opportunities for low-wealth individuals.

THE MATH PATHWAY IMPERATIVE

Students' experiences in mathematics send powerful signals to them about their academic potential and self-worth. Mathematics policies often present unnecessary, even arbitrary, barriers to students' progress to and through college. The resulting gatekeeping effect can be demoralizing for students who don't encounter early success in math. College students have historically faced placement tests that underestimate their math ability, remedial courses that rehash math they learned in high school, and math content with little relevance to their future studies. Such roadblocks deepen the challenges faced by students—particularly students of color, low-income students, and others who are already marginalized in the education system.

It's not that mathematical skill is unimportant. The issue is that, too often, policies and practices that shape math education have failed to foster quantitative reasoning as an essential competency students need as professionals, citizens, and consumers.

Javier Cabral knows that story too well: He is among hundreds of thousands of California community college students who couldn't earn a college degree after struggling with remedial math courses, even though the algebra content of those courses had little relevance to his aspiration to become a food writer.

The purpose of math education should be to *equip* all students for college and life success, rather than to *select* some students to pursue further education. Colleges and universities across the country are implementing new, evidence-based policies to deploy math as a foundation for students' future success, instead of as a filter. These policies involve three key reforms:

- Introducing new math pathways—such as statistics, data science, and quantitative

"I FAILED ALGEBRA SEVEN TIMES IN COLLEGE. AT A CERTAIN POINT, YOU START TO JUST QUESTION YOURSELF AS A HUMAN BEING."

Javier Cabral,
former college student[1]

"I WENT THROUGH SCHOOL HATING MATH, AND I DID THE MINIMUM. I NEVER THOUGHT ABOUT GOING TO COLLEGE."

Rebecca Galicia,
college student

"I ENDED UP SPENDING ALL OF HIGH SCHOOL REALLY DREADING MATH."

Mariam Shamon,
college student

[1] The current and former students quoted in this report shared their math journeys at Just Equations conferences in 2018 and 2019.

reasoning—that align with a range of student aspirations, to complement the traditional one-size-fits-all pathway to calculus that mainly prepares students for majors in science and engineering (Burdman & Booth, 2018; Fitzpatrick & Sovde, 2019).

- Using students' high school records for placement and limiting reliance on traditional college placement tests, which underestimate the math readiness of a significant proportion of students (Scott-Clayton, Crosta, & Belfield, 2014; Dadgar, Collins, & Schaefer, 2015; Rutschow, Cormier, Dukes, & Zamora, 2019; Bahr, Jackson, McNaughtan, Oster, & Gross, 2019; Melguizo & Ngo, 2020).

- Eliminating or reducing the prerequisite remedial courses that have typically been required for students deemed less than college ready in favor of "corequisites" (also called "support courses," or "lab courses") and other just-in-time approaches for helping students succeed in college-level mathematics (Mejia, Rodriguez, & Johnson, 2019; Ran & Lin, 2019; Hodara & Cox, 2016).

In concert, these strategies help ensure that a student enrolls in the math course that is most appropriate, generally a college-level[2] course that aligns with the student's intended major. They are also key components of the "guided pathways"[3] reforms being adopted by institutions across the country, especially community colleges. These collegewide strategies entail developing coherent program maps aligned with students' college and career aspirations. The guided pathways approach also involves revamping services such as onboarding and advising to help students stay on track to complete college and achieve their academic goals (Jenkins, Lahr, Fink, & Ganga, 2018).

In many states, community colleges[4] were the earliest large-scale adopters of the trio of math policy reforms (Burdman, 2012), partly because they had higher remedial math enrollments than universities. Under the reforms, community college enrollments in remedial math courses declined by 32 percent nationally from 2010 to 2015. During the same period, universities

[2] We use the term "college level" to refer to courses that meet the general education math requirements for a two-year degree and for university transfer. In California, the term "transfer level" is used, because some math courses that meet associate degree requirements don't match requirements at the state's public universities.

[3] The guided pathways framework is based on research demonstrating that community colleges and less-selective universities have traditionally operated under a "cafeteria," or self-service, model. This model, developed in the last decades of the 20th century, vastly improved access to higher education. However, it did not ultimately provide the program coherence necessary to ensure students could set and meet their educational goals in an efficient and cost-effective manner. The concept of guided pathways was developed through a series of foundation-supported initiatives at community colleges over the past two decades. It was articulated by the Community College Research Center at Columbia University's Teachers College and popularized by Complete College America, an advocacy organization. However, its origins have been traced to public universities, including Florida State University and Georgia State University. (For an overview of the guided pathways model, see Bailey, Jaggars, & Jenkins, 2015 and https://bit.ly/2C1NQ6i.)

[4] In this report, "community colleges" refers to institutions whose primary degree offerings are associate degrees and credentials. "Universities" refers to institutions whose primary undergraduate offerings are bachelor's degrees. We are not using the terms "two-year institutions" and "four-year institutions," because those normative timelines don't reflect the actual completion timelines of the majority of students. Also, some institutions offer both two- and four-year degrees.

Students' experiences in mathematics send powerful signals to them about their academic potential and personal worth. Mathematics policies often present unnecessary, even arbitrary, barriers to students' progress to and through college.

saw those enrollments increase by 21 percent (Blair, Kirkman, & Maxwell, 2018, p. 1). However, some public university systems, including those in Tennessee, Georgia, as well as California's 23-campus state university system, have been at the forefront of redesigning math pathways, eschewing unreliable placement tests, and implementing corequisite approaches instead of remedial courses (Burdman & Booth, 2018).

Remedial math courses are intended to prepare students for a general education math course, which is required to earn a degree. However, prior research made clear that the sequences do not fulfill that purpose: Only about a fifth of community college students enrolled in remedial sequences ultimately complete such a course (Bailey, Jeong, & Cho, 2010). Evidence supporting the trio of reforms demonstrates that ensuring that students take the most appropriate math courses is key to improving college-completion rates (Bailey, Jaggars, & Jenkins, 2015; Ran & Lin, 2019).

Javier ultimately left college without a degree before the new approaches were implemented. But Rebecca and Mariam benefited from the changes. Instead of remedial math, each of them enrolled in corequisite courses, and both are now well on their way to earning a bachelor's degree.

To close equity gaps, it is essential that math pathways are broadened to provide relevant options to students besides the calculus sequence. At the same time, it's critical not just to support students in earning any college degree but also to expand equitable degree completion in science, technology, engineering, and mathematics (or STEM).

Mariam is a case in point. She came to college thinking her poor record in mathematics meant that she couldn't pursue a technical field. But the opportunity to take a corequisite course completely turned that around for her. "I ended up liking math so much in that class," she said. "I was finally learning the basics, and that's how I ended up changing my major ... to engineering."

Mathematics has traditionally been the gatekeeper to STEM fields. It is also responsible for excluding students of color[5] from entering these fields (Bahr, et al., 2017; Park, Ngo, & Melguizo, 2020). In addition to contending with outright barriers, such as placement tests, students can be discouraged by the disheartening signals sent by those barriers. It is essential to break that pattern, by pairing policy changes with new messages about taking math. Ultimately, students must have the information they need to make optimal decisions about their educational goals and the paths to achieving them.

With its racial and ethnic diversity, California is an ideal setting for studying whether specific educational policies and practices foster equitable outcomes. The state's community college and public university systems are the largest postsecondary systems in the nation and among the first to adopt sweeping math policy reforms.

In our most recent report, *Go Figure—Exploring Equity in Students' Postsecondary Math Pathway Choices* (2020), we provide a preliminary look at

[5] We use the term "students of color" to refer to historically underrepresented groups. Most research studies cited in the report focus on Black and Latinx students. However, a broader definition is sometimes applied, as per the notes in the table, *Community Colleges and CSU Campuses Reviewed* on p. 17.

how students at the two California systems make decisions about enrolling in math pathways.

Findings from that report include:

- Students understand the need to triangulate information so that they have the most accurate and complete guidance.
- Students who are unsure about their major could benefit from additional counseling and guidance about which math course to take when they start college.
- Though the newly abandoned placement tests did a poor job of placing students into math courses, new tools and resources are needed to ensure that first-generation students or those with less math confidence are equipped to make optimal choices from among courses they are eligible for.

In focus groups, students told us they frequently relied on online resources to inform their decision-making (Purnell & Burdman, 2020).

THE CURRENT INQUIRY

In order to further understand the nature of the information students receive, this study examines the content accessible via college and university websites that students use to select math courses and pathways during the onboarding process. In particular, our analysis focuses on how that online guidance can support or detract from equitable outcomes. Accurate and easily navigable websites can go a long way toward helping students make optimal decisions (GAO, 2017).

