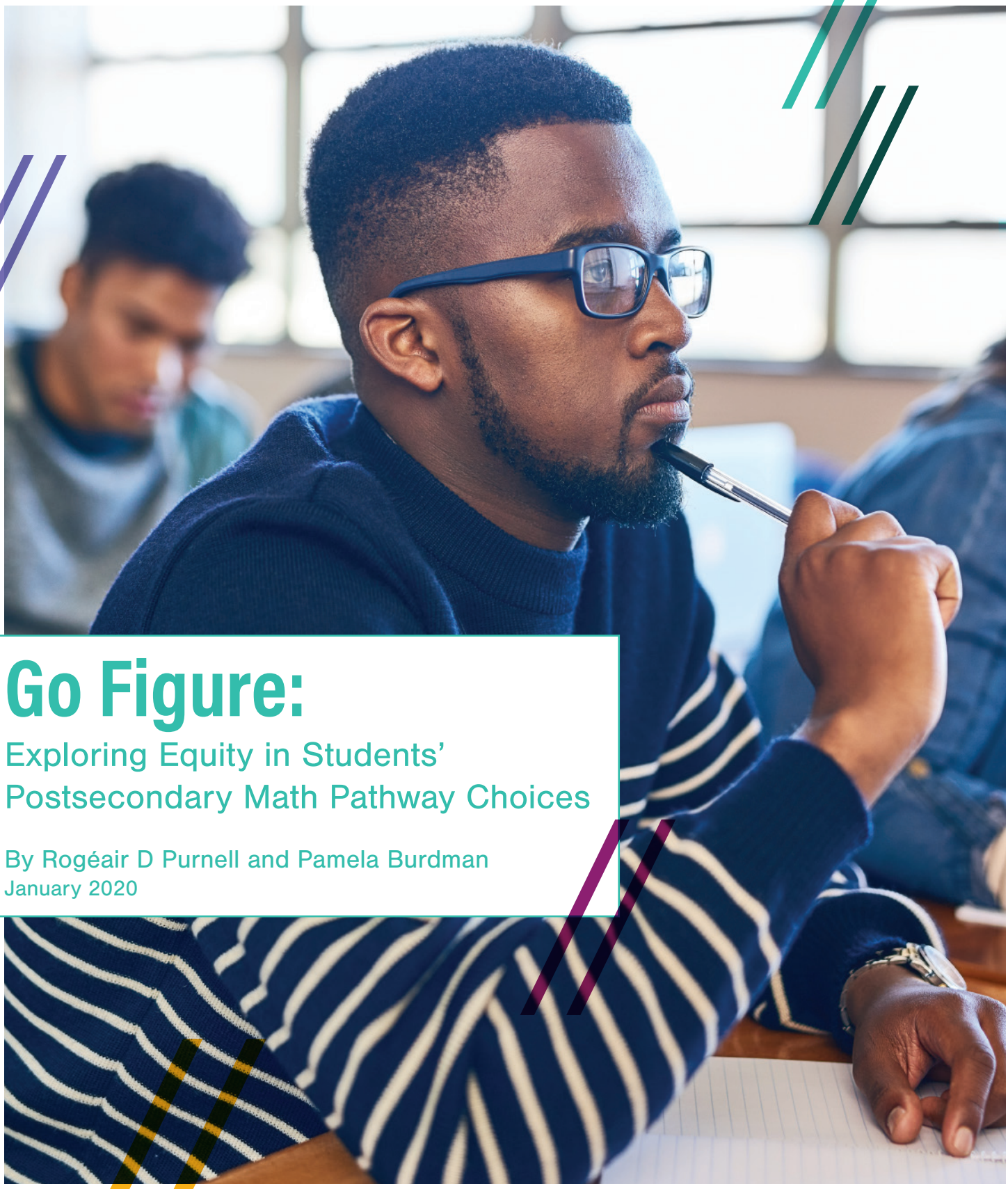

Go Figure:

Exploring Equity in Students' Postsecondary Math Pathway Choices

By Rogéair D Purnell and Pamela Burdman

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

ABOUT THE AUTHORS

Rogéair D Purnell, PhD is a researcher, evaluator, and facilitator and the principal 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.

Pamela Burdman, founder of Just Equations, is a policy analyst and strategist on college access, readiness, and success. 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.

INTRODUCTION

The traditional architecture of math opportunity often treats math as a gatekeeper that can stop students—particularly low-income students, students of color, and women—in their educational paths. Even in the absence of explicit bias, this architecture is undergirded by faulty assumptions about math ability that ration access to college opportunity in inequitable ways (Burdman, 2018).

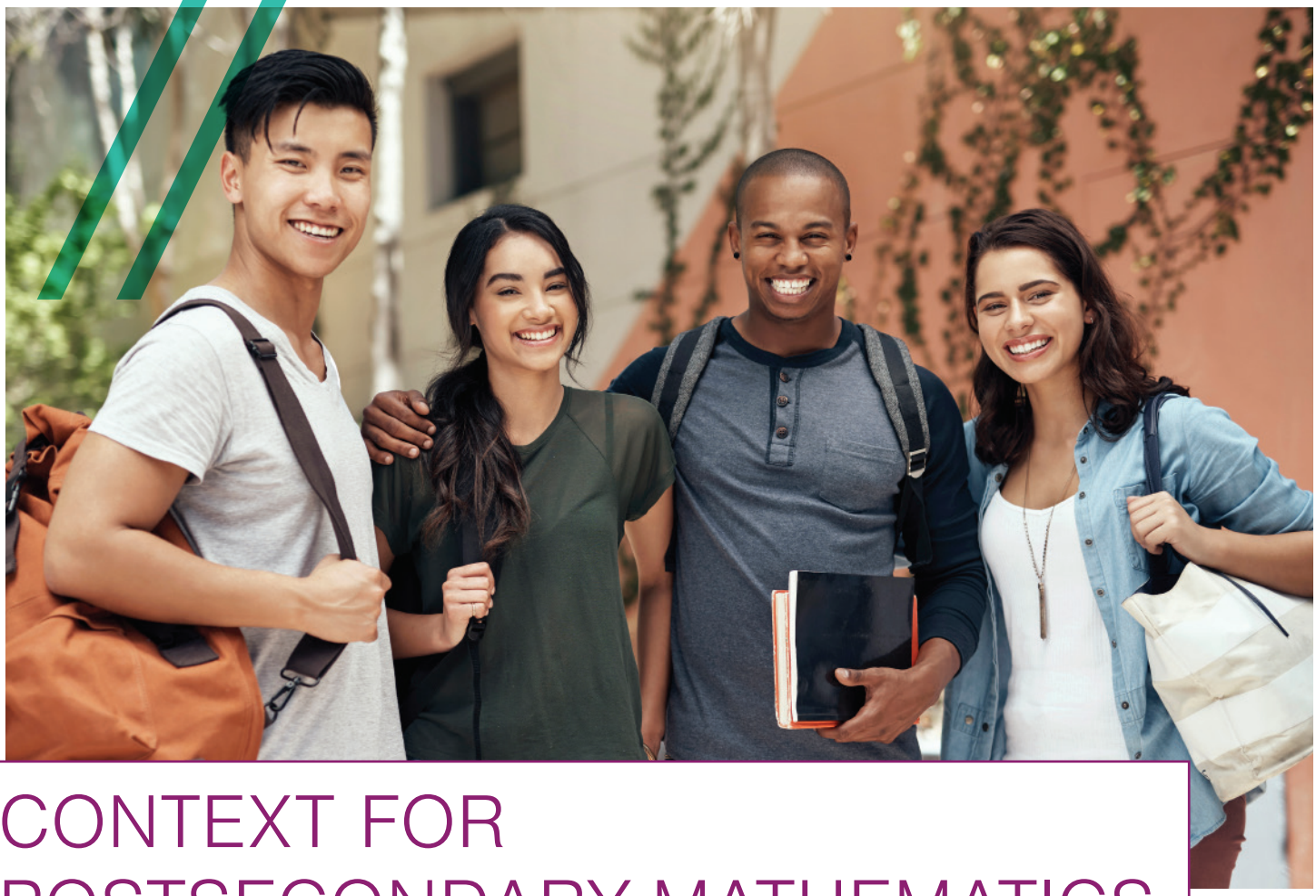
Across the country, higher education leaders have begun to recognize the need to revamp their approach to mathematics preparation to ensure that it supports student success and equity. Colleges and universities are adopting new evidence-based strategies including multiple measures placement, diversified mathematics pathways, and just-in-time supports such as corequisite courses. These reforms are expected to improve equity in outcomes by eliminating barriers that arbitrarily prevent students from successfully completing college and disproportionately impact low-income students and students of color.

However, more evidence is needed about the implementation of these new approaches to understand whether and how they promote more equitable outcomes. For the reforms to disrupt patterns of inequity, they need to reinforce the role of math in preparing students for their futures as opposed to sorting or filtering them. In particular, it is important that new math course options are broadening the opportunities available to students—without diverting them from pursuing pathways that lead to careers in STEM (Science, Technology, Engineering, and Mathematics).

To shed light on equity dimensions of math pathway implementation, we need to understand how students "figure out" which mathematics courses to take—and the structures that support or hinder them in making appropriate and aspirational choices. To begin examining this question, Just Equations invited Rogéair Purnell of RDP Consulting to lead an exploratory qualitative study at three California postsecondary institutions. The study is intended to highlight key equity issues in students' math choices and experiences and point to future research that will inform equitable implementation of the new strategies in California and other states.

Go Figure begins with an outline of the evidence that catalyzed new policies, background on the new reforms, and initial results from early adopters about their effectiveness in addressing inequitable outcomes. That is followed by an overview of the research methodology and key findings, including initial student outcomes from the three institutions. The report also includes recommendations for strengthening counseling and guidance in mathematics course selection and improving students' experiences in math class. The final section presents conclusions and points to directions for future research.

