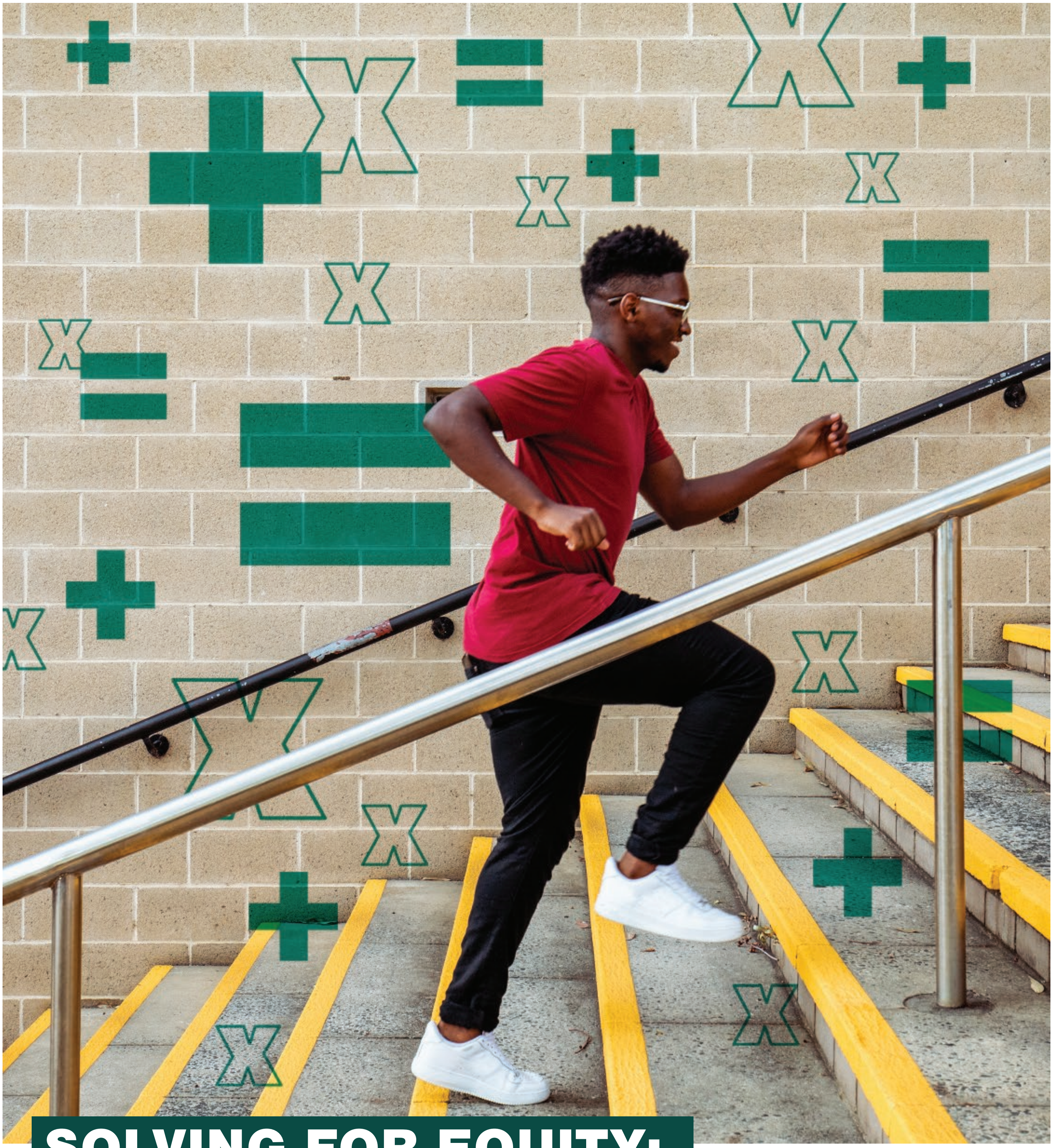

SOLVING FOR EQUITY:

DESIGN AND IMPLEMENTATION OF NEW POSTSECONDARY MATH PATHWAYS

By Mina Dadgar, Dina Buck, & Pamela Burdman

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JUST EQUATIONS

SOLVING FOR EQUITY

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ABOUT JUST EQUATIONS

Founded in 2018, Just Equations reconceptualizes the role of mathematics in ensuring educational equity. An independent resource on math-related policies in the transition from high school to and through college, Just Equations advances evidence-based strategies to ensure that all students have the quantitative foundation they need to succeed in college and beyond.