Equipping students to make optimal choices means improving a decision-making process that has been compared to "navigating a shapeless river on a dark night," in Judith Scott-Clayton's seminal analysis (2015) of community college structure. According to Scott-Clayton, "Without clear signposts, an experienced guide, or a visible shoreline to follow, many students make false starts, take wrong turns, and hit unexpected obstacles, while others simply 'kill the boat' trying to figure out where they are" (p. 103). Scott-Clayton also describes how various "norms and nudges" combine to "subtly influence individuals' decisions" (p. 103), particularly when students arrive at a fork in the river.

We begin our analysis by discussing specific challenges to equity in mathematics, in order to understand the obstacles that can interfere with students selecting the math courses that would suit them best. We then turn to a discussion of new policies that are changing the context in which California Community Colleges (CCC) and California State University (CSU) campuses offer and require math courses. We describe the methodology used to review CCC and CSU websites. Next, we share common themes that emerged from our analysis.

Finally, we share promising practices that the analysis revealed, as well as a checklist that institutions can utilize to strengthen and improve the quality of resources students use to locate and select math courses and pathways in sync with their academic goals.

EQUITY CHALLENGES IN IMPLEMENTING MATH PATHWAYS

Among academic disciplines, mathematics presents particular challenges in ensuring that all pathway options are truly open and that students' choices are well-informed and based on authentic agency (Purnell & Burdman, 2020; Brathwaite, Faye, & Moussa, forthcoming). By the time they complete high school and enter college (if they enter college), most students have already experienced tracking, or ability grouping, which insidiously divides them into "maths" and "math-nots." (See *The Prevailing Architecture of Math Opportunity*, p. 9.) In addition to splitting students into higher and lower tracks, schools often track math teachers as well, by assigning more experienced instructors to more advanced courses (National Council of Teachers of Mathematics, 2018). Placement into college developmental (i.e., remedial) courses can perpetuate these K-12 inequities (Ngo & Melguizo, 2020), a pattern that corequisite initiatives are designed to help reverse.

Likewise, expanding math pathways to include offerings such as statistics, data science, and quantitative reasoning also presents considerable equity dilemmas. On one hand, the new courses provide an enormous opportunity for more students to develop math literacy in ways that are rigorous and relevant to their futures (Burdman & Booth, 2018). One-size-fits-all prerequisites that require, for example, that every student passes College Algebra or Precalculus—even if they plan to pursue a field like performing arts, political science, nursing, or accounting—are arbitrary barriers to student advancement. For the majority of college students, other areas of mathematics are far more meaningful (Charles A. Dana Center, 2020).

Still, algebra-intensive math courses are essential stepping-stones for engineering, physics, and other sciences that have traditionally excluded students of color. In

fact, STEM majors "stand apart in their relative exclusion" of students of color: They are the only majors that Black and Latinx students are more likely to exit than white students (Riegle-Crumb, King, & Irizarry, 2019. p. 142). The primary reason students leave these majors more than any others is that, during their early years in college, they become more pessimistic about their performance in math or science. (T.R. Stinebrickner & R. Stinebrickner, 2011).

It is essential, therefore, that new pathways be implemented in ways that change the status quo—expanding, not limiting, access to STEM courses, especially for Black and Latinx students. Entry to a college math pathway is a major fork in the river for students. As such, it is also a key juncture for postsecondary institutions to identify and eliminate the signals that have traditionally discouraged or prevented students of color from proceeding in STEM fields and/or taking advanced math courses. Overlooking that opportunity would inadvertently reinforce the pattern of tracking.

In theory, such choices would logically follow students' educational goals. In practice, however, it is not that straightforward. Assumptions students make about their abilities, often in consultation with advisors who may hold their own biases, can influence their choices. Those assumptions or biases can cause mismatches in terms of which pathway students pursue, at what level they enter the pathway, or both (Purnell & Burdman, 2020; Fong & Melguizo, 2017). Students who receive implicit or explicit signals that emphasize their deficiencies rather than their potential can understandably develop math avoidance and lower their aspirations (Bustillos, 2019; Park, et al., 2020). The aspiring biology student who switches majors to avoid having to take calculus is a common example (Flaherty, 2015). It's also a tragic one, given that calculus is not foundational in many fields within biology (Burdman, 2015).

To mitigate the risk of students making suboptimal decisions, institutions have a responsibility to send effective signals. The literature on choice architecture reveals that the signals surrounding individuals' options can vastly influence the decisions they make. Be it for organ donations or retirement savings, for instance, people are more likely to participate under an opt-out system, where consent is presumed. When consent must be explicitly given, the default is to not participate. As a result, fewer individuals do (Krijnen, 2018).

The Prevailing Architecture of Math Opportunity

In Just Equations' conceptual framework, redesigning math opportunity requires dismantling the traditional "architecture of math opportunity" (Burdman, 2018) and its three key elements:

- A foundation of cultural **misconceptions about math learning** supports the belief that math ability is innate and that only some people can do it well. Deeply embedded assumptions, like the notion that math is about getting answers quickly with little creativity or expression, combined with the structure of traditional math classrooms send faulty signals to some students that they are just not cut out for math (Boaler, 2016).
- Scaffolded by **existing educational inequities** and biases, such misconceptions can be especially damaging to students who already lack equitable access to educational opportunity. They can diminish students' sense of belonging and leave them more vulnerable to experiencing math anxiety (Maloney & Beilock, 2012; Maloney, Schaeffer, & Beilock, 2013).
- Such anxiety can be further heightened by the way academic culture uses achievement in **mathematics as a form of pedigree** that preserves the position of those who already enjoy privilege. This practice can signal to students that they don't belong in advanced math courses or STEM fields, thereby fostering fragile math identities. Such messages can create a considerable barrier for marginalized students who lack access to math tutors or can't rely on parental help. They can also limit students' horizons in another way—by causing them to underestimate their own abilities when choosing math courses (Fong & Melguizo, 2017).

In practice, the presentation of options is not always informed by research. Higher education literature offers numerous examples of failed messages hobbling students' decisions about required core courses. (See *Research on Informing College Students' Decision-Making*, below.)

COURSES AND INFORMATION SOURCES

Course offerings themselves can serve as nudges. In California, for example, where the law dictates that community college students are not required to take remedial math courses, some colleges continued to offer numerous sections of remedial courses in 2019–2020, the year the law first took effect (Campaign for College Opportunity [CCO] & California Acceleration Project [CAP], 2019). The prevalence of those offerings might communicate to students that they aren't ready for college-level math courses, even though research indicates that starting in college-

level courses increases students' likelihood of college success (Ran & Lin, 2019). Another set of colleges offered an insufficient number of sections of classes such as Introductory Statistics, perpetuating the practice of directing the vast majority of students into College Algebra

Research on Informing College Students' Decision-Making

Prior research has highlighted some of the pitfalls faced by college students when information provided by institutions isn't sufficiently clear. One study noted that community college students are offered a "confusing array of hard-to-understand course and program choices with unclear connections to future career trajectories" (Rosenbaum, Deil-Amen, & Person, 2006, p. 129). This is particularly true for general education requirements, where a mistake could mean waiting an entire year before the appropriate course is offered again—a considerable obstacle, especially for students of color and those with limited resources.

Another study documented advice offered to language-minority students who were required to enroll in English courses at California community colleges. At the time, students were required to take placement tests. But as they searched websites for advice on whether to take a test in English or English as a Second Language (ESL), students encountered ill-considered guidance, such as: "The ESL test is for students whose native language is not English and who wish to enroll in ESL classes" or "If you are not sure, take the ESL test" (Bunch, 2011, pp. 26–7). One college official called the English test the "native speaker test" and the ESL test the "bilingual test" (p. 28). It wasn't clear to students that they might not be able to enroll in an English course if they took the ESL test, and vice versa. When choosing which test to take, the students were unwittingly making a high-stakes decision. A student misplaced into ESL would need to spend at least a semester in that program before switching to an English path, assuming the student has the knowledge or was advised to do so.

Though much of the research has focused on community colleges, universities use some similar practices. For example, math placement charts at universities tend to put a test-score range in the left-hand column. Courses available to students in that score range appear in the right-hand column. This format could discourage students from retaking the test. Reversing the columns could orient students toward the goal of completing a degree in their desired major rather than focusing on the limitations of their test score (Lewis, 2019).

Students need online resources that proactively and transparently support their academic progress, not a compliance-oriented maze in which students get lost trying to decipher the signals.

courses that may be irrelevant to their aspirations (CCO & CAP, 2019).

Then there is the question of how students choose (or are assigned to) specific courses. While having a broad range of choices presents more opportunities for students to be successful, it also points to the need for clearer, more nuanced guidance (Purnell & Burdman, 2020). To make effective math enrollment decisions, students need at least three ingredients:

- Clear educational goals or support in developing them.
- Information about the mathematics pathways (e.g., STEM, statistics, liberal arts mathematics) that align with those goals and guidance in choosing among them.
- Guidance in selecting the course level within a pathway that matches their preparation level while allowing them to progress through their program as efficiently as possible. If remedial options are offered, guidance on them should explain that beginning in college-level courses is associated with greater success in math.