Pamela Burdman
Director, Just Equations



CONTEXT FOR POSTSECONDARY MATHEMATICS PATHWAY INNOVATIONS

RESEARCH BASIS FOR REFORMS

Higher education institutions in California and across the country are transforming their approach to math education, with community colleges leading the change in many states. Traditional remedial education, originally intended to help underprepared students succeed in college-level courses, in fact was serving as a barrier for too many students, as research over the past decade has highlighted:

- **Traditional placement tests have limited validity:** The exams assign some students to developmental math who could have succeeded in college-level courses (Scott-Clayton, Crosta, & Belfield, 2014). About 20 percent of community college students (and more than 40 percent in California) are unnecessarily repeating courses they already passed in high school (Ngo, 2019; Burdman, 2015b). Research consistently shows that high school grades are a stronger predictor of success in college (Scott-Clayton, 2012).
- **The stakes of placement are high:** Taking developmental math often decreases students' chances of completing college (Community College Research Center, 2014), such that differences in placement have been shown to explain more than half of the gap in college completion (Stoup, 2015). Placement into lengthy math sequences creates a particular deterrent (Bailey, Jeong, & Cho, 2010; Xu & Dadgar, 2017; Hern, 2010).

- **The burden falls heaviest on students of color:** African American and Latinx students, often underserved in the K-12 system, are typically more likely to be placed into remedial courses than other students (Ganga, Mazzariello, & Edgecombe, 2018). For example, in California's community colleges, nearly 85 percent of African American and Latinx students were taking remedial math courses, compared to 72 percent of white students and 52 percent of Asian American students (Cal-PASS Plus, 2018). Underrepresented minority students were also more likely to be placed into longer remedial sequences. In California, for example, about 40 percent of African American students and 30 percent of Latinx students were placed into arithmetic, the lowest-level math course, drastically reducing their chances of completing college. Only about 15 percent of white and Asian students were assigned to arithmetic (Perry, Bahr, Rosin, & Woodward, 2010).
- **Traditional math requirements create irrelevant hurdles for many students:** The content of remedial math sequences offered limited preparation for most students' eventual fields of study: The algebra-intensive sequences typically required were designed to prepare students for STEM (Science, Technology, Engineering, and Mathematics) fields that require calculus. The sequences that deterred many from proceeding with their education did not offer students quantitative content relevant to their areas of study, such as statistics, data science, or mathematical modeling (Burdman 2015a; Burdman, Booth, et al., 2018; Liston & Getz, 2019).

Overall, the remedial math sequences that were supposed to be a foundation for success were actually serving as a filter preventing many students from progressing in college and exacerbating racial equity gaps (Scott-Clayton & Rodriguez, 2015; Mejia, Rodriguez, & Johnson, 2016). The courses served to delay students' progress toward a degree while providing more exit ramps for them (Xu & Dadgar, 2017).

THE POLICY RESPONSE

The response to this evidence, especially among community colleges, has been significant. Colleges have reduced remedial course-taking by changing placement practices and policies. The new approaches include corequisite courses, in which students can enroll in college-level courses and receive just-in-time support to succeed in those courses.

- By 2016, 57 percent of community colleges nationally were using **multiple measures** for placement, effectively putting greater weight on high school grades than in the past. This represents more than double the proportion of colleges that did so in 2011 (Rutschow & Mayer, 2018).
- By 2015, more than half of U.S. community colleges reported offering some form of **diversified math pathways**, redesigned courses or sequences that offer students the chance to accelerate through non-algebra-intensive introductory courses such as statistics and quantitative reasoning in addition to STEM-oriented options (Blair, et al., 2018).
- As of 2018, higher education systems in 15 states were mandating or encouraging **corequisite courses** (Rutschow, 2019). Corequisites are a form of just-in-time support that can be embedded into a college-level course or offered as a separate course parallel to a college-level course.

The net result of these reforms has been a dramatic drop in remedial math course-taking at community colleges nationwide. From 2010 to 2015, such course-taking fell proportionally by about 20 percent, including a 42 percent plunge in arithmetic enrollments, according to a national survey about undergraduate math course-taking (Blair, et al., 2018). Given that more states—including California—have adopted new policies since the survey was conducted, the extent of remedial math-course-taking is likely far lower today. In fact, reduction or elimination of remedial courses is considered integral to the success of corequisites and other reform approaches (Campaign for College Opportunity & California Acceleration Project, 2019).

Over the past decade, some of California's community colleges have been early adopters of innovations such as multiple measures placement and diversified math pathways, as well as corequisite courses. Now, by the fall of 2019, under a new law that drastically limits community colleges from placing students into remedial math courses, all colleges in the state had begun implementing these approaches at least to some extent (See: Parallel Systems, pp. 8–9).

Four-year universities have been somewhat slower to adopt such reforms, perhaps because their remedial enrollments have been proportionally lower than those of two-year colleges. In 2017, California State University (CSU) took a bold step in that direction, joining systems in states such as Tennessee and Georgia in eliminating stand-alone remedial courses in favor of corequisites and other just-in-time strategies. CSU went a step further than those states and also ceased using its placement test. The 23-campus system also voided a policy that had said any college-level math course needed to have an intermediate algebra prerequisite. Because intermediate algebra is not a true prerequisite for a course such as statistics, the new policy states that the prerequisite (or corequisite) for a college-level math course should consist of material that is actually required for success in the course.

EARLY EVIDENCE ON EQUITY

Researchers have suggested that these new strategies have the potential to make college opportunity more equitable, given that students of color disproportionately face remedial barriers. But some research has shown that developmental reforms expected to help students of color don't necessarily have that effect (Braithwaite & Edgecomb, 2018). This suggests the importance of monitoring implementation as well as outcomes, especially if equity is the goal.

Non-Algebra Pathways. Early research showed that statistics pathways led to dramatic improvements in completion of math or quantitative reasoning courses for students regardless of race or ethnicity. The California Acceleration Project's Path2Stats model produced improved outcomes across gender and race/ethnicity (Hayward & Willett, 2014).

However, such results can depend on implementation: Researchers in California found that even though the statistics pathways vastly improved outcomes for all demographic groups, there remained a statistically significant gap in outcomes for African American students (Rodriguez, Johnson, Mejia, & Brooks, 2017). They suggest that professional development for faculty could help shrink that gap through culturally-responsive teaching approaches. Furthermore, whatever benefits do exist for statistics pathways can accrue only for students who enroll in the pathways: A study in Texas found that students who enrolled in alternative remedial math pathways developed by the Charles A. Dana Center outperformed other students. The problem was that the pathways were offered only to a subset of students, and the majority of those who accessed those pathways were disproportionately white (Schudde & Meiselman, 2019).

Corequisites. The benefits of corequisite approaches have been particularly dramatic in general and in terms of shrinking the achievement gap. When Tennessee adopted the policy to assign all students to corequisite courses instead of remedial courses, the state witnessed a six-fold improvement in outcomes for non-white students, compared to a four-fold improvement for other students (Tennessee Board of Regents, n.d.).

Combining statistics pathways with corequisites, then, should have strong potential for reducing equity gaps, exactly what Alexandra Logue and colleagues (2019) found. Their study concluded

that City University of New York students who were underprepared and were randomly assigned to a corequisite statistics course rather than an elementary algebra remedial class were significantly more likely to pass college-level mathematics courses as well as to graduate three years later. "Given students from underrepresented groups are more likely to be assigned to remediation than are other students, then assigning students to statistics with corequisite support instead of traditional remediation would decrease racial/ethnic graduation rate gaps," they wrote.

LINGERING CONCERNS AND NEED FOR RESEARCH

A particular concern with diversifying math pathways has been whether the new pathway options, such as statistics, afford the same opportunities as do the traditional STEM pathways. Equity advocates are understandably wary of any potentially "separate but equal" strategies, especially given the history of tracking and the use of math as a filter in the education system. Success in STEM-oriented math courses has long been seen as a ticket to college and career success.

"STEM college graduates are predominantly white or Asian, a pattern that has persisted for years despite historically high black and Hispanic college attendance and completion rates," notes the Brookings Institute (Dougherty, et al., 2017). In California, though about 45 percent of California's working age adults are African American and Latinx, only about 17 percent of the engineering workforce are African American or Latinx. (Campaign for College Opportunity, 2016). A recent study notes the limitations that community colleges face in addressing inequities in STEM fields: Though women and students of color enroll in entry-level STEM courses, they are much less likely to progress to more advanced courses in those fields (Bahr, Jackson, McNaughtan, Oster, & Gross, 2017).

Just Equations has argued that non-algebra pathways need to be rigorous and prepare students to succeed in various fields of study. And to ensure that they are truly expanding opportunities, rather than merely continuing the pattern of diverting historically disadvantaged students from STEM careers, Just Equations' *Principles for Equitable Math Pathways To and Through College* (2019) also calls for features such as:

- Resources aligned to individual needs
- Agency for students in choosing math pathways
- Student-centered teaching
- Bridges between pathways (not dead ends)

To understand equity implications of these new pathways, it's important to monitor the quality of the courses as well as their outcomes, as some of the research cited above has begun to do. At the same time, studying students' experiences in navigating the pathways is essential to illuminate those outcomes and to guide implementation. That is what *Go Figure* aims to do.

PARALLEL SYSTEMS:
Postsecondary Math Pathway Reforms in California

		California Community Colleges	California State University
BEFORE	**Placement process**	Most colleges required students to take a placement test. A number of different tests were used across the system.	Students were required to take the Entry-Level Mathematics (ELM) examination (unless their high school records exempted them).
	Test scores	Cut-off scores for placement into remedial math varied by college, even among colleges using the same test.	Students with an ELM score below 50 had to take some form of remedial course. Students who scored "ready" on an eleventh grade test were exempt from the ELM. Those who scored "conditionally ready" were exempt if they passed an approved high school course, such as Pre-Calculus.
	High school records	Many colleges adopted "multiple measures" algorithms that incorporated students' high school grades and courses in addition to placement test scores. Some also accepted SAT, ACT, and AP scores.	Students with certain scores on tests such as the SAT, ACT, and AP could be exempt from remedial math testing, according to system policies.
	Remedial alternatives	Some colleges began implementing non-algebra-based remedial courses that prepared students for college-level statistics.	Students could begin, and in some cases, finish their remedial math sequence through a summer "Early Start" course.
	Remedial sequence	Remedial sequences ranged from one to four courses.	Students had up to three chances (summer, fall, and spring) to complete their remedial sequence before facing disenrollment.
	Prerequisite	Alternatives to intermediate algebra were accepted, however UC/CSU policy applied to students seeking to transfer.	Intermediate algebra was considered a prerequisite for all general education math courses.