ABOUT THE AUTHORS

Mina Dadgar, founder of Education Equity Solutions, is a researcher focused on ensuring that higher education policy is informed by practitioner and student voices. Mina has published studies on dual enrollment, developmental education reform, and community college guided pathways. Her 2014 study demonstrating the limited economic value of short-term college credentials was highlighted by NPR as an influential educational publication. Mina previously served as Associate Vice Chancellor for Guided Pathways at the California Community Colleges Chancellor's Office. Prior to that she worked at the Career Ladders Project, WestEd, and the Community College Research Center.

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Pamela Burdman, a policy analyst and strategist on equitable college access, readiness, and success, is the founder and executive director of Just Equations. She began her career as a reporter for the San Francisco Chronicle and first focused on math equity issues as a program officer at the William and Flora Hewlett Foundation. Her reports and articles on math opportunity have influenced policy changes in California and beyond.

SOLVING FOR EQUITY:

DESIGN AND IMPLEMENTATION OF NEW POSTSECONDARY MATH PATHWAYS

Mathematics education has been a distinct source of inequity in students' educational journeys. The way mathematics is taught and tested can determine students' chances of completing high school, entering the college of their choice, and earning a degree in a field that interests them. Black, Latinx, and other marginalized students are most likely to be filtered out of opportunities due to policies such as tracking (Burdman, 2018; Daro & Asturias, 2019). Postsecondary mathematics pathway reforms have the potential to reduce or eliminate racial stratification, but evidence to date suggests that they haven't consistently done so (Brathwaite et al., 2020). Incorporating new strategies into the design and delivery of these reforms will be essential to their effectiveness in achieving equity goals. This brief investigates ways of doing so.

The work to modernize postsecondary math requirements began more than a decade ago, with a move toward diversified math pathways that align with students' academic and career interests, instead of the conventional, one-size-fits-all pathway to Calculus. Traditionally, general-education math courses focused on preparing students for Calculus, regardless of whether they were pursuing a field that required Calculus. This practice deprived many students of the quantitative skills that would be relevant to their lives and academic pursuits, while simultaneously weeding significant proportions of students out of college altogether. Increasingly, colleges and universities are offering students alternate pathways for meeting math requirements, through courses such as Statistics, Data Science, and Quantitative Reasoning, in which students can gain competencies related to their majors (Burdman, 2015a; Burdman et al., 2018; Charles A. Dana Center, 2019a and 2020).

For more than a decade, leading mathematics associations have encouraged these moves to align students' math pathways with their fields of study (Burdman et al., 2018).[1] They have also called for students to have early exposure to statistics, modeling, and computation, skills employers say need more emphasis. "The largest discrepancies between need and perceived availability were seen for solving real-world math problems, taking and interpreting measurements, and calculating basic statistics," noted the West Virginia Department of Education about a 2019 employer survey (West Virginia Department of Education, 2019).

In the past several years, the math-reform efforts have evolved to include a movement against traditional remedial courses and in favor of corequisite courses and other just-in-time strategies that streamline students' pathways to degrees. Remedial prerequisites, such as intermediate algebra, divert students from college-level[2] math courses and discourage them from pursuing postsecondary degrees and credentials (Xu & Dadgar, 2017; Scott-Clayton & Rodriguez, 2012; Boatman & Long, 2018). States and institutions that have implemented corequisite courses—which provide additional support to students while enrolled in college-level math courses—have demonstrated that these approaches can lead to improved student outcomes (Tennessee Board of Regents, 2016; Ran & Lin, 2019; Logue et al., 2019; Mejia et al., 2020).

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[1] In 2004, the Mathematical Association of America called for an end to the use of College Algebra as a terminal mathematics course, citing a serious mismatch between the original rationale for College Algebra and mathematical needs of students who take the course. The Society for Industrial and Applied Mathematics called for mathematics pathways that align with students' fields of study, some of which should include early exposure to statistics, modeling, and computation (Saxe & Braddy, 2015). Model pathways vary but often focus on statistics, quantitative reasoning, or algebra/calculus.