College and university students report that online resources are an important source of information for making such decisions (Purnell & Burdman, 2020). For some community college students, websites are a primary source of advice (Center for Community College Student Engagement, 2018). For others, information available through websites—like course catalogs and class schedules—supplements guidance from college staff, instructors, family members, and fellow students.

Students' use of online information may not provide the full picture of the role websites play as an information source. Even counselors and advisors may rely on web-based information while guiding students. Given high counselor-to-student ratios in some states, including California, accurate online information is essential for effective and efficient counseling. Furthermore, websites are likely an even more important source of information during the ongoing COVID-19 pandemic, as students have had reduced access to college instructors, advisors, and fellow students since most campuses closed in March 2020.

Prior research has shown that websites can either enhance or detract from colleges' role in guiding students to make the best decisions about their educational goals and how to achieve them. A 2018 analysis of transfer pathways information on Texas community college websites found cases where information was "inadequate, disorganized, riddled with broken links, or otherwise out of date" (Schudde, Bradley, & Absher, 2019, p. 17).

"Even the savviest students—those who know precisely which program they hope to earn a degree in—may come up against barriers to transferring and to attaining a bachelor's degree if they face information constraints along the way. The cost of missteps is high," the authors noted (p. 26). (For more evidence on how information can affect students' choices, see *Research on Informing Students' Decision-Making*, p. 10.)

Students need online resources that proactively and transparently support their academic progress, not a compliance-oriented maze in which students get lost trying to decipher the signals. The challenge of providing such resources is likely the greatest for under-resourced postsecondary institutions, especially when their processes are shifting in response to policy change.

POSTSECONDARY MATH REFORM: THE CALIFORNIA CONTEXT

Many postsecondary systems have initiated math policy reforms in the last few years with the goal of expanding educational equity. Ensuring that goal is met will depend in part on what options are made available to students and how those options are communicated. Shifts in pathway offerings and requirements, as well as the process by which students access them, could profoundly influence which pathways students ultimately pursue.

To understand how students learn about and access various math pathway options, this study focuses on students attending California Community Colleges and California State University campuses. The purpose is to shed further light on those processes by examining how college websites support or detract from students' abilities to make appropriate choices about their math courses and pathways. In particular, we focus on how that guidance supports equitable outcomes.

Both California systems have recently adopted reforms designed to accelerate students' progress to and through required college mathematics courses: Each requires students to complete at least one gateway or general education course[6] to complete a program.

Since the fall of 2018, the 23 CSU campuses have been implementing reforms to entry-level math requirements mandated a year earlier in executive orders by Chancellor Timothy P. White. And in fall 2019, a new law, Assembly Bill 705, took effect at the state's 115 community colleges, updating the way students are placed in math courses.

Though the mechanisms are different, both systems now emphasize placing students in college-level courses, based on multiple

[6] We use the terms "gateway course" and "general education course" interchangeably in this report. While the CCC generally refers to "math" requirements, the CSU calls its General Education B4 requirement a "quantitative reasoning" requirement. We also use those terms interchangeably.

measures from their high school records, and providing various forms of support. Corequisite courses—college-level courses with additional support in the form of a one- or two-unit course, lab, or workshop—are being widely adopted by institutions in both systems. In some cases, the college-level course has been redesigned to embed additional support. Both systems have abandoned math placement tests to determine which courses students can access. And both direct students to enroll in math pathways that align with their programs of study, rather than deploying the pathway to calculus for all.

But, as our website review in the next section shows, the two systems have implemented these ideas in different ways:

- At the CSU, stand-alone remedial (or developmental) courses have been eliminated entirely. The only exception is that students who had lower grades or took fewer math courses in high school might still be required to attend a summer bridge program.[7] That program must confer at least some college credit. By contrast, most community colleges continue to offer at least some remedial math courses. In some colleges, remedial courses constitute more than 30 percent of introductory math offerings (CCO & CAP, 2019). While the CCC legislation limits colleges' ability to place students in such courses, it doesn't bar them from *offering* them.
- Both systems are encouraging just-in-time support approaches. These include corequisite models, in which students enrolled in a college-level course receive additional support as part of the course or through a companion course. The CSU policies specifically permit "stretch" models, in which the content of a general education quantitative reasoning (or GE B4) course is spread out over more than one term—i.e., up to two semesters or three quarters (Bracco, et al., 2019), particularly for students who need significant additional support. The CCC system doesn't have a specific policy on stretch models, but colleges adopting them could face scrutiny under AB 705's requirement that students enter and complete a college-level math course expeditiously.

- With respect to placement, the vast majority of community college students no longer take placement tests. Instead, the colleges use placement rules or guided self-placement tools to review students' high school records and math backgrounds and to help them select math courses. The CSU also eliminated its systemwide math placement test. However, some CSU campuses have retained other tests that had been used to supplement the systemwide test to determine which college-level math courses students may take. These tests limit access to the majority of math

[7] CSU's summer program, Early Start, has been canceled as a systemwide requirement in 2020 due to COVID-19, though individual campuses may still offer Early Start programs.

courses, especially STEM-oriented courses (Burdman, 2017).

- The process of identifying math courses that align with a student's program of study varies across the two systems. While the CSU process generally presumes that students know their major upon entry,[8] community college students are somewhat more likely to make a final choice of major after entering college. Some CSU campuses require students to choose a major when they apply. Others allow students to enter as "undeclared." All CSU students must choose a major before completing 60 semester units, or two academic years. Though switching majors is generally permitted, the process is not always easy, simply because of the high proportion of so-called "impacted majors" that can't admit all interested students. In practice, an unknown number of students entering both systems are uncertain of their ultimate major, as well as of the implications for their choice of initial math course.

What the two systems have in common is that they both require students to complete at least one mathematics course (a gateway or general education course) before completing a program. Similar to systems across the country (Booth & Burdman, 2018), both offer diversified pathways aligned with students' fields of study, with the most common being:

STEM—sometimes referred to by community colleges as B-STEM, which includes business, since many business departments require a STEM-oriented course such as Calculus for Business or Finite Math.

Statistics—most commonly Introductory Statistics. Other courses include Probability and Statistics, Statistics for Behavioral and Social Sciences, Introduction to Research Methods in Psychology, and Statistics in Everyday Life.

Quantitative Reasoning or Liberal Arts Mathematics—a range of courses with a wide variety of titles, such as Ideas of Mathematics, Nature of Mathematics, Patterns of Mathematical Thought, Principles of Mathematics, Contemporary Math, and Explorations in Quantitative Reasoning.

At community colleges in California, the second two categories are often grouped together and dubbed SLAM, for statistics/liberal arts math.

[8] About 85 percent of CSU students enter having declared at least an initial major, according to the CSU Institutional Research and Analysis dashboard. Though major selection is harder to track in the CCC data system, an estimated 78 percent of students declare a major before entering, though this includes a large proportion who select "general studies." An unknown proportion of students in both systems change their major.

METHODOLOGY

To understand the nature of the information students receive online, we analyzed 17 community college and five CSU websites. The community college sites were identified by generating a random set of numbers between one and 114, which were then linked to the alphabetized and numbered list of colleges on the California Community Colleges Chancellor's Office (CCCCO) website. For the CSU, we used data recently made available by the CSU Chancellor's Office (CSUCO). We also asked other researchers who are studying the implementation of the CSU's new policies for input before we selected five campus websites for review. Finally, we checked the sample to ensure that it included institutions of varied sizes, located in different regions, and having diverse student populations. (See *Community Colleges and CSU Campuses Reviewed*, p. 16-17.)

The CCC and CSU websites were analyzed in April and May 2020, respectively. Our research reflects content on the websites at that time.[9]

This period represented the end of the CCC's first year implementing the new law, AB 705, and the CSU's second year implementing the system's executive orders. Our reviews didn't include information accessible via password-protected portals. To ensure inter-rater reliability, each of the two reviewers completed an initial review of two websites, followed by a session to align approaches and emphases. Those reviews were then finalized before reviewers studied the remaining sites. The intention was to understand the experience of students searching for and consuming information on these websites. We captured information on key indicators associated with a set of review criteria. (See Figure 1, p. 17.)

[9] In anticipation of the next academic year or in response to the ongoing COVID-19 pandemic, some information on the campus websites may have changed before the publication of this report.