		California Community Colleges	California State University
AFTER	**New Policy: 2017**	Legislature passed Assembly Bill 705	Chancellor issued Executive Orders 1100 and 1110
	Implementation timeline	Took effect in Fall 2019	Took effect in Fall 2018
	Placement test	Placement tests were eliminated, and the system ceased work to develop a common statewide assessment instrument.	Entry-Level Mathematics test was eliminated. (Some campuses continue to use tests for placement into calculus-path courses.)
	Placement	Students cannot be placed into remedial courses unless research shows such placement will increase their chances of success in the college-level course.	All students are placed into a credit-bearing math course based on a complex matrix that accounts for high school courses and grades, test scores, and interest in STEM vs. non-STEM.
	Remedial courses	Though students cannot be placed into remedial courses, some colleges continue to make them available to students.	Stand-alone remedial courses were eliminated, though some of the content is covered in summer "Early Start" program.
	Just-in-time support	Many colleges offer corequisite courses, supplemental instruction, and other forms of just-in-time support for introductory math courses.	Most campuses offer corequisite courses, stretch courses (i.e., two-semester versions of courses), and other forms of just-in-time support.
	Pathways	In addition to STEM options, colleges are offering statistics, quantitative reasoning, and other introductory transfer-level math options.	General education math courses can include computer science, personal finance, statistics, or other quantitative reasoning courses.
	Prerequisites	Intermediate algebra is no longer a blanket prerequisite for all college-level math classes.	Prerequisites must be reflective only of skills and knowledge required in the course. (Intermediate algebra is not a blanket prerequisite.)

THE CURRENT STUDY: OVERVIEW AND METHODOLOGY

As community colleges and universities in California and nationally focus more explicitly on offering diverse math pathways aligned with students' goals, it is important to understand whether students have equitable access to these pathways, regardless of characteristics such as their race, ethnicity, income status, or gender. A related question is how adoption of new pathways interacts with placement and corequisite reforms, since they are often pursued in tandem. The reforms would not achieve their intended goals if they were to perpetuate tracking of certain student groups into non-STEM or (for community college students) non-transferable math sequences at odds with students' long-term educational goals.

The current study focused on how students were affected by math pathway reforms in California colleges and universities that included broadening the math pathways available to students, as well as offering students greater autonomy over their math pathway choices. The new policies, which were adopted in the state in 2017, parallel postsecondary math pathway reforms occurring in other states (See: Parallel Systems, pp. 8–9).

California Community Colleges. The legislature passed Assembly Bill 705, which requires colleges to ensure that students complete college-level math and English within a year of their first attempt. The law also says that students should not be placed into remedial classes unless research shows that doing so will increase their likelihood of completing a college-level course. Though the law did not explicitly require the use of diversified math pathways or corequisite courses, those are two strategies that colleges are adopting in order to comply with the new law (Burdman, Booth, et al, 2018). Those strategies are also compatible with colleges' work to implement Guided Pathways, which organize programs into meta-majors[1] and map programs to career and transfer outcomes to help students stay on track and complete their programs efficiently. AB 705 officially took effect in the fall of 2019, but some colleges—including those in this study—began making some changes before then.

California State University. CSU Chancellor Timothy P. White issued two executive orders, both of which took effect in the fall of 2018. Executive Order 1100 on general education courses stated that general education mathematics/quantitative reasoning courses can include "computer science, personal finance, statistics or discipline-based mathematics or quantitative reasoning courses," and that prerequisites for the courses should be "reflective only of skills and knowledge required in the course" (CSU, 2017b). (This negated a previous policy stating that general education math or quantitative reasoning courses must have an intermediate algebra prerequisite.) Separately, Executive Order 1110 eliminated the system's math placement test and ended the use of traditional remedial courses, replacing them with corequisites and other just-in-time strategies to support student success (CSU, 2017a).

Community college students seeking to transfer to a California public four-year university must complete general education courses that meet the CSU (or UC) systems' general education requirements. So CSU's revised policy on general education math afforded community colleges

[1] Meta-majors refer to clusters 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 Guided Pathways, a student-centered institutional transformation framework, adopted by the California Community College system.

greater latitude in math pathway offerings. All three higher education systems now allow general education math courses aligned with a range of pathways, such as statistics, data science, and quantitative reasoning courses, in addition to traditional STEM-pathway courses such as pre-calculus. Though pathway availability tends to vary by system or even by college, the most common non-STEM pathway course in both California systems has been statistics (Academic Senate of the California State University, 2016; Burdman, Booth, et al., 2018). Since many business programs require a STEM-pathway math course, some colleges refer to STEM pathways as B-STEM pathways.

Under both systems' new policies, students play a primary role in placing themselves into math courses, often with support from counselors or faculty. To explore whether early implementation of these policies was encouraging and promoting aspirational math pathway selections, the overarching research question asked:

Does implementation of new math pathway strategies increase and support math success for students, particularly those who are historically underrepresented on college campuses and in STEM-related majors/fields?

The study paid primary attention to three areas: (1) the type of information and guidance provided to students, (2) the degree of agency students experienced in choosing math courses, and (3) the range of intentional strategies employed to help students be successful in their math pathways (See: Specific Research Questions).

Specific Research Questions

Regardless of their high school math course taking patterns and grades, what **information** are students given and in what ways are students counseled to consider math pathways associated with STEM and non-STEM fields, especially if their interests include STEM-related careers?

How are students given **authentic agency** in their choice of math pathway regardless of personal characteristics?

What are some **intentional strategies** to ensure that all math pathways foster quantitative skills in rigorous ways and that students successfully complete their math pathways?

COLLEGE SELECTION CRITERIA

The researcher and the director of Just Equations contacted a number of community college and California State University (CSU) colleagues to identify institutions that had:

- Implemented changes to math counseling and guidance aligned with noted math reforms (i.e., AB 705, Executive Order 1100, 1110)
- Clear STEM and non-STEM pathways
- A substantial number of African American and Latinx students

Among the three CSU campuses and five California community colleges that were initially contacted, College of Alameda, California State University, Sacramento (Sac State), and Los Angeles (LA) Pierce College administrators and faculty expressed a willingness and interest in sharing their stories of early implementation and recruiting students to participate in focus groups.

METHODOLOGY

This qualitative research study relied on student focus groups and interviews with administrators, counselors, and math chairpersons to investigate various approaches, structures, policies, and practices associated with math-related guidance, counseling, and supports. The interviews with administrators and faculty were conducted in person on the day of the student focus groups or, in some cases, subsequently by telephone. These 30- to 45-minute conversations focused on mathematics guidance, coursework, and support, as well as advice for other college colleagues about how to improve students' math experiences. As with the student focus groups, these conversations were audio-recorded and transcribed.

Administrators and faculty helped to recruit students from math courses and in common areas on campus to participate in 60-minute conversations guided by nine questions designed

to explore students' experiences selecting, enrolling, and completing math courses at the participating colleges. They were also asked to offer suggestions to their peers based on lessons learned. The audio-recorded conversations were transcribed to ease coding and analyses. Each participant received a $20 Target gift card in appreciation for their time.

The student focus group and college representative interview protocols can be found in Appendices A and B, respectively (available online only).

PARTICIPANTS

A total of 37 students across the three colleges—College of Alameda, LA Pierce College, and Sac State—volunteered to participate in focus groups. Students were recruited from math courses through teachers and counselors, and in one case, in common areas on the campus. Four groups were scheduled; two at College of Alameda, and one each at LA Pierce College and Sac State. Most of the participants were students of color in STEM-related majors. The majority (22) were enrolled in or had completed pre-calculus. Statistics, which is accepted as a general education math course for most non-STEM majors, was the second most common nonremedial course. However, because some of the students had begun their academic careers before the new policies had been fully implemented at their campuses, about a third of students had also taken intermediate algebra, a remedial course that is no longer required in either system. Most students landed between loving math and considering the subject important to their life and career and seeing it as a necessary requirement that they could complete even if it didn't clearly relate to their long-term goals. (For additional characteristics of the students, see: Student Focus Group Participants).

Interviews with college representatives included conversations with math chairs at the three institutions. At all three, statistics and math are offered in the same department. The remaining interviewees were administrators, classified staff, counselors, or managers. Many of those interviewed had been at their institutions for many years, but tenures ranged from less than one year to 23 years. All had been involved in the design and implementation of math reforms at their institutions.

Student Focus Group Participants

- Thirty-seven students (15 College of Alameda, 15 Sac State, 7 LA Pierce)
- Had completed one to six semesters
- Nineteen female and 18 male students of various ages
- Included first-year and continuing students, including many (among the community college students) with a goal of transferring to a university
- Business or STEM (B-STEM) (22) and non-STEM (12) majors; only 3 were undecided
- Large majority were students of color
- Majors: art, biology, business, child development, computer science, engineering, environmental sciences, finance, IT, kinesiology, physical science, psychology, social work, and Spanish

LIMITATIONS

The students in the study are not broadly representative of college students. Many of the students who participated in this study were recruited through their math courses or by their math instructors and volunteered to participate. Though fewer than 10 percent of community college graduates and only about 20 percent of university graduates earn STEM degrees (NCES, 2019), most of the students who participated were STEM majors who were taking or had taken a pre-calculus course. Instructors in these courses may have had greater success in encouraging students to participate. One possible explanation is that STEM students could be more confident in their math skills and therefore more willing to discuss their math guidance and placement experiences.