[2] We use the term "college level" to refer to courses that meet the requirements for two- and four-year degrees. In some states, such as California, these are known as "transfer-level" courses, to differentiate them from courses that are accepted for two-year degrees but do not meet the requirements of four-year transfer institutions.

ABOUT THE REPORT

The literature review was the starting point for the research and the basis for developing the following set of research questions:

1. What are the main obstacles in creating equitable postsecondary mathematical opportunities that contribute to access to credentials with labor-market value for racially minoritized students?

2. What are key considerations in designing different math pathways for the purpose of closing racial gaps in access to credentials with labor-market value?

3. What are key considerations in classroom practices that promote equitable math course success and support students' math identities? What are the levers for institutionalizing and scaling those practices?

4. What are key considerations outside the classroom? What is the role of student support, career exploration, and recruitment of students into mathematics courses in reducing or closing racial equity gaps in mathematics success and access to credentials with labor-market value?

The interviewees, listed below, were selected because of their expertise related to equitable mathematics pathways and their ability to speak to those issues through diverse lenses, including research, on-the-ground practical knowledge, and experience working with students and faculty.

Susan Bickerstaff, Senior Research Associate and Program Lead, Community College Research Center, Teachers College, Columbia University

Jessica Brathwaite, Senior Research Associate, Community College Research Center, Teachers College, Columbia University

Phil Daro, co-Author, Common Core State Standards for Mathematics; Just Equations Research Fellow

Tristan Denley, Executive Vice Chancellor for Academic Affairs and Chief Academic Officer, University System of Georgia

Amy Getz, Manager of Systems Implementation, Higher Education, Charles A. Dana Center, University of Texas at Austin

Michelle Hodara, Manager, Research and Evaluation, Education Northwest

Luis Leyva, Assistant Professor of Mathematics Education, Department of Teaching and Learning; and Faculty Affiliate, Department for Gender and Sexuality Studies, Vanderbilt University

Aisha Lowe, Vice Chancellor for Educational Services and Support, California Community Colleges Chancellor's Office

Tammi Marshall, Mathematics Instructor and Department Chair, Cuyamaca College

Tatiana Melguizo, Associate Professor, Rossier School of Education, University of Southern California

Ricardo Moena, Assistant Department Head, Professor, and Director of Entry-Level Mathematics, Department of Mathematical Sciences, University of Cincinnati

Mallory Newell, Director of Institutional Research and Planning, De Anza College

Jacqueline Raphael, Senior Program Advisor, Education Northwest

Jerry Rosenberg, Dean of Physical Sciences, Mathematics and Engineering, De Anza College

Myra Snell, co-Founder, California Acceleration Project; Mathematics Professor, Los Medanos College

Philip Uri Treisman, Professor of Mathematics and Public Policy, Executive Director of the Charles A. Dana Center, University of Texas at Austin

Though many of these efforts were not designed purposely to address racial inequities, some reform leaders expected the changes to lead to more racially equitable outcomes, given that prior policies had disproportionately limited opportunities for Black and Latinx students. However, with some exceptions, the new strategies have not met those expectations (Brathwaite et al., 2020).

Acknowledging the untapped opportunity presented by these movements to advance educational equity through math-pathway redesign, this brief highlights key principles for designing and delivering math pathways with an explicit goal of erasing racial inequities in student outcomes. It is based on a review of the literature, as well as semi-structured interviews with 16 research, policy, and practice experts. (See About the Report, p. 5.)

"(DIVERSIFIED MATH PATHWAYS) ARE ABOUT THE MODERNIZATION OF AMERICAN EDUCATION... FOR US, IT WAS A PERFECT PLACE TO WORK ON EQUITY, BECAUSE, IF WE GET TO BE INVOLVED IN THE CONSTRUCTION OF THE NEW SYSTEM, WE COULD DESIGN IT UP FRONT FOR EQUITABLE OUTCOMES."