Community Colleges and CSU Campuses Reviewed

College	City	Region*	Community**	Size***	Diversity****
Community Colleges					
Allan Hancock College	Santa Maria	Central Coast	Urban	Medium	Very Diverse
Bakersfield College	Bakersfield	Southern San Joaquin	Urban	Medium	Highly Diverse
Chabot College	Hayward	San Francisco Bay Area	Urban	Small	Diverse
Clovis Community College	Fresno	Southern San Joaquin	Urban	Small	Diverse
College of Alameda	Alameda	San Francisco Bay Area	Suburban	Very Small	Diverse
College of the Desert	Palm Desert	Inland Empire	Suburban	Small	Highly Diverse
Crafton Hills College	Yucaipa	Inland Empire	Rural	Very Small	Diverse
El Camino College	Torrance	Los Angeles County	Suburban	Medium	Very Diverse
Los Angeles Trade-Technical	Los Angeles	Los Angeles County	Urban	Medium	Highly Diverse
Monterey Peninsula College	Monterey	Central Coast	Suburban	Small	Diverse
Mt. San Antonio College	Walnut	Los Angeles County	Suburban	Large	Diverse
Pasadena City College	Pasadena	Los Angeles County	Urban	Large	Diverse
Sacramento City College	Sacramento	Superior California	Urban	Medium	Diverse
San Diego Miramar College	San Diego	San Diego-Imperial	Urban	Medium	Moderately Diverse
Shasta College	Redding	Superior California	Suburban	Small	Moderately Diverse
Sierra College	Rocklin	Superior California	Suburban	Medium	Moderately Diverse
West Hills College–Lemoore	Lemoore	Southern San Joaquin	Rural	Very Small	Very Diverse
California State University Campuses					
Cal State East Bay	Hayward	San Francisco Bay Area	Urban	Small	Moderately Diverse
Fresno State University	Fresno	Southern San Joaquin	Urban	Medium	Diverse
Cal State Los Angeles	Los Angeles	Los Angeles County	Urban	Medium	Very Diverse
Cal State Monterey Bay	Seaside	Central Coast	Suburban	Very Small	Diverse
San Diego State University	San Diego	San Diego–Imperial	Urban	Large	Moderately Diverse

*Regions are based on the state's 10 census regions: Superior California, North Coast, San Francisco Bay Area, Northern San Joaquin Valley, Central Coast, Southern San Joaquin Valley, Inland Empire, Los Angeles County, Orange County, San Diego–Imperial.

**Community designations are based on the "urbanicity" category used by the Integrated Postsecondary Education Data System of the National Center for Education Statistics to describe the degree of urbanization of the campus location.

***Size of CCC colleges is based on data on total full-time equivalent students from the California Community Colleges Chancellor's Office's Management Information Systems Data Mart and reflects data from 2017 to 2018. We defined large as more than 20,000 students, medium as 10,000–20,000 students, small as 5,000–10,000 students, and very small as fewer than 5,000 students. Size of CSU campuses is based on data from fall 2019 on the CSU system website. We defined large as more than 30,000 students, medium as 20,000–30,000 students, small as 10,000–20,000 students, and very small as fewer than 10,000 students.

****Diversity of CCC colleges is based on the percentage of historically underrepresented minority (URM) students (African American, American Indian/Alaska Native, Filipino, Hispanic, Multiethnicity, Pacific Islander) enrolled in 2017-2018, according to the CCC Data Mart. Diversity of CSU campuses is based on the percentage of URM students (Hispanic/Latino, Black/African American, Hawaiian/Pacific Islander, American Indian/Alaska Native, Two or more Races) enrolled in fall 2019, according to the CSU Institutional Research and Analyses dashboard on State-Supported Enrollment. Colleges with 25 to 50 percent URM students are considered moderately diverse, those between 50 and 65 percent are diverse, those in the 66 to 75 percent range are considered very diverse, and those above 75 percent are considered highly diverse.

Figure 1: Key factors and related indicators reviewed

Information on Placement	Location of Information on Math Courses	Guidance for Undecided Students	Explanation of Math Pathway Options	Availability of Math-specific Supportive Services
• Up-to-date • Consistent • Clear • Language-deficit or asset-based	• Course schedule • Catalog • Transferability information	• Career/major exploration • Clear link between math pathways and majors/ metamajors	• Remedial sequences • Prerequisites • Corequisites	• Tutoring center • Embedded tutoring • Special Programs

*Throughout the report, these icons will be used to note policies, practices, and approaches related to these criteria.

VITAL SIGNS: ANALYZING POSTSECONDARY WEBSITE MESSAGES ABOUT MATH PATHWAYS

Since completing a math course is required across the board for hundreds of thousands of California college students, the process of doing so should be as seamless and transparent as possible. Indeed, a key goal of pathway reforms, including math pathways and guided pathways, is to support students' timely progress toward a degree or credential. That entails limiting bureaucratic obstacles and building clear and accurate guidance into the design of colleges.

While campus websites are not the sole source of information available to students, their significance has increased due to the COVID-19 pandemic. Even counselors and advisors[10] frequently turn to campus websites to answer student queries (E. Flores, personal communication, June 15, 2020). Therefore, inaccurate and/or misleading information on websites can diminish the effectiveness of academic counseling and advising. It can also undermine the efforts of college leaders and math faculty who are championing student-centered practices and promoting equity in student outcomes.

Overall, we found that, in their current form, the websites reviewed did only a moderate job of addressing students' needs and advancing the goals of the reforms. There was plenty of helpful information across all 23 sites. Viewing the sites collectively offered a bird's-eye view of math education trends around the state. But an individual student entering the system and

[10] While California community colleges use the term "counselor," others systems including the CSU, primarily offer "advisors". In some cases in this report, "counselor" and "advisor" are used interchangeably.

relying on the information on any one website as a first port of call is likely to hit roadblocks or feel confused about available course options and how to choose a relevant and appropriate math course. Although each website provides some useful guidance, navigating website pages with opaque menu options can be a cumbersome experience.

There were varying degrees of confusing, outdated, inaccurate, or inconsistent information on the sites. The CSU websites were generally clearer and easier to navigate than the CCC websites. Though community college students tend to have less social capital and arguably need more guidance than their counterparts in the CSU system, the discrepancy likely reflects larger budgets for websites at universities (The Century Foundation, 2019). An additional explanation may be that the transparency of the CSU's systemwide placement rules relieves individual campuses of the burden of creating and communicating the policies.

Our preliminary report pointed to insufficient support for students who are undecided about their major (Purnell & Burdman, 2020). The current analysis echoes that finding, observing that many of the sites did not transparently address students' educational goals or how math pathways align with them.

The four interconnected themes that emerged from our review of the 23 sites are reminiscent of the "shapeless river" described by Scott-Clayton (2015):

Obscure signposts: Navigating the websites and locating reliable information about enrolling in mathematics courses was not always obvious or intuitive.

False starts: Few sites offered resources for students to explore and make connections between their interests and aspirations and the school's available programs and majors. The resources that were available tended to be difficult to find and follow.

Wrong turns: Although most sites reference current policies to some extent, information about the placement process was not always consistent, clear, or up-to-date.

Unexpected obstacles: Vestiges of prior remedial math policies and deficit-oriented language could lead students to make suboptimal decisions and delay their progress to completion, the very barriers that pathway policies are intended to eliminate.

OBSCURE SIGNPOSTS:
Navigating the websites and locating reliable information about enrolling in mathematics courses was not always obvious or intuitive.

Ideally, campus websites should be easy for students to navigate. Our reviews weren't a precise simulation of a student's process and experience: We focused solely on math course options, just one of several decisions a student typically has to make. Also, while students might follow the first piece of advice they encounter, we searched more thoroughly to assess each site for accessibility, accuracy, and consistency.

Each review required an average of 90 minutes from start to finish, with a range of 75 to 120 minutes. In many cases, despite having more understanding of college requirements than most students, we struggled to find relevant information and noticed discrepancies in information posted on different pages and places (e.g., course catalog vs. class schedule), and, in some cases, on different sites (e.g., college vs. district or campus vs. system). We also encountered unwieldy search functions that required following links that were outdated and irrelevant. Attributes such as intuitiveness, limited number of clicks, and smooth redirection made searching and identifying resources easier. (See Figure 2, p. 20.) Some colleges had password-protected portals for viewing information on recommended placements. Because we did not have access to those portals, we could not assess the quality of that information compared with that on the public sites. Even if that information is useful, it is unavailable to prospective students, their counselors, or their parents.