In addition, given that students were not randomly chosen, focus group findings cannot be generalized to the entire College of Alameda, LA Pierce College, Sac State, or the CSU or California community college systems. The nature of the conversations was likely influenced by the particular personalities, interests, and dynamics of the participants. It is possible that important issues may not have been raised or sufficiently explored given who volunteered to be part of these conversations. Further, the limited scope of the study also did not allow for conclusively assessing whether students' experiences resulted from implicit bias.

Lastly, as mentioned above, though the timing of the study coincided with the adoption of the new policies, some of the students who participated in the study had taken their initial math courses under earlier policies, when remedial course-taking was more common.

Nevertheless, the students' comments and feedback may offer useful insights for colleges as they consider how specific guidance and counseling procedures, practices, and systems affect equity in students' math access and course selection. In addition, they underscore critical questions that future research can more thoroughly explore and point to recommendations that additional study can potentially confirm.

RESEARCH QUESTIONS AND FINDINGS

The following section highlights common themes and experiences of students and insights from administrators[2] at the participating colleges gleaned from the focus group conversations and interviews. The high-level findings are as follows:

- Because of experiences with inconsistent or inaccurate information, students triangulate information to decide which courses to take and with which instructors. This is especially true for community college students seeking to transfer, given the need to consider policies at one or more potential four-year destinations.
- Since math pathways are intended to align with students' fields of study, counseling is more effective, and information is better received, if a student has selected a major or area of interest or, in the case of community college students seeking to transfer, narrowed down their desired destination. Undecided students in particular could benefit from additional counseling support that offers major and career exploration.
- The elimination of placement testing removes the specific risks associated with tests, but first-generation students or students with lower math confidence, which include significant proportions of students of color, may not make optimal choices under self-placement mechanisms, suggesting the need for improved communication about options as well as other safeguards.
- Students recognize and appreciate colleges' efforts to expand structured and proactive support and instructional strategies—such as corequisites and support courses—to ensure more students have needed math support.
- A safe and empowering classroom environment that builds students' confidence as well as math mastery is critical and students tend to prefer faculty who are known as supportive.

Research Question 1:

Regardless of their high school math course-taking patterns and grades, what information are students given and in what ways are students counseled to consider math pathways associated with STEM or non-STEM fields if their interests include STEM-related careers?

The first research question focused on any counseling, guidance, and information students had accessed to make decisions about enrolling in math courses. This question included the type of information provided, in what forms, and through what vehicles. Students need such information to engage in the self-placement process required by the state's community colleges and some CSU campuses. Information abounds—through outreach to high schools, the application process, initial acceptance email or letter, self-placement tools, websites, catalogs, flyers, posters, student portals, counselors, online resources about transfer, peers, and social media, but these information sources are not accessed equally. Nor are they always up to date.

Administrators and students noted three sources as foundational to helping students be aware of and have the details necessary to select the appropriate math course given their math background and their academic and/or career goals:

[2] To maintain the college representatives' anonymity, the general term "administrators" will be used when highlighting specific quotes from their interviews, including interviews with math chairs.

- Print materials
- Counselors
- College websites and other online resources

These resources are often used in conjunction with each other.

Printed Materials. Flyers, posters, checklists, and course catalogs were common printed materials that let students know about new requirements and the self-placement process[3]. Ideally, course catalogs were updated to offer additional details on available math courses such as the pre- and corequisites as well as transferability of community college courses. However, the pace of reform has created difficulties in providing timely, accurate, and consistent information across such a wide range of information sources. As one administrator lamented:

Administrator:

One of the things that we've struggled with as a department is, because we made all these changes, sometimes is that information is a little inconsistent when it permeates out. And in some sense, we've had to fight a sort of a disinformation campaign ...the website too, that's another issue we've had because some of that information on our catalog is already outdated...We have to put the information up a year ahead. For example, math [course number], I believe in the catalog, it still says [it] requires a diagnostic test score of [certain number] or higher. That's not true... by the time we got around to rolling out math [course], that that score, if you have a pulse, you qualify for at it... [but] the changes in catalog lag behind...

Counselors. Students' experiences with counselors varied. Regardless of what information the students had accessed, several community college students and a few Sac State students reported that they valued the counselors' input. In some cases, students—particularly those who were pursuing a major in Business or STEM (B-STEM) and were planning to transfer—noted that a counselor had provided accurate and timely math selection information. However, several other students reported meeting with counselors who provided confusing or inaccurate information, perhaps due to misunderstandings about students' goals or lack of knowledge about specific majors or meta-majors and their math requirements. In these cases, students were often unsure of whom to turn to for clarification.

Some participants, particularly those who were undecided or choosing between two majors, wished that sessions with their counselors could have been extended. With more time, the sessions could go beyond developing an education plan to allow more discussion and attention to students' long-term goals and choice of major, students commented.

In one group, students suggested that an undecided student in the group see a special program counselor for STEM students who would be able to devote more time for each counseling appointment. Students who had spent extended time with a special program counselor reported feeling more informed and confident in their educational plans. One student reported feeling more connected to their desired transfer institution after working with a specialized counselor.

Student:

I don't know if you guys are like STEM majors, but MESA is like one of the programs that we have here at [the college] for engineering or just for science or like stuff that's science based. Anything like math based... There's just one counselor ...and she's really good and she knows her stuff... So if [other counselors are] not working out for you and you're a STEM major, I recommend her.

[3] Assembly Bill 705 requires implementation of a guided placement process for mathematics/quantitative reasoning that takes into account a student's high school performance data. Many colleges have employed a self-guided approach that encourages students to complete a brief online form that asks them to reflect on and evaluate their academic history, educational goals, and familiarity and comfort with topics in mathematics. Students receive a recommended course placement at the completion of the placement process.



Student:

[This same counselor] helped me a lot with engineering. She made me contact the, engineering people [at the UC where I wanted to transfer]. She led me to be connected with them so when I transfer, it will be easy.

Student:

.... I made an appointment [to see a counselor to develop an education plan], but it still seemed kind of rushed and the counselor didn't really know all of the requirements I needed because the UCs changed a lot, especially for math. Like I had to find out from [another student] the class wasn't available at any [college district] schools. And then I needed math [course number] ...but it said I needed like algebra and geometry, which I didn't need...I understand there's a lot of ... changing [information] so it's kind of difficult, but... I don't know... most of the classes I needed [the counselor] didn't really know. We were just basing our student ed plan on the schools I wanted to like transfer to... It just seemed kind of confusing ... she left me more confused, so I had to reach out to other people and do research on my own to be able to organize it.

While counselors, as noted above, are a critical resource for math guidance and course selection, students who do see a counselor could benefit from longer appointments to fully discuss course options based on academic and career goals, and to develop a truly comprehensive education plan (e.g., semester-by-semester course schedule for the student's entire educational journey). Especially for undecided students, whom administrators said were typically directed to take statistics, longer appointments could help them to explore possible careers and related majors and areas of interest, as well as to identify the optimal math pathway. This concern is most salient for students choosing between a STEM field and a non-STEM field.

Online Resources. Students also used a variety of online sources, including institutions' websites, to determine needed math coursework. Many community college students seeking to transfer accessed information via www.assist.org, an official website that helps students identify and confirm the appropriate courses to transfer to a CSU or UC campus. Those focused on transferring to UC could also access that system's website on the Intersegmental General Education Transfer Curriculum (IGETC). Many students depended on counselors, and in some cases peers, to confirm the information they had gathered, realizing that information is often fluid. Some students said they found online information difficult to decipher without coaching and guidance, specifically from a counselor. However, some of the students said they took the initiative to develop their own educational plans using online resources after receiving the wrong information from a counselor.

Figuring It Out. The following four comments illustrate the breadth of responses about how many students used available counseling and information to select their math courses:

Student:

It was probably my second semester. I started researching to figure out which classes I really needed just for a [non-STEM] degree. No one told me I needed stats. So I started taking trig[onometry]. That's when figured out what assist.org was... really [became upset with counselor] cause all of a sudden... "you're wasting my time" ...full year of tuition on something I didn't need. So I started to use assist.org.... everything [on assist.org] I circle ...then [I have a counselor] review it...

Student:

I actually went to... a [special program counselor] ... when I went to him and he also figured out what should I take and what [universities] I transfer to. But secondly, I actually went to my friend who transferred to [University of California campus]. The same major that he has is the same major as me. So... I just followed the steps laid out. He made it easy and ...I also went to assist.org to see where to transfer to.

Student:

I know some math classes are required for other certain classes. Like for chemistry, you need a background in algebra and some people are actually sent back to take algebra [before new policies took effect] because we weren't really strong in that criteria. So that's something that I experienced. Like I had to take stats for my research class for psych[ology].

Student:

So some of [the UC] standards had changed. And so, for instance, one of the classes that I had taken...had changed, so I had to actually talk to a counselor to make sure that I was taking the right courses based on the UC standard and based on what the college was going to be able to send to the UCs and what they were going to be able to accept. I had to kind of network with counselors and make sure because one counselor had told me one thing and then I found out that ... I actually needed to retake certain classes based on the curriculum changing and based on what the UCs was going to accept and based on what I was allowed to send from here to the UCs.

Counseling: A Survey of California Community Colleges

Between May 3 and July 12, 2019, an online survey developed by the Research and Planning Group (RP Group) for California Community Colleges, in collaboration with the Academic Senate for California Community Colleges, was sent to counseling staff at each of California's 115 community colleges. The purpose of the survey was to gather information about counseling services and practices and learn about the role counseling/advising plays in the implementation of Guided Pathways at each college. Of the 45 colleges that responded, 38 addressed effective math course selection processes. Counselors reported that colleges are using guided self-placement, multiple measures, and/or a combination of resources to assist students in choosing the appropriate math course. A few mentioned professional development and/or collaboration with math faculty to ensure counselors understand the curriculum. Many respondents described how their colleges valued one-on-one appointments with students to inform their decisions. Most colleges that participated rely on all of the above in various combinations (RP Group).