Uri Treisman, Charles A. Dana Center

DEFINING AND MEASURING EQUITY

We begin with a description proposed by math-education scholar Rochelle Gutierrez: Equity is attained when it is not possible "to predict mathematics achievement and participation based solely on student characteristics such as race, class, ethnicity, sex, beliefs, and proficiency in the dominant language" (Gutierrez, 2012, p. 19). With respect to student outcomes, we build on this concept in two ways:

1. *Closing the gaps between groups is a necessary but not sufficient goal. Because of harmful structures such as prerequisite remediation and placement tests with limited validity, the rates of access to and success in college-level math courses are relatively low across the country for all students, particularly in community colleges. So there is a need* ***not only to close gaps, but, in many cases, also to raise the bar for all students****.*

2. *Because students of color—as well as white women—have faced barriers in access to STEM (science, technology, engineering, and mathematics) degrees, we also note the necessity of* ***equalizing access to math pathways that lead to STEM degrees****, given the labor-market advantages of such degrees.*

Consistent with Gutierrez's conception of equity, our research suggests that these equitable outcomes cannot be achieved without ***intentionally addressing students' classroom experiences and their social and cultural environments****, to ensure they can develop a math identity and a sense of belonging. To understand and address inequity is not context free: It must "take into consideration the critical roles students' backgrounds and identities have played and continue to play in their experiences in education" (Adiredja & Andrews-Larson, 2017, p. 447).*

STRATEGIES:

ENSURING EQUITY IN MATH PATHWAY IMPLEMENTATION

Based on the literature and on our interviews, four principles stand out as necessary components to solving for equity in postsecondary mathematics:

1. Designing pathways and courses based on inclusive notions of rigor and relevance.
2. Replacing prerequisite remedial courses with corequisite courses and other types of embedded support.
3. Institutionalizing practices that foster students' math identity and sense of belonging.
4. Actively recruiting and providing support for Black, Latinx, and other students traditionally underrepresented in STEM pathways.

We elaborate on each below.

STRATEGY

DESIGNING PATHWAYS AND COURSES BASED ON INCLUSIVE NOTIONS OF RIGOR AND RELEVANCE

It is important that **all pathways are rigorous and relevant**, so all students can benefit from developing problem-solving skills needed for their majors, careers, and civic participation, and not be tracked into dead-end sequences. In developing math course sequences, institutions and states need clear definitions of rigor and relevance to guide their work.

However, because traditional conceptions of rigor have been used to reinforce meritocratic notions about mathematical ability and the standard gatekeeping role of math education and STEM pathways (Leyva et al., 2021; Battey & Leyva, 2016), a **new, inclusive definition of rigor is needed**. To ensure equity, all pathways—not only STEM pathways—should include rich, engaging content and should lead to college degrees or credentials that have high labor-market value. If some math courses lead only to credentials with lower labor-market value, students who have had fewer opportunities for quality math instruction, especially students of color and low-income students, are subject to being tracked into low-value credentials.

- Rigor should include:
  - Fostering the problem-solving and reasoning skills that are needed in future courses and careers in engaging ways.
  - Emphasizing critical thinking, conceptual understanding, and communication over procedural mastery.

According to our interviewees, a rigorous course promotes the ability to define a problem, develop the critical-thinking skills to solve it, and communicate the solution clearly. Employer surveys often reveal the importance of critical-thinking and problem-solving skills over knowledge of high-level or technical mathematics for most careers (West Virginia D.O.E., 2019). According to the Common Core State Standards, "Rigor refers to deep, authentic command of mathematical concepts, not making math harder."

"TECHNICAL PERFORMANCE AT HIGH LEVELS IS NOT NEEDED FOR MOST MAJORS, NOT EVEN ENGINEERS.... RIGOR IS MEASURED BY THE DEPTH OF UNDERSTANDING OF STUDENTS, THE OPPORTUNITIES TO REASON MATHEMATICALLY AND COMMUNICATE THE RESULTS CLEARLY. A RIGOROUS COURSE GIVES OPPORTUNITY TO STUDENTS TO MAKE CONNECTIONS AND RELATE WHAT THEY ARE LEARNING TO WHAT THEY WILL BE DOING IN THEIR FUTURE LIVES."