Figure 2. Key Attributes of Easily Navigable Websites

Intuitiveness	Three-click rule	Redirection	Search
• Information can be found on pages where the student would expect to find relevant resources (e.g., admissions, how to apply)	• No more than two or three clicks between pages necessary to find relevant information	• Easy to return to previous page or information without starting search from the beginning	• Using the search feature provided list of relevant or updated informaton

Our previous report found that, in order to make the best decisions, students tend to rely on more than one source of information. They value online materials and self-placement tools, as well as one-on-one advice or counseling. (In some cases, unfortunately, that reflects students' lack of confidence in the reliability of any one source.) Especially for students who haven't decided on their majors, counseling can help identify and select the most appropriate math courses and pathways (Purnell & Burdman, 2020). Our review of the websites revealed uneven access to such resources, particularly for community college students:

- Since placement policies differ by community college, there was no central location for students across the system to search for clear guidance. (There are, however, research-based recommendations to colleges on how to set their placement rules.)
- Seven out of the 17 community college websites reviewed had limited information about math placement options online. They required students to book an appointment with a counselor to learn more about the math placement process and/or to receive course recommendations. The lack of web-based information creates barriers for students with child care demands or work commitments, who can't easily schedule appointments with counselors. It also makes it hard for students who do make appointments to prepare for them. Given the high student-to-counselor ratio at community colleges,[11] the requirement to make an appointment can be an obstacle for students who most need assistance. (The move to online counseling appointments in response to the COVID-19 stay-at-home orders could make it easier for students to secure an appointment.)
- Other colleges seem to ration counselor appointments by steering students toward online guided self-placement tools or recommending a counselor visit only if the student has questions about the tools.
- Five of the 17 community colleges had no details about math pathway options on their public-facing websites. Instead, they required students to access a password-protected portal to view information about the process or to bring their transcripts to a counseling appointment.

By comparison, the CSU websites provided somewhat clearer information about the system's four placement categories—either on the campus site or through a link to the CSU system site, or both. (See *CSU and CCC Placement Policies*, p. 21.) Information students provide during the application process, including their high school records and intended major, is the basis for indicating which math courses they are qualified for. Students who have not selected a major or who have questions about which math courses they can take are directed to meet with their advisor.

[11] As of fall 2015, the student-to-counselor ratio was 615:1, according to The Campaign for College Opportunity (2017).

CSU and CCC Placement Policies for STEM and non-STEM Math Course Enrollment

California State University

Based on their high school records (a combination of grade-point average, math courses taken, math course grades, and standardized test scores), CSU students are assigned to one of four categories: (1) exempt from taking a general education math course based on college-level work completed during high school, (2) ready for a college-level math course, (3) ready to take a college-level math course with support, or (4) expected to take an Early Start summer bridge course followed by a college-level math course with support in the fall.

The rules differ depending on whether the student is pursuing a STEM or non-STEM math course. For example, a student who doesn't meet the test-score benchmarks but earned a high school GPA of 3.0 can take a non-STEM math course with support (category 3). If the same student wanted to take a STEM math course, they would need at least a 3.3 average in their math courses. Otherwise, the student would be required to take an Early Start summer course (category 4). Likewise, without certain test scores, a student with a high school GPA of 3.5 and four years of high school math could take a non-STEM math course without support. But to take a STEM math course without support, a 3.5 plus five years of high school math would be required. (It is not uncommon for California students who take Algebra 1 or Math 1 in the eighth grade to accrue five years of math credit. In fact, a majority of students who attend the University of California do so.)

California Community Colleges

Though individual colleges set their own placement policies, they must comply with AB 705, which requires them to replace placement tests with measures such as high school grades and courses taken. The system has two recommended placement levels: college-level math with and without concurrent support. For enrollment in a statistics or liberal arts math course (SLAM) without support, a high school GPA of 3.0 or higher is recommended. Enrollment in a college business or STEM math course without support is recommended only for students with high school GPAs of 3.4 or higher, assuming the student has completed Algebra 2.

Though the CSU placement categories are clear, each campus determines how the categories pertain to specific course offerings—for example, whether courses are considered STEM courses. The highly detailed CSU placement rubric relies on factors such as number of math courses taken in high school, high school grades, grades in math courses, and scores on assessments such as SAT, ACT, and Advanced Placement tests. Cut-off scores also vary for STEM and non-STEM math courses. Despite the transparency and consistency, the inherent complexity can be a source of confusion for students.

Some of the CCC and CSU sites had clear and consistent information about math course options and placement processes, but, in many cases, different versions of the options and processes appeared on different pages (e.g., catalog, course schedules, application pages, math department, and meta-majors[12]). This required analyzing various versions. The inconsistencies mean that students might be receiving outdated or incomplete information, depending on which pages they look at. Or, if they notice the inconsistencies, they may struggle to determine which page is accurate, as we did at times. For example:

- Most CSUs and some community colleges offered courses in departments outside of mathematics that meet the general education math requirement for CSU freshmen or

[12] "Meta-major" refers to a cluster of academic and career-focused areas of interests and their related courses. Examples include "arts, language, and communication" and "science, technology, and health." The use of meta-majors is foundational to the guided pathways framework.

students transferring from community colleges to CSU. Such offerings may add valuable diversity to the options available to students, assuming they are part of a coherent set of offerings. However, these courses were not always reflected on math course pathway lists or flowcharts designed to help students choose a gateway math course, especially when those lists were hosted by mathematics departments. For some students, particularly those whose interests fall outside of STEM, those oversights could lead them to make choices without knowing all of their options.

- At one college, the math course pathway flowchart listed only course numbers. It did not list the corresponding course names. Therefore, a student may have to cross-check information with the course catalog or schedule when deciding which classes to take.
- A few community colleges had course schedules that did not indicate whether a math course fulfills general education requirements for transfer, requiring a search of the catalog or transfer resources for this information. Across colleges, a few courses that met the CSU's general education requirement for transfer students did not meet the requirements for the state's other public system, the University of California (UC). This was not always clearly marked, and, in several cases, the sites directed students to consult a counselor if they had questions about UC transferability.

The most common locations of reliable math placement course and pathway information for the CCC were course schedules, catalogs, pages about general education math requirements, and sometimes math department pages. (For additional details on community college sites, see Figure 3, below.)

FALSE STARTS:
Few sites offered resources for students to explore and make connections between their interests and aspirations and the school's available programs and majors. The resources that were available tended to be difficult to find and follow.

Students who are undecided about their academic or career trajectory need tools to explore the existing programs and learn how they can build on and speak to their skills, knowledge, and interests (Jenkins, Lahr, Pellegrino, Kopko, & Griffin, 2020). Selecting and entering a major or pathway that aligns with long-term goals early in college may help a student avoid costly and time-consuming changes.

More than half of the community college sites reviewed appeared to assume that students had made these decisions or would seek out resources to make them via other means. Some offered resources, such as surveys or interactive tools, to assist students with exploration. But most were not integrated well into the sites. Many of the sites

Figure 3. Signposts for Locating Community College Math Course/Pathway Information

Course Schedule	Catalog	Course Transfer Information
• Correct co- and prerequisites that are reflective of new reforms are noted	• Mirrors, complements, or is consistent with information provided in course schedule, placement page, and pages for programs or meta-majors • Easy-to-find information on math reforms and courses	• All courses listed are college level • Course number system indicates whether transferable and to where • Transfer search provides information on math course transfer options for both university systems

simply listed programs alphabetically, making meaningful comparisons of programs cumbersome at best. Overall, most of the community college sites had an ad hoc feel that did not reflect the clarity and coherence that guided pathways recommends.

Understanding the range of available math pathways and their relationship to students' program of study is also key to students' progress toward their goals. This ideally requires some understanding of the purpose of the math requirement. Though most of the sites made it clear that students were expected to complete a math course, very few explained the reason for the requirement. This omission can contribute to the sense that the requirement is merely a hurdle to clear.

Across both systems, some of the sites did have lists or diagrams that showed, for example, which math courses were associated with STEM majors and which were better suited for students pursuing liberal arts or social science. For example, eight of the 17 community college sites offered varying degrees of information on SLAM vs. B-STEM math options. Few among them provided clear illustrations of alignment with majors and/or transfer pathways. Only a handful of the community college sites featured required math courses as part of program maps sorted by meta-major, a useful signpost and component of the guided pathways framework. Most of the CSU sites offered some information on STEM and liberal arts math options, but they varied in usefulness.

Across sites, there was little information to assist students who had not yet settled on a major, or who were thinking of changing their major, to decide between STEM, statistics, or liberal arts pathways. This was especially true for community college students.

> Many of the [community college] sites simply listed programs alphabetically, making meaningful comparisons of programs cumbersome at best.

The CSU's process, and the systemwide site that describes it, generally assumes that incoming students know whether they are pursuing a STEM or non-STEM field. It provides limited guidance about these terms and assumes that students who have not chosen a major have ruled out a STEM major. This could be problematic if students unknowingly end up closing the door on a STEM field. Campus sites often direct students to meet with an advisor to select the most appropriate math course or if they want to consider a major different from the one to which they were admitted.

Figure 4 describes site components that could be barriers to the selection of the most appropriate math course or pathway for students who have yet to identify a major.

Figure 4. Challenges and Potential Obstacles for Undecided Students

Detailed Math Pathway Descriptions	Link Between Math Pathways and Majors	Opportunities to Explore Relationship Between Long-term Goals and Math
• Incomplete description of the various math pathway options	• Unclear what majors are associated with each math pathway • Unclear what careers and types of jobs are associated with each pathway	• Limited resources to allow a student to explore various careers, skills and knowledge needed, and their relationship to majors/relevant math pathway

WRONG TURNS:
Although most sites referenced current policies to some extent, information about the placement process was not always accurate, consistent, or clear.