Role of Implicit Bias. The possibility that implicit bias on the part of counselors impacted the guidance some students received was not directly examined by this exploratory study. Our focus was understanding students' perceptions and experiences. Some students reported being directed to take a math pathway that was not aligned with their major or career interests or with their math experience and confidence. These students did not report believing that they were treated inequitably because of their race or ethnicity.

Instances of students' receiving inaccurate or incomplete information from a counselor also may have been due to the counselor's lack of knowledge about the correct pathway or untested assumptions about students' academic goals. These barriers could have been compounded by the limited time allotted for each counseling appointment. One student of color felt that the misinformation they received was not related to bias, but perhaps the result of the counselor not asking the right questions due to limited time or the student not stressing that their major was engineering and that transfer was the goal:

Student:

This counselor told me you need to take the prerequisite [math course] just to transfer. So I did ask... "You need to take the class to transfer, not to like to have an associate degree, right?" ...I took it and then after I finished, I met with [a new] counselor ...and I told him this... [he said] your major is engineering so you need to take pre-calculus. So I was like, okay, but the first counselor did not tell me anything. He was just like take this and that [for the associate's degree].

Interviewer:

So which math class did the first counselor tell you you should take?

Student:

Statistics.

Nevertheless, lack of accurate information and limited time for counseling are examples of structural impediments that place disadvantaged students at further disadvantage. Students with lower academic confidence, or first-generation students, are most vulnerable to being hurt by lack of available information or lack of counseling appointments (Fay, Bickerstaff, & Hodara 2013; Fong & Melguizo, 2017). Even if overt racism or bias is not observed, some students may still be subject by structural inequities to additional hurdles to academic success (Deil-Amen & DeLuca, 2010).

In summary, the participating colleges offered students a wealth of information in various forms regarding their math course selection. However, prior research (Scott-Clayton, 2015; Venezia, Bracco, & Nodine, 2010; Rosenbaum, Deil-Amen, Person, 2009; Fay, Bickerstaff, & Hodara, 2013; Bunch, Endris, Panayatova, Romero, & Llosa, 2011) has noted the difficulty of providing consistently accurate and timely information for both students and those supporting them, and this study suggested that the pace of reform may have complicated that challenge. Students' main complaint was the receipt of confusing or inaccurate information. Though students did not report experiencing counseling and guidance as inequitable or discriminatory, when information is confusing or inaccurate, students with more confidence and those whose parents attended college are often better able to navigate the system.

RECOMMENDATIONS: INFORMATION

The following recommendations are suggested by the experiences of the administrators and students related to available information about math pathways and courses. Further research could confirm and refine these suggestions:

- Consider offering more professional development resources for counselors. This could include assigning and preparing dedicated counselors to be specialists in particular majors or meta-majors who know the specific requirements of departments and/or transfer destinations. For students seeking to transfer, the counselor could also help make connections to specific individuals at transfer institutions.
- Offer extended counseling appointments for initial educational planning that allow for

a discussion of students' long-term career interests and how their educational pathways should be structured to align with them. This is especially important for students who are undecided between STEM and non-STEM fields.

- Develop a protocol that includes a template or checklist for counselors and students that helps both to avoid assumptions and explore the questions most important to developing an accurate educational plan.
- Ensure timely updates to print and online materials as well as continuous communication among faculty, counselors, and students so that counselors and students have the information necessary to inform math course selection.

Research Question 2:

Regardless of their personal characteristics, how are students given authentic **agency** in their choice of math pathway?

A sense of agency has been described as important for students' mathematics success. To make appropriate course selections and be positioned for success in those courses, a student needs to perceive that they can progress in mathematics (Schoenfeld, 2016). "Positive academic identity and agency cannot happen without deliberate work on the part of educators to address implicit bias, assumptions about student capabilities, and the ways that math traditionally reinforces privilege," note Daro and Asturias in a recent report (2019, p. 12).

For the purposes of this research, the focus was on whether the process students engaged in, including the campus' self-placement mechanisms, supported students in accurately assessing their math preparation and making optimal decisions about their math courses and pathways.

From Placement to Self-Placement. Math pathway placement and choice have considerable equity dimensions. Self-placement is intended as an improvement over traditional placement approaches, which have been shown to underplace significant proportions of students (Scott-Clayton, 2012). Before the reforms were adopted, students who tested into remedial math coursework could have needed a year or more to complete a developmental sequence to become eligible to take a general education math course required for their major.

This practice resulted in considerable attrition, especially at community colleges. At the CSU, the majority of students who did not complete their remedial math requirements in their first year were "disenrolled." After the new policies were adopted, non-STEM majors typically had to take only a single math course. However, there are also considerable risks to self-placement: Students may experience math anxiety or lack a sense of agency that causes them to underestimate their capacity to progress in mathematics and fields that rely on math content.

In studies conducted when remedial math courses were still offered, self-placement systems have led to fewer students being placed in lower levels of remedial mathematics. However, studies also found that African American, Latinx, and female students are most likely to underestimate their math abilities (Fong & Melguizo 2017; Kosiewecz & Ngo, 2019)[4]. Kosiewecz and Ngo (2019) noted that the positive effects of self-placement were "concentrated among male, white, and Asian students, and may thereby have the potential to widen already existing racial and gender completion gaps" (2019, p. 24).

[4] Studying the pre–AB 705 placement system at a community college where students could choose which level math assessment to take, Fong and Melguizo found that underrepresented racial groups as well as women were most likely to choose a lower-level test than their high school math records allowed them to take. For example, a student who had completed Pre-Calculus during high school would choose to take an Intermediate Algebra test. Even a perfect test score would require the student to repeat Pre-Calculus, whereas success on the Pre-Calculus test would have allowed the student to take Calculus. The researchers speculated that lower math confidence might be the cause. Another study of a self-placement experiment occurred when officials at one college forgot to renew their Accuplacer contract: Kosiewecz and Ngo found that the benefits of self-placement accrued primarily to white, male, and Asian students.

Such findings are consistent with research showing the prevalence of math anxiety, whose effects may be most pronounced among students who face other educational disadvantages, including racial and gender stereotypes about their competence (Maloney & Beilock, 2012). To enhance equity and ensure students make meaningful choices, self-placement processes need to address such systemic inequities.

Online self-placement tools are a common feature of recent mathematics reform. These tools, such as LA Pierce's guided self-placement and Sac State's Placement, Learning and Understanding Mathematics (PLUM) tool, invite students to consider their math skills, aptitude, and ability, and in response, offer information and guidance on math courses to consider (See: An Online Self-Placement Example). In conjunction with these tools, students and administrators described three key resources that can support agency in students' math course selection:

- Triangulation of various sources
- Meetings with counselors
- Use of various online resources

All three institutions had a self-placement process. For community colleges, self-placement tools are subject to regulations for implementing AB 705. The point of the restrictions was to ensure that self-placement instruments weren't used as a substitute for traditional placement tests, with their faulty assumptions and limited predictive validity (See: Title V Regulations on Self-Placement). Not all CSU campuses use a self-placement process, and unlike community colleges, the CSU has systemwide placement rules.[5] Even though CSU eliminated its remedial placement test, some campuses continue to use placement tests to determine whether students are ready for specific STEM courses.

If the tools themselves function as replacements for traditional tests, with their limited validity, they could be replicating the inequities associated with placement testing. That is particularly true in cases where colleges continue to make remedial courses available and where math anxiety is present.

California Community Colleges: Title V Regulations on Self-Placement

"District placement methods based upon guided placement, including self-placement, shall not:

(i) incorporate sample problems or assignments, assessment instruments, or tests, including those designed for skill assessment, unless approved by the Chancellor; or

(ii) request students to solve problems, answer curricular questions, present demonstrations/ examples of course work designed to show knowledge or mastery of prerequisite skills, or demonstrate skills through tests or surveys."

Source: California Code of Regulations

AN ONLINE SELF-PLACEMENT EXAMPLE

Sac State uses Placement, Learning and Understanding Mathematics (PLUM), a tool that offers "a self-inventory to review [students'] background and feelings about [their] quantitative reasoning skills, and a quantitative reasoning activity" (Sac State, PLUM webpage). Sac State plans to update this process in 2020. STEM majors also must complete the ALEKS Placement, Preparation and Learning (PPL), an assessment that provides real-time math course recommendations based on the students' scores. If a student does not score well, they can access "personalized learning modules to refresh key concepts" and retake the assessment up to three times (See: the ALEKS placement webpage).

The self-placement process was intended to provide students agency in their choice of math pathway and support optimal choices. One administrator shared how the institution attempted to ensure via the process that students had both STEM and non-STEM choices available to them:

[5] For more information on CSU's placement rules under Executive Order 1100, see the Executive Orders 1100 and 1110 Policy Changes website.

Administrator:

We didn't want to make that assumption off the bat that students already knew what pathway they wanted to take. We wanted to make sure that we're asking students questions [on the college's online guided placement tool] about both the stats pathway and the B-STEM pathway. So they will give recommendations for both. We can kind of show them on the stats pathway, you would be eligible for statistics. But on the B-STEM pathway, you're eligible for pre-calculus with support. Then we show them the two pathways they're eligible for and then pull the conversation about their career and major into it to then help them make a decision which pathway they want to take.

Yet some educators have misgivings about how the processes are being implemented. As this study was being completed, one administrator shared that their campus was reconsidering its approach to self-placement because of difficulties "reinforcing the message and guiding students along the path."

Students in the focus groups also expressed concerns about the process. Some students reported that in courses that were recommended—based on the self-placement tool or the advice of a counselor—the content felt like review for them. Others did not feel they had the breadth of information needed to feel confident about their decision. Students wondered, "If I'm not strong in math, should I take a different course?" "What if I'm undecided and considering both a B-STEM and non-STEM major, which math class is best?" "I've already taken this course and feel I could take a higher-level math course, so what do I do?"