Ricardo Moena, University of Cincinnati

The field is moving past the use of traditional algebra-intensive content as a marker of rigor, as noted by the Charles A. Dana Center at the University of Texas at Austin: "When College Algebra is used as a proxy for rigor, mathematical modeling, geometric and numeric methods, statistics, and quantitative reasoning often are labeled as not rigorous" (Charles A. Dana Center, 2019b, p. 4).

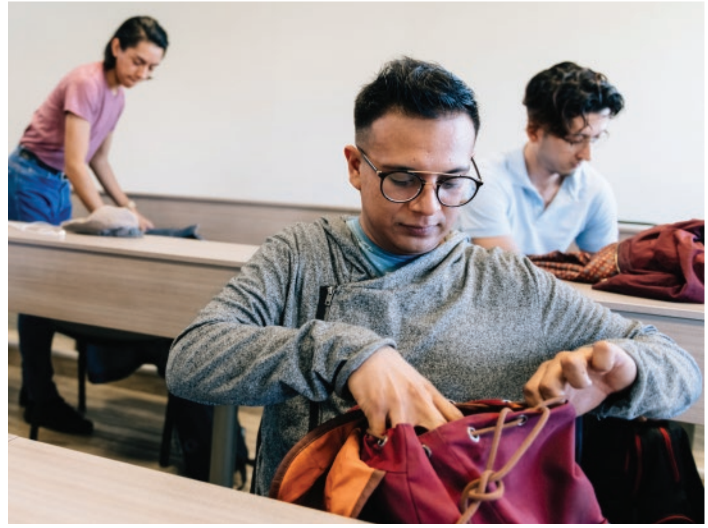
Additionally, **math content should be relevant** to a student's social contexts as well as their desired area of study (or meta-major) and promote success in upper-division major courses and career competencies. In focus groups of Texas students enrolled in new math pathways, students have reported greater levels of motivation to succeed when their math requirements are relevant to their program and career interests (Rutschow & Diamond, 2015). Similarly, researchers have found that students, particularly Black and Latinx students, are more likely to engage in math and form a math identity when they can see the links between what they are learning and their communities, and have their thinking affirmed (Miller-Cotto & Lewis, 2020; Priniski & Thoman, 2020; Oppland-Cordell, 2014; McGee, 2016; Adiredja & Andrews-Larson, 2017).

- Relevance should involve mapping course content backward from competencies needed to succeed in higher-level courses or related careers, eliminating unnecessary or obsolete content, and shortening course sequences as needed. Attending to students' personal experiences as well as their social and cultural contexts is also an important element of relevance (Adiredja & Andrews-Larson, 2017).

"HISTORIC ATTITUDES TOWARD RIGOR DRIVE INEQUITIES... IF YOU ARE NOT DIRECTLY MAPPING CONTENT BACKWARDS FROM SKILLS STUDENTS NEED TO KNOW TO SUCCEED IN THEIR MAJOR COURSES, LIFE, AND RELEVANT CAREERS, YOU ARE CREATING UNNECESSARY STUMBLING BLOCKS FOR THE MOST DISADVANTAGED STUDENTS."

Myra Snell,
California Acceleration Project

When rigor and relevance are not clearly defined, institutions or individual instructors may add arbitrary requirements, including decontextualized mastery of procedures that tend to weed out students who have not previously encountered the use of notation or complex procedures. This practice can elongate math sequences and delay or deter students' progress (Burdman, 2015a). Weed-out courses, a source of inequity in STEM fields (Leyva, et al, 2021), have been described as "mind-numbing, something to be endured rather than enjoyed—the exact opposite of what you get with inclusive pedagogy and active learning" (Malcom, 2019, p. vii). Irrelevant content can lengthen sequences, create unnecessary financial burdens for



students, lengthen their time to degree, and put them at greater risk of not completing a program.

"RIGOR HAS TO BE CLEARLY DEFINED. IT IS OKAY TO TEACH STUDENTS GEOMETRY AS A WAY TO DEVELOP DEDUCTIVE REASONING, BUT PUTTING IN DIFFICULT OR PROCEDURAL ASPECTS OF ANY COURSE TO SEE WHICH STUDENTS WILL FLUNK IS A LAZY AND UNFAIR WAY OF ENSURING RIGOR."