We analyzed the campus sites for features like consistency, accuracy, and clarity (See Figure 5). On many sites, some pages and documents were updated, and others were not. In addition to confusing students and consuming their time, inaccurate information can lead students to perceive more obstacles to enrolling in a math course than exist under current policies:

- Nearly half (eight of 17) of the community college sites directed students to an assessment webpage or center even though placement tests are no longer required.
- One community college catalog said students were required to watch an orientation video. But, since the video was produced in 2016, before remedial policy reforms took effect, it directed students to take a placement test. Placement tests are no longer required, and most information about the tests has been removed from the site, so the video has likely confused countless students.
- In explaining the CSU's Early Start summer program for students needing mathematics support, one CSU website said it is required for students who haven't met the "ELM proficiency requirement," apparently referencing the Entry-Level Mathematics test, which the system hasn't administered for two years.

In other cases, the information about specific math courses was either outdated or appeared inconsistent with system policies:

- Some community college websites and catalogs listed courses that were no longer offered. This could mislead students who don't consult the course schedule or catalog supplements and confuse those who do.
- There were inconsistencies across pages focused on the placement process and those highlighting math options on some community college sites.
- On some sites, general education math requirements for specific programs did not seem justified based on the discipline (e.g., a liberal arts major at one CSU required three semester-long math courses, though most liberal arts majors require only one.)

Figure 5. Reliability of Math Placement Information

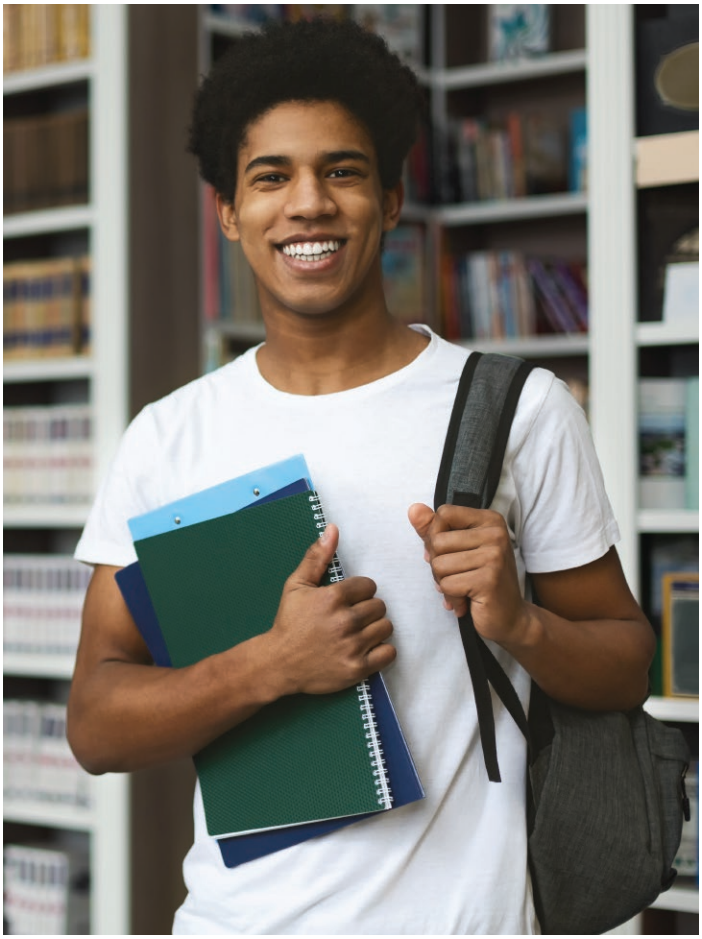
Up-to-Date	Consistent	Complete	Clarity
• Clear that a placement test is not required (no mentions of assessment) • Highlights key steps in placement process	• Placement page, catalog, and math department site provide the same information	• Steps to complete needed forms or submit required transcripts are complete and clear	• Easy-to-understand • Focuses on positives of enrolling in college-level course immediately

UNEXPECTED OBSTACLES:
Vestiges of prior remedial math policies and related deficit-oriented language could lead students toward suboptimal decisions and delay their progress to completion, the very barriers that pathway policies are intended to eliminate.

Under California's new policies, community colleges are expected to assign the majority of their students to college-level math courses, providing academic support as needed. Only in cases where research shows that a remedial course would improve student outcomes should students be assigned to remedial math classes. In fact, a growing body of research demonstrates that students are more likely to complete their math requirements and reach other milestones if they are given the chance to start in a college-level math course with support (Ran & Lin, 2019; Logue, Douglas, & Watanabe-Rose, 2019; Mejia et al., 2019). At the CSU, since remedial courses have been eliminated, no students should be taking placement exams or remedial courses. Yet websites within both systems contain deficit-based messages that appear to discourage students from pursuing college-level courses and/or STEM math pathways.

For example, community colleges are not forbidden from offering remedial courses, and some continue to offer large numbers of them without clear justification (CCO & CAP, 2019). Our analysis revealed that, along with those offerings, numerous vestiges of old remedial math policies still remain on many college sites. Rather than explaining to students that they are more likely to succeed in mathematics if they begin in a college-level course, many sites give the false impression that remedial courses are required or at least recommended. This could explain why students eligible for corequisite courses and other just-in-time supports are instead enrolling in remedial courses. For example:

- Nearly half of the colleges' online catalogs list remedial math offerings before college-level ones.



- At nearly three-fourths of the colleges, catalogs list remedial prerequisites, such as Intermediate Algebra. While this practice is most common for STEM math courses such as College Algebra and Precalculus, some websites also listed Intermediate Algebra or Elementary Algebra as a prerequisite for Statistics. In many cases, the so-called prerequisite is featured prominently at the front of the course description. Language explaining that students need not take such prerequisites is often buried on the page and presented in bureaucratic jargon.
- Some websites implied that there are hurdles to enrolling in college-level (also called transfer-level) math courses. One website, for example, said: "We recommend that you speak with a counselor before registering in a transfer-level math course. Counselors can provide a multiple-measures review of your preparation for transfer-level work." In the absence of a similar warning for registering in remedial courses, this message could nudge

students toward enrolling in a lower-level course that doesn't align with their ability.

- One college appeared to promote remedial prerequisite courses in several places on its website. A math sequence flowchart showed prerequisites for all eight general education math courses in dotted lines, likely suggesting that they are optional. A side note on the chart also stated: "Students may enroll in any first-level transfer course." That explanation and the dotted lines were easy to overlook, because the flowchart itself presented prerequisites as part of the natural sequence.
- The same college also used inviting language to encourage students to take a pre-algebra course: "This course is free and students may repeat this course until mastery of the skills is met. This is a great class for students who are transitioning to college, who are unsure of their abilities, or who have been out of school for a while and want some more mathematics preparation before transitioning to college-level math." Though the course being offered is a noncredit course, the distinction may not be immediately evident to degree-seeking students who are expected to complete college-level math within two semesters of starting a math sequence.

It was unclear whether such deference to prior policies stemmed from colleges' lack of capacity to update their websites or a deeper institutional resistance to embracing the policy changes. These observations echo the findings of a recent study on Latinx students that shows that in the first year of AB 705 implementation, most Latinx students at one community college were not aware that a new law provided access to transfer-level math courses (Flores, 2020). Even students who were aware of the policy opted to take a remedial math course, according to the study. These patterns occurred against a backdrop of what the study calls "fierce resistance" (p. 56) to the reforms by math faculty at the college. Another study found that faculty did not "readily trust high school data" unless it "fit their existing understandings of student abilities as measured by placement tests" (Ngo, Velasquez, & Melguizo, 2021).

The CSU has its own version of the prerequisite barrier. Most CSU campuses still require various placement or proficiency tests, despite the CSU abandoning its statewide ELM test in 2018 and eliminating traditional remedial courses. Such impediments could nudge students away from pursuing STEM fields.

- All of the CSU campus websites indicated that students were required to take a placement test (usually ALEKS PPL[13]) before they could take a calculus course. Some also required students to take the test for precalculus or other STEM-oriented math topics.
- One CSU campus required students seeking entrance to a popular liberal arts major to pass a mathematics proficiency test after completing their gateway math course.
- Another CSU campus offered a math survey to help students "reflect" on their math course options. Since the survey questions were behind a firewall, we could not assess whether the survey supports students' sense of agency in making aspirational choices.

[13] ALEKS PPL is a commercially developed set of assessment and learning modules used by some colleges as a placement or self-placement tool. The acronyms stand for "assessment and learning in knowledge spaces" and "placement, preparation, and learning."