Although self-placement tools are designed to be a first step in determining an appropriate math pathway, students often do not take the next step—meeting with a counselor—to confirm the placement recommendations. Even when students do meet with a counselor, strategies to address math anxiety and lack of math confidence may be needed to support students in enrolling in the most appropriate courses. One student shared why she decided to take a lower- level math course than the class suggested by her counselor:

Student:

I'm a [science] major and I do have [a counselor]. She helps me a lot ... she actually told me I can enroll in calculus, but I actually thought that I needed help more. So I placed myself in pre-calculus to help strengthen my algebra a little bit.

Administrators had hoped that the new self-guided process would encourage and ensure that more students attempt higher-level courses than they did when placement tests were in use. However, they noted that some students fear they may not be successful and, as a result, decide to take a lower level course than is recommended. Precisely for this reason, other research has noted that the practice by many community colleges of continuing to offer remedial math courses can undermine completion efforts: "The surest way to maximize student completion is to eliminate these classes and offer 100 percent transfer courses," noted one study (CCO & CAP, 2019, p. 9).

Choice of Level. One administrator described the challenge counselors have faced in guiding students' placement choices, including the use of test scores for placement pre-reform (or for placement into STEM courses post-reform):

Administrator:

Some of these cut scores for these classes overlap. So, for example, if the student... scored high enough to place in a pre-calculus and they're a biology major, well they don't need to be in that class. They

need to be in Math [course number], which is a calculus for life science and they have the score, they can just go right in...and interestingly enough, you point out that some students, they score high enough, but yet they still feel a lack of confidence and so they still place themselves lower and that they can do that. They can just take it at a lower level course if they want to... we try to talk them out of it. But... they're very insistent.

One student described using available information to decide between two math courses:

Student:

For me, personally, they gave us a little... planner and in the beginning of the planner there was a page that showed you the different pathways for math and English. And so that was kind of helpful, but it was a little bit outdated because it had changed within the year. And it was a good tool to get you started but depending on your major in particular... like STEM majors... it kind of varies. In particular, now they have this one thing where for mine, being [a particular STEM] major at the time, I could do Math [course number] or I could do calculus. And I could choose between doing one that was a unit less or doing one that was a unit higher, but it was just more straightforward. And there was still room for flexibility, which was really nice.

At the same time, another administrator pointed to the opportunities that are opened up for those students who have the confidence to advocate for taking a higher-level course:

Administrator:

They can just talk to the instructor...if it happens [recommended placement in course they student feels is too low]. We've had a lot of students go in with lower scores and they do just fine and we've had some going in with the lower scores and they have trouble. Usually what ends up happening though is if they have a lower score, then the advice is, they can go in...we can't enforce it, but we tell them that we require some supplemental instruction. And nine times out of 10, they take [the higher-level course with support]...

Choice of Instructor. Though students sometimes lack confidence when it comes to choosing which level or area of mathematics to take, students can exercise agency by recognizing the need to access various sources of data not only to select the most accurate and appropriate math courses, but also to choose instructors who are supportive of students who may struggle with mathematics or experience anxiety. Common sources of information mentioned by students included assist.org, Rate My Professor, IGETC, peer networks, and counselors. The following two quotes highlight how students use various sources to select math courses or pathways:

Student:

It's always full [math classes with] good teachers meaning the ones that people recommend ... this [instructor is] highly recommended, but then [his/her courses] all get full and then I feel like I don't want to take [math] if I'm not going to take it with someone that will work well with me to learn something [so] I don't take it. And then I had a pile up... [a] couple semesters of two math classes in one semester.

Structural Barriers. Structural barriers can also lead students to make suboptimal choices. Students don't face a genuine choice of math course unless courses are available in the volume and variety that align with their interests. At Sac State, for example, some students were confused by campus policies: Though the CSU system abolished its placement test and stopped offering traditional remedial courses, some Sac State STEM majors required courses that were open only to students with certain scores on a locally-used placement test. This practice left some students confused and unsure where to seek guidance about what to do if they struggled to reach the needed score.

Likewise, even though community college students can't be placed into remedial courses, continued availability of the courses at some community colleges is also seen as an impediment to changing course-taking patterns and ensuring that students make aspirational choices. A related barrier is the fact that many

colleges still don't offer a sufficient number of non-STEM mathematics courses to meet the needs of the vast majority of students who don't choose STEM fields (CCO & CAP, 2019).

In summary, to provide students authentic agency in the selection of their math courses information must be accurate, confirmed by multiple sources (including a counselor) and timely (e.g., at the start of the semester versus after the Add-Drop date). Students also needed to have confidence in the information and the choices they make. Although colleges have made concerted and strategic efforts to provide information in various forms and in various ways, some information (e.g., regarding transfer requirements) may be difficult for students to decipher without some coaching.

RECOMMENDATIONS: AGENCY

Based on the students' and administrators' experiences, the following recommendations and suggestions related to providing students' authentic agency surfaced. Further research could confirm and refine them.

- Consider ways to help students effectively use various sources of information to inform their math course and pathway selection.
- Eliminate structural barriers that can lead students to make suboptimal choices of math pathway.
- Develop additional strategies to ensure students have the confidence and support necessary to enroll in a recommended course so that they don't needlessly place themselves into lower-level courses.

Research Question 3:

What are some intentional strategies to ensure that all math pathways foster quantitative skills in rigorous ways and that students successfully complete their math pathways?

The final research question examined the ways that the colleges had designed and restructured approaches, policies, and practices to ensure and promote math success. Three main strategies emerged:

- Restructure math sequences to promote college-level coursework through the use of corequisite models or support courses, rather than remedial courses.
- Expand academic supports, particularly tutoring.
- Ensure that classroom pedagogy and classroom environment are student-centered.

Restructuring. For all three institutions, elimination or reduction of noncredit and/or remedial math coursework was central, due to newly mandated policies. Each college had addressed the requirement to focus on college-level, credit-bearing math courses by eliminating or scaling back remedial courses that would not meet general education requirements for four-year universities. CSU campuses no longer offer any stand-alone remedial math courses (with the possible exception of "Early Start" courses offered in the summer before enrollment). Community colleges may not place students into remedial classes, but some community colleges, including the two in this study, haven't completely eliminated remedial math courses. The law didn't explicitly bar colleges from offering the courses, but some college professionals view making them available as violating the spirit of AB 705.

In response to the reduction of remedial offerings, sections of entry college-level courses such as pre-calculus and statistics have been expanded. Statistics course sections were increased from 18 to 48 sections at LA Pierce, for example. Sac State increased statistics offerings from 19 to 25 sections, including 5 sections of a new statistics with support option. Statistics was seen by many as a default course for students who were undecided about their major or those who were unsure they were ready to successfully complete STEM math courses recommended by the self-placement process. While the practice is understandable, it may lead students to make suboptimal choices, if they are not provided opportunities to explore career options and if they

don't have a chance to bridge to a STEM pathway if their interests expand in that direction.

Some administrators were ecstatic about dismantling the developmental math sequence so that students could complete necessary courses sooner in their educational tenure:

Student:

I don't have to take [so many] math classes before I can transfer?!

Administrator:

It's just really exciting to be able to know that this is like an option for them... I don't even show any of our remedial-level classes. And so when students are interested in [remedial coursework], I'll flip the handout over and I'll show them all the courses that we technically still offer that are below transfer. And that map looks like crazy, like all the lower-level math [courses] that we offer. But when I talk to students when they first come in, I don't even want to show them that mess. I just start out with what is transferable, where they're at to show them how close they are to being done with their transfer-level math.

Administrator:

Like, this is different and you're really lucky to be in school during the time when these laws have changed things because it's going to benefit you in the long run and you're going to be in and out... and you're going to [realize] your end goal so much faster... so I think that's been really like important for students and for counselors and staff and faculty across the campus... how would you say, like that kind of energy for students. I really, I think that it's been so far, I mean, I haven't seen the numbers yet of completion, right. But so far, I feel like it's been a really positive experience for students.

Academic Supports. Just-in-time academic supports, including corequisites, have been expanded, strengthened, and restructured to ensure students' math success. Administrators said that additional academic support was offered both inside and outside of the classroom at all three participating institutions in more robust and intrusive ways than previously available to ensure that students have extra assistance to succeed in math if they need it. The most popular intentional strategies included tutoring and student-centered pedagogy, according to students.

Because so many community college students have lacked the opportunity to develop positive math identities, what happens in the classroom is crucial; commonly used practices include culturally-competent pedagogy, assignments, and examples that are relevant to students' lives and careers, as well as small group work that promotes peer-to-peer support rather than solely depending on lecture. Some instructors explicitly address the existence of math anxiety by teaching students about fixed and growth mindset. As one student shared:

Student:

[A specific math instructor] is a good teacher and he treats you like an adult... he doesn't treat you lesser than and he helps you. I wish I had him my first semester because the first week or two

we had people come in and talk about different stuff about the college that can help you in the future, and that helps. And then he also doesn't put people down about math. He kind of changes your mindset about math.

More Than Just Tutoring

LA Pierce's Center for Academic Success provides tutoring, but also supports academic departments in accessing and effectively using the additional math support students may need. Faculty tutoring liaisons inspire instructors to use the Center to support their students' math success and ensure that information flows between the Center and academic departments. Instructors can request that tutors be "embedded" in their classes regularly, but when requests for embedded tutors dropped, the Center developed information to help faculty more effectively use this type of tutoring support. To offer instructors another resource, a "Tutor on Demand" program was also launched in which an instructor can request a tutor to drop in to the class and help students as needed.