Phil Daro, Co-author,
Common Core State Standards for Mathematics

MAKING IT HAPPEN:
COORDINATION IN PATHWAY DESIGN

Interviewees emphasized that math departments should develop course content in close collaboration with faculty from other disciplines, guided by an awareness of relevant academic and career competencies, as well as students' social and cultural contexts.

There are several challenges to doing so. These include the need to work across intra-institutional silos, as well as the silos across institutions, especially between community colleges and universities. Most interviewees acknowledged that close collaboration between programs is rare. Math departments and individual faculty often create course content without input from or collaboration with other academic departments. Additionally, there are often few opportunities for two- and four-year colleges to collaborate or agree on curricular content (Bickerstaff & Moussa, 2020; Burdman, 2015b). In fact, in the absence of state-level coordination, each institution and department needs to develop curriculum and align with individual transfer partners (Leyva, 2018). When coordination does occur, ensuring that discussions are equity minded is an additional challenge.

"I KNOW THIS SOUNDS RADICAL, BUT AT CUYAMACA COLLEGE, WE COLLABORATE WITH OTHER DEPARTMENTS WHEN WE CREATE MATH COURSE CONTENT. WE PUT A CALL OUT TO OTHER PROGRAMS ASKING THEM TO SEND PROJECTS INVOLVING MATH THAT STUDENTS STRUGGLE WITH, AND WE INCORPORATE THOSE INTO OUR COURSES. BECAUSE WE DON'T PRETEND TO KNOW THE OTHER PROGRAMS, WE COLLABORATE WITH THEM. WHAT WE HAVE LEARNED IS THAT STUDENTS NEED TO DEVELOP CRITICAL-THINKING SKILLS TO SUCCEED, NOT A LOT OF PROCEDURES."

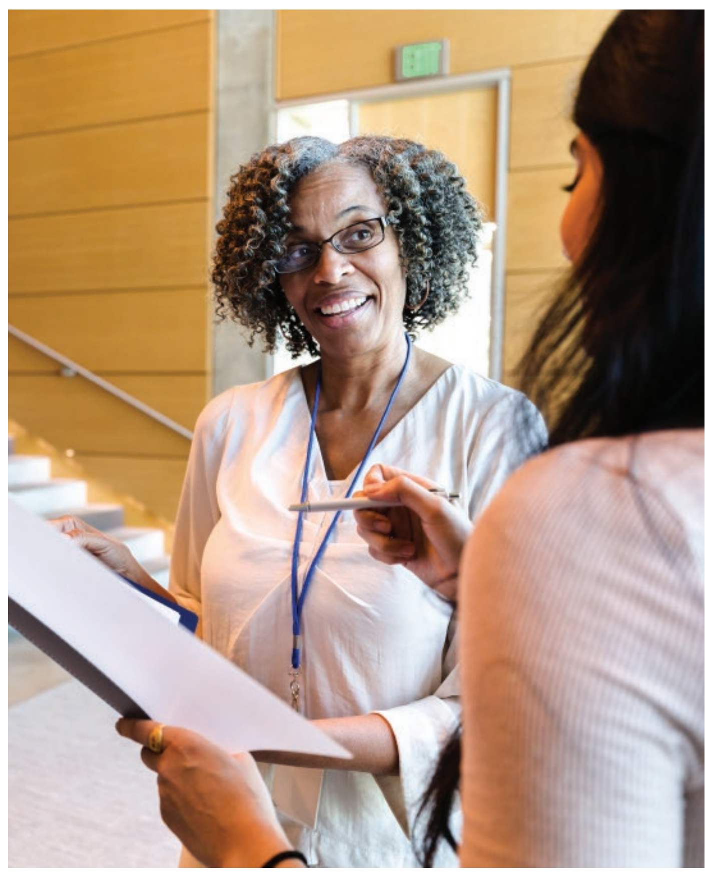
Tammi Marshall,
Cuyamaca College

States that have taken responsibility for coordination across two- and four-year institutions have been able to ensure that math curriculum is informed by relevant major and career competencies and meets their collective criteria for rigor. For example, in Ohio, as part of a state pathways initiative, the Ohio Department of Education facilitates meetings of faculty representatives from two- and four-year colleges to develop curricular content across different fields, including mathematics. These efforts are informed by employers' perspectives and benefit from cross-departmental input and collaboration. In addition, they provide a faculty-driven space for collaboration between two- and four-year colleges to create consistent, relevant, and rigorous curriculum (Moena interview, November 10, 2020).