CLEAR SIGNPOSTS: PROMISING PRACTICES FOR ONLINE MESSAGES ABOUT MATH PATHWAYS

Our review of campus websites also highlights unique, creative, and student-centered approaches that institutions have adopted for providing math pathway information, support, and guidance. Although we have not evaluated these approaches beyond criteria summarized in Figures 1-5 above, they appear to align with the evidence for or the intention behind the reforms.

AVAILABILITY AND CLARITY OF MULTIPLE NONREMEDIAL MATH PATHWAYS

Elimination or reduction of remedial math offerings ensures that all, or virtually all, students enroll in college-level mathematics. This practice also makes websites far more useful for making decisions about courses. Among community colleges whose websites we reviewed, only **Pasadena** and **West Hills–Lemoore** have been identified by prior research as providing 90 percent or more of their fall 2019 introductory mathematics sections through courses that meet quantitative reasoning requirements for transfer (CCO & CAP, 2019). At the time, 68 percent of offerings statewide met the transfer requirements. That share may have increased in the intervening year.

Clear access to nontraditional math pathways, including statistics courses, ensures that students can make optimal decisions. Prior research has shown that, as of fall 2019, community colleges have decreased the proportion of introductory math offerings in STEM-related courses from 76 percent of offerings to 53 percent. This lower proportion is still much higher than the estimated one-quarter of students who major in STEM fields (CCO & CAP, 2019). Though our review did not include a quantitative analysis of offerings, or a

qualitative analysis of specific courses, it showed that institutions in both systems are offering a growing array of pathways and moving away from algebra-intensive courses for all students. Doing so can help meet needs of students across a range of disciplines. For example:

- **San Diego State** confers general education credit for a wide variety of courses outside the math department, including Computational Thinking (Computer Science), Geographic Information Systems and Spatial Reasoning (Geography), Introduction to Logic (Philosophy), and Infections and Epidemics (Public Health).
- While community colleges have a narrower range of offerings, several provide general education math courses outside of math departments. **Clovis**, for example, offers Discrete Math for Computer Science. **College of the Desert** and **San Diego Miramar** offer gateway math courses in their sociology departments. **Crafton Hills** and **Monterey Peninsula** offer courses on psychological research methods in their psychology departments.
- **El Camino** is an example of a community college prioritizing access to non-STEM introductory classes. The college offers 52 sections of Elementary Statistics with Probability and 24 sections of STEM-oriented gateway math (13 Precalculus and 11 College Algebra).
- **LA Trade Tech** offers a set of courses aligned with various credentials, such as Electrical Mathematics and Modern Merchandising Math, though they don't meet general education requirements for transfer.
- **Cal State LA** has eliminated College Algebra. We consider this a promising practice, because mathematics discipline leaders have noted that the course has no natural audience. It provides neither a true stepping-stone to calculus for STEM majors nor relevant preparation for liberal arts fields (Saxe & Braddy, 2015).

Transparency around math course alignment with specific majors also supports students in making effective decisions. Community colleges, including **Bakersfield**, **Pasadena**, and **Sierra**, link information about majors with program maps and their specific course pathways. **Cal State Monterey Bay** provides a list of majors and applicable introductory math courses and aligned majors. **Cal State LA**'s course finder allows students to plug in major and placement information to generate a list of the most relevant math course options. It also provides a link to an external site that provides information on courses at other schools that might meet the GE B4 (mathematics/quantitative reasoning) requirement. **Fresno State** students have access to term-by-term educational road maps (e.g., for a Bachelor of Science in biology) that outline required courses, including any specific requirements for general education math.

Clarity around college-level credit and transferability is also important for community college students. It can ensure that students enroll in courses that align with their educational goals. Colleges that continue to offer remedial courses should ensure that students understand the advantages of enrolling in college-level courses—with support, as needed. In our review, we unfortunately did not identify any good examples of colleges doing this. Clarity around transferability is also crucial. Some community colleges have labeled course descriptions to visibly signal to students whether a course will transfer to one of the 23 CSU or nine UC campuses. An example is **LA Trade Tech**'s catalog, where math course listings indicate transferability for each system right after the course title (e.g., "Math 225 Intro Stats [3] UC/CSU.")[14]

Clarity about course options via flowcharts or course lists supports effective decision-making by students. For example, flowcharts shared by **Cal State East Bay** and **Pasadena** are easy to read and offer updated guides to the sequence

[14] Math courses that don't meet the quantitative reasoning requirement for transfer to the CSU include courses that satisfy associate degree requirements, as well as noncredit math courses. While most courses that meet the CSU's general education requirement also meet UC's requirements, there are some exceptions, and not all sites provided clarity on those, instead referring students to counselors (which could constitute a barrier to students transferring to UC campuses).

of math courses for STEM and other pathways. Each prioritizes college-level courses that meet general education requirements to facilitate the goal of the reforms to offer every student access to a college-level math course. Details provided in Cal State East Bay's flowchart are consistent with the course schedule and catalog and illustrate the alignment with categories of majors.

Lastly, **clarity about the purpose of math requirements** supports students' agency in choosing mathematics courses. Courses should be relevant and offer observable benefits to students, rather than simply constitute requirements to check off. For example, **Cal State East Bay** shares the following rationale on its website:

"Area B4 courses provide practice in computational skills as well as engagement in more complex mathematical work. Upon completion of the B4 requirement, students will be able to:

- demonstrate a proficient and fluent ability to reason quantitatively;
- demonstrate a general understanding of how practitioners and scholars collect and analyze data, build mathematical models, and/or solve quantitative problems; and
- apply quantitative reasoning skills in a variety of real-world contexts, defined by personal, civic, and/or professional responsibilities."

Visibility and availability of concurrent support to ensure access to college-level math courses, as well as to maximize student success

Recent math reforms allow students to enroll in college-level courses when they begin their postsecondary journey. Students who previously would have been placed in a remedial math sequence that few were likely to complete now have an opportunity to spend less time and money to complete their educational plans.

Using corequisites in place of remedial coursework is an evidence-based, student-centered practice foundational to CCC and CSU math reform. However, effectiveness is contingent

on colleges offering sufficient numbers of corequisite course sections and students being aware of their availability. A promising practice that numerous colleges are implementing involves scheduling a support course immediately after the core course in a student's scheduling plan. This helps to provide additional time and space for students to work with the same instructor.

Helpful strategies for offering corequisite courses include:

- Offering a significant number of support sections in both precalculus and statistics. Colleges such as **Bakersfield**, **College of Alameda**, and **Allan Hancock** offer multiple sections in both topics. As a result, limited availability doesn't drive students to take a remedial course or choose a math pathway that does not align with their interests.
- Assigning a common course number to a core course and its linked support course. Among the community colleges reviewed for this study, several followed this practice. Ideally, the support course is embedded in the core course, so that students don't have to register for two separate courses. **Cal State LA** offers such courses.

Tutoring and Other Academic Support

Since the onset of the COVID-19 pandemic, students in California and beyond are experiencing an elevated need for academic support. A May 2020 poll by Education Trust, an education equity advocacy organization, found that 88 percent of students of color in California community colleges and universities expressed an interest in accessing tutoring, advising, or other academic support during the pandemic. At the time of the poll, only 51 percent of institutions were providing those services virtually.

Though our review of campus websites could not evaluate the quality of these services before COVID-19 or their availability since the pandemic started in March, it shows that all colleges and universities reviewed typically offer some form of math support. Commonly, campuses offered a learning lab or other physical space where students could drop in to access tutors, computers, videos, and calculators, among other forms of support. During our review process, colleges and universities continued to update their websites to provide virtual access to more of these services.

Some promising practices include linking math-related tutoring to specific classes. This is being done at **Bakersfield**, **Chabot**, **Pasadena**, and **Sierra**. **Sierra** is also offering a one-unit course on overcoming math anxiety. **College of the Desert** has started offering guided video resources for some math courses. **Cal State LA** offers peer-led undergraduate study sessions that are now being scheduled virtually.

Other forms of academic support include cohort-based programs such as MESA (Mathematics, Engineering, Science Achievement). MESA is offered at eight of the community colleges and two of the CSUs we reviewed. The program assists students, especially those from historically underrepresented groups, in pursuing STEM fields. Its offerings include community-building activities, study centers, and counseling. Students interviewed during our previous round of research for Go Figure noted that their MESA advisor was a particularly helpful resource.

Guidance for students who are undecided

Resources that promote career exploration for students are especially important for those who are undecided about their major. As highlighted in Go Figure, these students find it particularly challenging to make informed choices about math pathways. The most useful resources allow students to explore possible careers and make linkages to specific academic programs explicit (The Education Trust-West, 2020).