Tutoring. Colleges are using various approaches to tutoring or supplemental instruction: These include tutors assigned to or "embedded" in classrooms as well as the use of tutoring centers. Some students received extra credit or points for visiting the available tutoring center. This helps to normalize seeking tutoring assistance. Another challenge can be simply finding tutors to hire, as administrators explained. To address a shortage of statistics tutors, LA Pierce College has developed a "House of Stats" where a tutor hosts 30-minute rolling workshops in a dedicated room all day one to two days per week. One administrator described the challenge:

Administrator:

I've got about 200 people here and about 165 of them are tutors and the rest are all faculty... it's kind of a big operation. And I would say half of that operation is math. ...It is huge here...We can't actually get enough math [tutors]. So my theory is that if we just offered $1 million worth of math tutoring, it would be insufficient.

Similarly, a student reported:

Student:

I know the math [tutoring center] is helpful but the thing is I ...was overhearing... there are budget cuts that's been happening... [I've] gone [to the math tutoring center] and there's a lot of people and not enough tutors.

See: More Than Just Tutoring for more information about LA Pierce College's Center for Academic Success and how the college is addressing tutor shortages.

Pedagogy. The classroom environment was also important to students' engagement with their math courses and sense of confidence in their ability to be successful. Students preferred instructors who found a balance between the use of the textbook, online resources (e.g., Khan Academy, YouTube), and lecture. Students appreciated assignments and examples with real-world applications and culturally competent pedagogy that examined math from different cultures. Some students felt they would be more engaged in their math coursework if they understood why and how a particular math concept could be important to their majors and their daily lives. The following three quotes—the first two from students and the third from an administrator—highlight how relevant and culturally-responsive approaches help to address students' lack of math confidence and anxiety:

Student:

So going off of what you said about like how math is the universal language, I wish that teachers could do a better job at transcribing that to us because... especially if it's so important, at least give us some real-life problems and how we, how to deal with math. Like honestly like I don't want to learn about ...what angle ...give me like an example, like an actual word problem that you see in real life ...and teach me how to actually do that ...I need like a real-life application... And it needs to be taught well. If it's supposed to be a universal language, teach it better.

Student:

I know for [one math] class it was we had to pick a rap album that had to do with a social justice problem and then we had to find songs that ...had these topics that they had to follow and we had to check all the ones... like the lyrics and kind of what the song's based about, and then we had to find the statistics on it... And then in pre-calc[ulus]... we had to take pictures of buildings that we'd seen or like murals or something and then we had to [find] shapes and stuff, [and] we had to explain how it related to math. We had to break it down.

Administrator:

I like to really address some of their negative self-talk that someone has taught them that they suck at math when they're all born math people... We investigate the math of non-Western people. Pythagoras gets all the credit for A squared plus B squared equals C squared, but he's studied in Africa, because there aren't pyramids in Greece like that, but he's a European guy. There are pyramids in central South America. And I want my students to see themselves in the math that it's in their blood, it's in their ancestry to be engineers. So that's one way I addressed the affective domain because someone told them they suck, but it's in their blood, that they are good at math. That's a curricular piece. The other piece is like building community and having students support each other. There's been support for faculty in implementing these practices in their classes.

Students appreciated a student-centered environment in which they worked in small groups and received shared grades based on contributions of each member of the group. The group work promoted peer-to-peer connections and helped to alleviate math anxiety since the collaborative work was just as important as individual mastery.

Corequisites. Another form of just-in-time support for students who aren't fully prepared for a college-level course is corequisite courses (sometimes called support courses or lab courses), additional one- or two-unit classes, taken in conjunction with the core math class. These were valued by students, as one student shared:

Student:

[The instructor] helped everyone [enrolled in the support course] because he uses [the support course] as an extra-long class to go over stuff and do different things.

Interviewer:

So how did you know to sign up for the extra one hour?

Student:

[The counselor] helped me. She knew that I told her, I said, "Well, is there anything I can do to help with the math just so I ... stay on top of it?" And she said that [the support course] would work.

Paralleling research on implementation in other states, early findings suggest that these courses are leading to higher success rates than traditional remedial approaches are, therefore helping to address math opportunity gaps. A recent study found an 18 percentage point increase in the proportion of first-time math students completing a math course required for transfer (Mejia, Rodriguez, & Johnson, 2019).

The following tables highlight differences in course success rates at College of Alameda with and without a support course.

Introduction to Statistics at College of Alameda (2017–18)

There is an opportunity gap for African-American and Latinx students.

Statistics	No. of Students	No. of Success	Success Rate	No. of Retained	Retention Rate	No. of Withdraws
Black / African American	143	86	**60%**	115	**80%**	28
Hispanic / Latino	188	113	**60%**	162	**86%**	26
White	100	76	**76%**	90	**90%**	10

Introduction to Statistics with Support at College of Alameda (2017–18)

The opportunity gap is narrowed, but not eliminated, as success rates increase for all students.

Statistics with Support	No. of Students	No. of Success	Success Rate
Black / African American	35	26	**74%**
Hispanic / Latino	34	24	**71%**
White	18	15	**83%**

Though the support courses have shown positive results, they generally require additional units, thereby affecting student fees, leading to caution at some campuses about implementing them.

In summary, intentional strategies have focused on collaboration and coordination of efforts across academic departments and traditional support services to provide students with needed help both inside and outside the classroom. Professional development offered to instructors and ongoing guidance and promotion of more student-centered approaches to teaching and classroom set-up appear to benefit students—particularly those who may struggle in math or experience math anxiety.

RECOMMENDATIONS: INTENTIONAL STRATEGIES

Based on the reflections of the administrators and students about intentional strategies to ensure students' math success, colleges are advised to develop:

- Ongoing engagement and professional development of math faculty to develop student-centered course outlines and relevant assignments and examples, as well as classroom environments that promote math mastery while reducing math anxiety
- Structures that encourage, promote, and develop support across departments and functions to ensure an accurate and seamless process for students to access needed math support
- Strategies and pedagogical approaches that address the affective realm, and take math anxiety seriously
- Coordination of academic support with the math faculty to provide the level and types of services needed and to encourage students to access and faculty to use the available supports (e.g., embedded tutoring)

CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

Recent math reforms have inspired positive changes that have great potential to address opportunity gaps for students of color regardless of their majors. The self-placement process and related supports have increased enrollment in college-level coursework. Expansion of academic supports and structures both inside and outside the classroom are also promoting math success. The coordination of these efforts—academics and support services—has the potential to break down silos and encourage more student-centered strategies and perspectives.

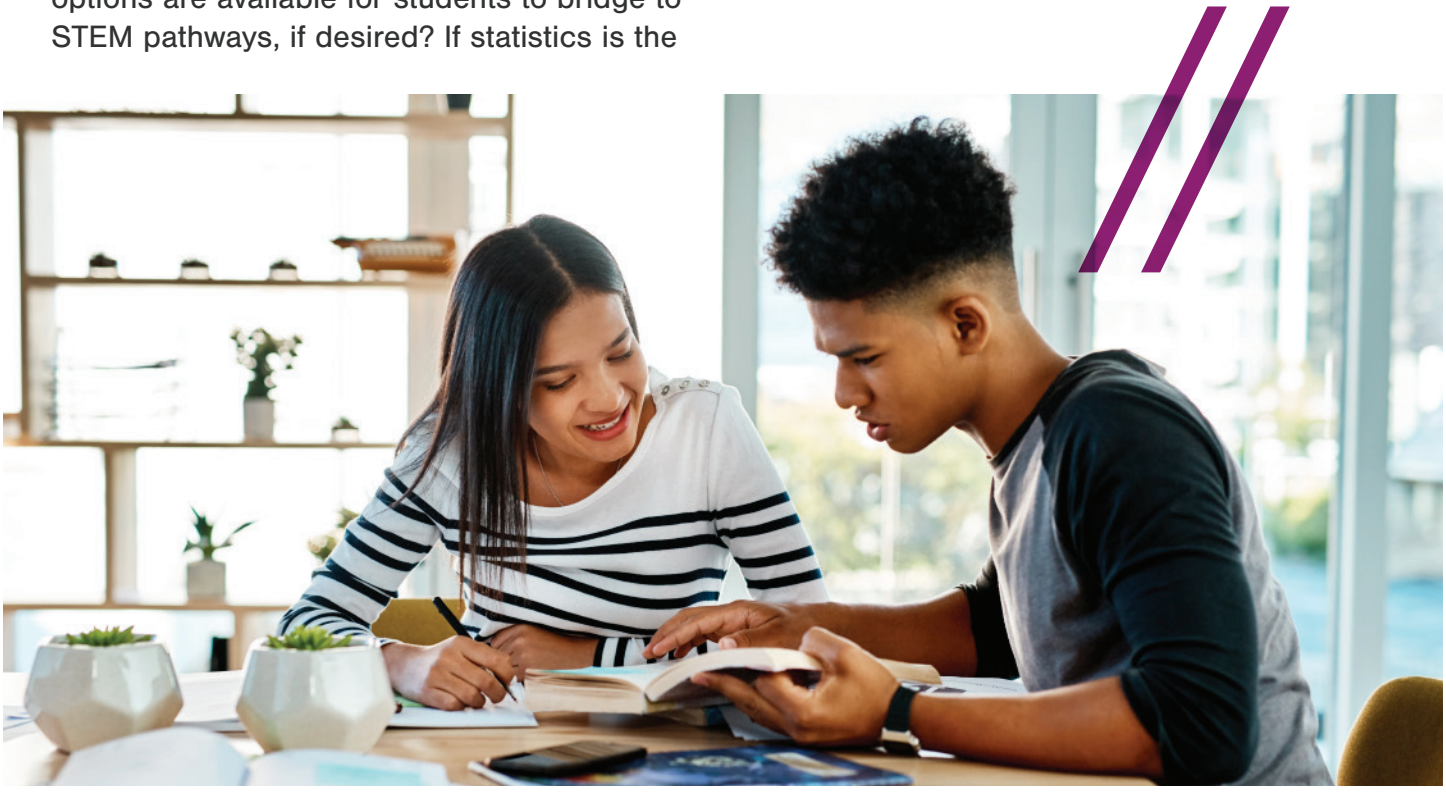
Though the focus of this study is the course placement and selection process, other structural changes are called for, such as (1) ensuring that the variety and availability of math course offerings match the range of student interests, (2) eliminating all or most remedial courses so that lack of information or lack of agency doesn't cause students to needlessly enroll in them, and (3) offering options, such as corequisite courses, for students who develop an interest in a STEM field after taking statistics or another non-STEM math courses. Two areas where the placement process itself risks undermining equity are misinformation and self-placement.