Similarly, the University System of Georgia implemented a systemwide task force on the role of mathematics in college completion to improve student success rates. The task force included eight mathematics-field experts, representing the research, regional, state university, and state college sectors. The task force acknowledged that course requirements, such as intermediate algebra, haven't always been relevant to a given program of study (University System of Georgia, 2013). Its recommendations include aligning "gateway mathematics course sequences with academic programs of study." The University System of Georgia currently offers five mathematics pathways, designed to give students the math skills needed for their program of choice.

Ohio and Georgia were the first states to establish math task forces. About two dozen states have since done so, many with the support of the Dana Center and the advocacy organization Complete College America. The work in many of these states has more recently expanded to include K-12 systems, in order to address alignment between high school and postsecondary pathways. However, many of the task forces were not explicitly focused on equity, and the degree to which they have adopted effective definitions of equity is unknown. (A subsequent section addresses the need for professional development around implicit bias for faculty and support staff: the same may be needed for state-level leaders.)

There are also models available for working across disciplines. A project of the Mathematics Association of America, for example, analyzed the specific



quantitative needs for students majoring in various STEM and non-STEM fields. The researchers found, for example, that in biology, "Statistics, modeling and graphical representation should take priority over calculus" (Ganter & Barker, 2004, p. 15). And, in the social sciences, faculty agreed on the importance of "introducing students to some basic statistical methods, including measures of central tendency, variables, covariation, and standard deviation," as well as "developing an understanding of graphical representation and interpretation" (Ganter & Haver, 2011, p. 13).

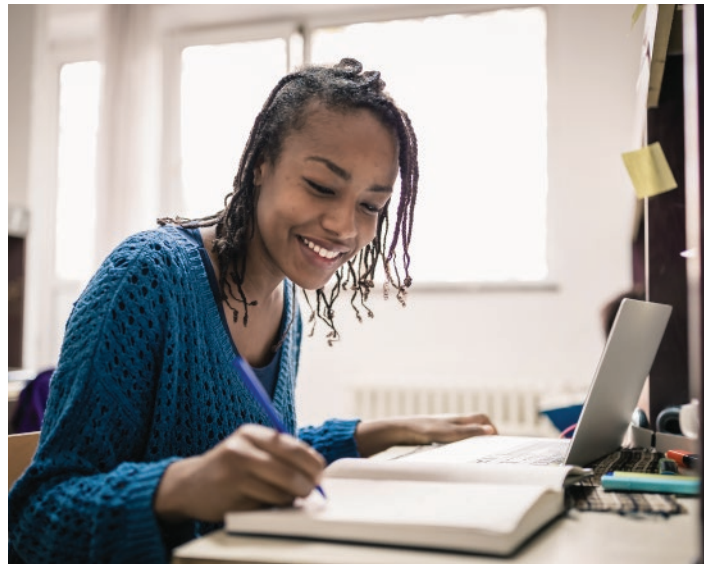
STRATEGY

REPLACING PREREQUISITE REMEDIAL COURSES WITH COREQUISITE COURSES AND OTHER TYPES OF EMBEDDED SUPPORT

The cumulative evidence over the past decade makes clear that prerequisite remediation hinders students' progress and disproportionately affects racially minoritized student groups, particularly at community colleges. By contrast, states and institutions are increasingly documenting positive outcomes after abandoning prerequisite remediation in favor of corequisite and other embedded supports (Tennessee Board of Regents, 2016; Ran & Lin, 2019; Logue et al., 2019; Mejia et al., 2020). Still, the majority of students entering community colleges continue to enroll in prerequisite remedial courses, and that is disproportionately true for Black and Latinx students (Hodara, 2019; Chen, 2016).