The **Bakersfield** and **Chabot** websites both provide such resources. Sites at other schools, including **LA Trade Tech**, **Pasadena**, **Shasta**, and **Sierra**, provide career exploration surveys and questionnaires without links to academic programs. **LA Trade Tech** and **Shasta** also provide links to career assessment tools, including information on skills, knowledge, and earnings associated with various jobs. **Pasadena** offers a career-planning course.

Students interested in choosing a major or changing their major also need support. **San Diego State** offers various online tools, including a "strong interest inventory," to assist these students in selecting majors or identifying career opportunities. The university has waived the fee for the interest inventory tool during the COVID-19 pandemic.

Undecided students, or those who have only tentatively settled on a major, could benefit most from these resources during their initial onboarding process, or as part of orientation and educational plan development. Well-designed websites would steer such students to these features via links on key pages.

Transparent, consistent, and asset-based information regarding placement policies

The CSU has systemwide placement rules that provide specificity and clarity for all 23

campuses; there is also an online placement estimator for students. Since the CCC system includes 114 colleges that are locally governed, the Chancellor's Office provides only general guidelines showing college personnel how to use high school coursework, grades in math courses, and high school grade-point average to determine a student's entry level in math. That flexibility allows each college to devise plans that are informed by local needs and strengths. At the same time, it makes transparency harder to achieve. Identifying appropriate courses for students to consider at forks in the math pathway is critical to supporting students' momentum toward completion and preventing them from languishing in the "shapeless river."

Regardless of what tools or resources a college website offers, simplifying the process for students is key.

The most straightforward processes, such as those used at **LA Trade Tech**, **Sierra**, and **West Hills–Lemoore**, asked students to submit a few pieces of information. These included students' high school GPA, list of math courses completed, and intended program of study. Based on this information, these colleges recommended math courses tied to a student's meta-major. At **Pasadena**, the submission is part of each student's application process.

As described in the Go Figure report, some community college counselors are pleased that they no longer have to steer students away from college-level courses. Instead, they can focus on helping students complete their math requirements within a year. In doing so, counselors report a need to discourage some students from pursuing remedial courses, or those that are less advanced than they are eligible to take.

A focus on helping students reach their goals puts the onus on colleges to be proactive in how they support their students. One way colleges are embracing this role is by using positive, asset-based language and messaging. We found several examples of this on pages devoted to placement:

- **College of Alameda:** "The faculty and staff in mathematics at CoA are dedicated to working hard with you—helping you succeed in a positive atmosphere that is conducive to your learning math in the most enjoyable and competent manner possible."
- **CSU:** The system's math placement estimator tells students: "You are on your way to a successful college experience."
- **Pasadena:** A video noting AB 705 reforms, tells students "Don't leave it to chance." It highlights students' ability to move directly into college-level courses, save money, and get support via corequisites and other college services.
- **West Hills–Lemoore:** "We are pleased to share that all students have an opportunity to qualify for transfer-level math and English using a 'new' placement guide which focuses on using your high school records instead of our old assessment tests. Using this information, we can provide you with a variety of academic and student support services to help you succeed!"

SIGNALING THE WAY FORWARD

"THEY GOT RID OF THE PREREQUISITE AND MADE IT INTO A COREQUISITE. I'M ETERNALLY GRATEFUL FOR THAT, BECAUSE I SAVED MONEY, AND I DID LEARN."

Mariam Shamon

"I FAILED TWO REMEDIAL MATH CLASSES. ... I WOULD HAVE HAD TO BE THERE FOR TWO MORE YEARS IN ORDER TO EVEN TRANSFER. MY COUNSELOR REFERRED ME TO THIS NEW [COREQUISITE] CLASS. ... I ENDED UP PASSING THE CLASS WITH AN A, BUT WE HAD AN EXTRA SUPPORT TEAM."

Rebecca Galicia

Colleges in California and across the nation are reforming their policies to ensure that more students can be successful in their math pathways and, ultimately, complete college. Research has shown that new math pathway policies can accelerate students' progress toward a college degree. If those pathways are effectively implemented, the door to STEM fields will remain open to students who, like Mariam, previously struggled with math. At the same time, students like Rebecca, whose interests lie outside of STEM, will not be hindered from pursuing their aspirations by irrelevant math requirements.

But students who aren't aware that such opportunities are available to them can't receive the benefits of the new policies. They could, like Javier, languish in remedial courses and emerge with no degree. Ideally, colleges need to be structured so that poor options, such as lengthy remedial sequences, are not even offered. Still, even with only good options available, students need support in making the choices most suitable for them.

This study echoes prior research (Rosenbaum, et al., 2006; Scott-Clayton, 2015) that found that marginalized students often lack the timely and accurate information they need to make decisions that best advance their educational progress. As Scott-Clayton notes, "There is little substantive argument against providing students with better information—and better ways to search and navigate this information—to help them manage the sheer complexity of gathering and correctly utilizing all of the relevant information on the costs, benefits, and requirements of alternative educational paths" (2015, p. 119).

This analysis specifically underscores the need for websites—as the primary and, in some cases, only source of connection and information for students—to more effectively support students

If those pathways are effectively implemented, the door to STEM fields will remain open to students who, like Mariam, previously struggled with math. At the same time, students like Rebecca, whose interests lie outside of STEM, will not be hindered from pursuing their aspirations by irrelevant math requirements.

in understanding their math course options. Websites offering comprehensive and transparent information can enhance students' understanding of their math placement options and make the process more seamless and effective. (For specific recommendations that institutions can consider, see the Checklist for Strengthening Math-Related Guidance on pp. 34-35.)

That is even more true today, as colleges and universities in California and elsewhere have completely shifted to an online world, in order to mitigate transmission of the new coronavirus. The CSU and CCC systems were among the first to announce their intention to operate primarily online in Fall 2020. This shift has predictably created significant challenges for students, three-quarters of whom say they are worried about their grades or about whether they'll be able to graduate (Education Trust: The Education Trust-West, 2020).

In addition to the specific challenges of distance learning, basic needs for California college students have dramatically escalated since the pandemic began. More than 75 percent of students are worried about not being able to afford tuition. About 50 percent of students are also concerned about affording food and housing. Only a third say that their college or university is providing emergency financial support. Therefore, it is no surprise that about two-thirds of students are feeling higher-than-usual stress levels (Education Trust: The Education Trust-West, 2020).

With students facing so many needs amid the shift to distance learning, a shift that will continue at least through the fall at the two California systems and many others, it is more important than ever that students receive relevant guidance about math courses as seamlessly as possible.

To examine further how students access online information and other college resources to make critical decisions about their math course-taking, our next phase of research will supplement these findings with quantitative analyses as well as qualitative research. The goal is to delve more deeply into how campuses are implementing math reforms as they respond to the challenges of distance learning. We will also examine how students have experienced those changes, a key indicator of their success.

Checklist for Strengthening Math-Related Guidance on College and University Websites

Criteria of Focus	Recommendations
Information on math placement 	• Simplify math placement processes by streamlining steps students take to identify recommended courses • Use asset-based language and positive messaging that highlight the benefits of enrolling in college-level or transfer-level courses (e.g., saving time and money, accessing available support, seizing opportunity to enroll in college-level coursework without undergoing testing) • Communicate the rationale for current policies and what they mean for students' long-term success • Eliminate mentions of assessments or tests when discussing placement • Confirm accuracy and currency of placement information regularly and update, as needed • Focus on the responsibility of the college to provide the support that students need
Location of information on math 	• Outline general education math options consistently across various webpages, e.g., math department, pages for onboarding, registration, and (for community colleges) transfer • Place math information on pages where students are most likely to search for it • Research accessibility of information through focus groups, surveys, or beta-testing
Guidance for undecided students 	• Offer opportunities to explore career interests and the skills and knowledge needed, and their connection to available programs or areas of study • Provide clear direction on who can support students' educational planning and offer multiple time windows and methods for reaching them (e.g., phone, email, chat) • Outline complete descriptions of various STEM, statistics, and liberal arts math pathway options • Identify and implement strategies to engage proactively with and offer guidance and direction to students who are undecided

Checklist for Strengthening Math-Related Guidance on College and University Websites, Cont.

Criteria of Focus	Recommendations
Explanation of math pathway options 	• Explain why a math course is required and its learning outcomes • Offer clear descriptions or program maps illustrating various math pathways and their alignment with majors • Include course numbers and names on program maps, flowcharts, and course lists • Eliminate or limit remedial prerequisite courses and present college-level courses as default options for the majority of students • Clarify the status of courses as relates to students' transfer or program goals
Availability of math-specific supportive services 	• Offer corequisites and other just-in-time approaches to support students' success in college-level courses • Consider embedding corequisite support into core courses rather than as a free-standing course, to integrate instruction and allow students to register for a single class • Incorporate career planning into the onboarding process and highlight alignment with specific majors and programs • Offer course- or pathway-specific tutoring • Ensure that academic support services, such as tutoring, math labs, and other resources, are clearly listed on websites with information on how to access them

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