Misinformation, regardless of the source, can promote inequities, depending on students' knowledge and use of resources to help them make informed math pathway selections. And although the self-placement process attempts

to remove biases and opportunities for misguidance, it may need to be designed more explicitly to address math anxiety since negative math experiences can cause some students to unnecessarily elect lower-level courses or avoid STEM options, despite the self-placement recommendations. Counselors will continue to be a critical and important force in fighting inequities in math success. However, to do so, they will need additional expertise in implementing culturally-relevant and equity-focused approaches as well as knowledge about newly developed math pathway options. In addition, students' experiences suggested a need for counselors to have access to timely and accurate information as well as the luxury of more time with students to ensure appropriate math selection and, ultimately, math success.

One goal of this exploratory study was to surface possible directions for future research that would further illuminate strategies for ensuring that implementation of new math policies enhances equity, especially with regard to students' math pathway choices. Research questions that emerged include:

- What is the range of non-STEM math pathways available to students and what options are available for students to bridge to STEM pathways, if desired? If statistics is the default course recommendation for undecided students, how can they retain the option to pursue a STEM field in the future?
- To what extent is written information provided to students consistent, up-to-date, and conducive to students' making optimal choices about their majors and related math pathways? Are there exemplary practices that colleges can replicate?
- What strategies (including Guided Pathway strategies) have the potential to support students' sense of agency so that lack of confidence or math anxiety don't interfere with students' ability to make appropriate decisions about majors and math pathways through self-placement processes?
- Are there specific types of guidance and information that best support students who are historically underrepresented in college and in STEM fields to make informed, thoughtful math pathway selections?
- What sort of training or professional development can best help counselors and faculty dislodge harmful preconceptions about student abilities to ensure that they are providing students with the most effective advice and classroom experiences?



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APPENDIX A

Student Focus Group Protocol

INTRODUCTION AND GROUND RULES

Personal introduction: My name is Rogéair Purnell-Mack. I am the principal and founder of RDP Consulting. I am working closely with Pamela Burdman of Just Equations and the Opportunity Institute, which is an organization that looks to promote educational opportunities including higher education completion.

Introduction of study: I am here because we are working on a study that seeks to increase our understanding of the process by which California community college students learn about, select, and enroll in various math pathways at their colleges. We are eager to speak to students about their math journeys and experiences. Another part of the study will involve interviewing the math chairperson and possibly counselors at your college.

Audio-recording and context: I will audio-record this 60-minute session, and our conversation here today is one of three focus groups we have planned. To show you how much we value your time and willingness to share your experience as a student, you will receive a $20 Target gift card.

Confidentiality: We will analyze the information we gather across all of the focus groups to identify common themes. We will not report out in a way that can be connected back to you as an individual. Our focus is not on who says what, but on what you all say.

Consent: Thank students for participating. Inform them that their participation is voluntary and that they can withdraw at any time by leaving. Ask them to sign the consent form. HAND OUT 2 COPIES OF CONSENT FORM; one for the students to complete and submit and another for them to keep for their records.

Ground rules: Review the following ground rules.

- No idea is a bad idea; show respect for others' comments and ideas
- Share the air
- Respond/add to others' thoughts
- All comments are confidential
- Have fun!
- [What would you add?]

Do you have any questions? If not, let me start by asking you to...

STUDENT FOCUS GROUP QUESTIONS

Introduction

1. Briefly introduce yourself (first name). How many semesters have you been a student at [name of campus]? What is your educational goal and major, if you have one. What are your future plans after you graduate?

Math Guidance

2. Do you have an educational plan/know which courses you need to take each semester to realize your educational goal? Did you receive help to complete this plan? If so, who helped

you put together your ed plan? What recommendations did you receive about which math courses to complete and when? What led you to enroll and complete these math courses? (RQ1, RQ2) How did this relate to your choice of major, etc.?

Math Experience

3. How many college math courses have you completed at this point? Were these remedial courses or credit-bearing courses? When did you complete these courses? First semester, second semester, etc.? Have you been able to enroll in the math courses you need when you need them? [Have a list of the math courses (dev, college, transfer level) at the campus. Provide a handout with a list of math courses and ask students to indicate which ones they have completed.]

4. What best describes how your math courses have been structured? (RQ3)

   - Contextualized (applied, hands-on activities that are related to your major or career)?
   - Broken out into small chunks (modalized)?
   - Two back-to-back developmental courses were combined into a single one-semester course (compression)?

Which type of structure was most effective in advancing your knowledge and skill?

5. If you had to select between these three options, which one best describes you: (RQ2)

   - Math is fun and my favorite subject! I love math and see it as important to my life and career.
   - Math is required so I will take it and I'll do okay grade-wise, but it's not my favorite subject and I'm not completely sure how it will help me long-term.
   - Math is the worst and I dread it. It causes me great anxiety and I don't see how it is relevant for my career or major.

Please share why you picked this option. For those of you picked 2 or 3, what could/should the university do you help you feel more positive about math? [PROMPTS]: Would additional counseling about which courses to take or more tutoring or academic support help? (RQ3) Do you need more information about how your math classes connect to your career or major? (RQ1)

Math Support

6. What services, supports, and resources have you used to help you succeed in your math courses? What resources/supports/services are you currently using? What other sources of support would be useful to you? (RQ3)

Math Advice

7. What would you share with a new student who is trying to figure out which math courses to take? Someone who is struggling in his/her math courses? (RQ1)

8. If you could share with the university one or two ideas for how to improve students' math experiences from course placement and selection to course registration and enrollment to course completion, what would you share with them? (RQ2, RQ3)

9. Is there anything else you would like to share about your math experiences at [name of college]?

Thank students for their participation and help with our research.
Hand out a $20 Target gift card to each student.

APPENDIX B

Faculty/Administrators' Interview Protocol

INTRODUCTION AND GROUND RULES

Personal introduction: My name is Rogéair Purnell-Mack. I am the principal and founder of RDP Consulting. I am working closely with Pamela Burdman of Just Equations and the Opportunity Institute, which is an organization that looks to promote educational opportunities including higher education completion.

Introduction of study: Pam and I are working on a study that seeks to increase our understanding of the process by which California community college and state university students learn about, select, and enroll in various math pathways. As part of this research study, we are conducting focus groups to speak to students about their math journeys and experiences. We are also interviewing administrators, counselors, and math chairs to learn about various approaches, structures, policies, and practices associated with math-related guidance and counseling.

Our key research question explores the following:

Community colleges are focusing more explicitly on offering diverse math pathways aligned with students' goals under implementation of guided pathways, AB 705, and California State University (CSU) Chancellor's Executive Order 1110. Given the history of tracking in mathematics and its impact on equity, does the new legislated math pathway guidance reduce or exacerbate inequities for students, particularly those who are historically underrepresented on college campuses and in Science, Technology, Engineering, Mathematics (STEM)-related majors/fields?

Audio-recording and context: I would like for your permission to audio-record this 45-minute interview. Our conversation is one of nine counselor and administrator interviews to be conducted at three colleges. Is this okay with you? What you share will provide context for the conversation we will have with your students.

Confidentiality: We will analyze the information we gather across all of the interviews to identify common themes. We will not report out in a way that can be connected back to you as an individual. Our focus is not on who says what, but on what you all say.

Reporting: What we learn from administrators and faculty and from students will be summarized in a report to be completed later this year. Initial findings and learnings will be shared at the Strengthening Student Success conference in October at the Hyatt Regency San Francisco Airport. Please let us know if you can join us for this presentation!

Do you have any questions? If not, let me start by asking you to...

INTERVIEW QUESTIONS

Introduction

1. Briefly introduce yourself. How long have you worked at [college]? What is your current title/role/responsibilities?

Math Guidance

2. How are students informed about which math pathway to pursue? What information is accessed to inform how students are counseled? [PROMPTS] Who provides this guidance?

What are the key types of information/messages provided, and how is it structured? What policies, practices, and strategies support students' math pathway selection? (RQ1)

3. What changes were considered/made to how students receive math pathway guidance in light of guided pathways, AB 705, and EO 1110/1100? How have the required changes helped or hinder ensuring students are taking the correct math courses? (RQ1, RQ2)

Math Coursework

4. Roughly how many math courses are offered? How many are precollegiate, college, and/or transfer level? What percentage of incoming students are placed in college/transfer level math compared to pre-AB 705 / EO 1110?

5. Are students able to enroll in the math courses they need when they need them? What changes are needed to increase math access? (RQ2)

6. Considering the following approaches to math instruction, in what ways is math offered at your institution? What percentage of your math courses are...? (RQ3)

   - Contextualized (applied, hands-on activities that are related to your major or career)?
   - Broken out into small chunks (modalized)?
   - Two back-to-back developmental courses were combined into a single one-semester course (compression)?

Which type of structure do you feel is most effective in advancing students' knowledge and skills? Do you have data you can provide on students' math completion rates? (RQ3)

Math Support

7. What services, supports, and resources are available to help students succeed in their math courses? How do students find out about these supports and resources? What resources/supports/services are most widely used? What other sources of support would be useful to students? (RQ3)

Math Advice

8. If you could share with a colleague at a college that is working to improve students' math experiences from course placement and selection to course registration and enrollment to course completion, what would you say? (RQ2, RQ3)

9. Is there anything else you would like to share about how math guidance, coursework, and supports are structured at [name of college]? (RQ1)

Thank you for completing this interview and your help with our research!

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