Rigorous evaluation of statewide efforts to move away from prerequisite remediation has shown promising increases in completion rates of college-level math courses. In 2014, the Tennessee Board of Regents designed a pilot program that automatically enrolled students into corequisite college-level math courses, instead of into prerequisite courses. The proportion of students successfully completing college-level math increased from 12 percent to 63 percent. Forty-two percent of students of color completed math in their first year, compared to just 7 percent in the prior year (Tennessee Board of Regents, 2016). Once the program was established statewide, a rigorous evaluation later validated its effectiveness (Ran & Lin, 2019).

Colleges and universities in California have implemented similar approaches: In 2018, when an



executive order required California State University campuses to stop offering stand-alone remedial courses, the proportion of students considered "unprepared" who passed a college-level math course in their first semester grew from 5 percent to 46 percent (California State University, 2019). And, in 2019, after the implementation of statewide legislation, Assembly Bill 705 (AB 705), greatly reduced the number of prerequisite remedial offerings at community colleges, twice as many entering students passed a college-level math course in their first semester as compared to previous years (Mejia et al., 2020). Though college-level math completion rates increased across all races, underrepresented students experienced the greatest gains: Latinx students' math completion rates increased from 8 percent to 33 percent, and Black students' increased from 15 percent to 48 percent (Mejia et al., 2020).

An analysis comparing Georgia's various approaches to remediation, including prerequisite and corequisite courses that were offered in 2017, found that students who enrolled in corequisite math courses were twice as likely as students with similar ACT scores enrolled in prerequisite remediation courses to complete a gateway math course within a year. The gains were especially high for students within lower ACT bands (Denley, 2021). Similarly, a study of the State University of New York system, which randomly assigned students to different placement mechanisms, found that students who were bumped up from a prerequisite course into a corequisite college-level math course had 33-percent higher gateway-math completion rates (Barnett et al., 2020).

"I THINK THERE ARE PLENTY OF OTHER THINGS YOU CAN DO TO SUPPORT STUDENTS' LEARNING WITHOUT HOLDING THEM BACK BY PUTTING THEM IN PREREQ COURSES. THERE ARE SO MANY ALTERNATIVES OTHER THAN MAKING THEM TAKE A LONG SEQUENCE, OR MAKING THEM SPEND MONEY."

Jessica Brathwaite,
Community College Research Center

There are many reasons why prerequisite remediation can divert students from taking college-level courses and from pursuing college altogether. Lengthening students' journeys to college-level courses creates additional financial and non-financial burdens on students, many of whom have multiple demands on their time. In addition, students enrolled in remedial courses are likely to encounter deficit orientations and drill-and-kill pedagogies (Grubb, 2013; Larnell, 2016). Moreover, research suggests that being assigned to remedial courses may be particularly problematic for students of color, depressing their sense of belonging and undermining their performance in ways that corequisite approaches might not (Brathwaite et al., 2020).

In California, despite the impressive gains in outcomes across racial groups under the state's new policy, community colleges serving a predominantly Black and Latinx population have continued to offer more prerequisite math courses and disproportionately place students of color into those courses (Hern et al., 2020). Even when remedial courses are not strictly required, the fact that they are offered and included in course catalogs can lead students to believe they should enroll in them (Burdman & Purnell, 2020). Additionally, research has shown that when remedial courses are an option, Black, Latinx, and female students are more likely to choose to enroll in them than white, Asian and male students (Kosiewicz & Ngo, 2020).

MAKING IT HAPPEN:
THE ROLE OF STATE-LEVEL LEADERSHIP

Some institutions have scaled back remedial courses voluntarily, through approaches such as corequisites. In fact, the early pilots were at individual institutions, such as Austin Peay State University in Tennessee and Community College of Baltimore County in Maryland (Vandal, 2017). However, broader implementation has meant eliminating traditional placement approaches and stand-alone remedial courses, which often requires state-level leadership or policy change. Tennessee's Board of Regents, for example, built on the Austin Peay model to launch its nine-college pilot in 2014. Based on that program's success, the board required corequisite implementation at all community colleges, with participation by some universities as well (Tennessee Board of Regents, n.d.). California State University's policy was established through a systemwide executive order from Chancellor Timothy White.

In other cases, such as California's AB 705 and Florida's Senate Bill 1720, legislation has been required to bring about policy change. The Illinois Legislature recently passed House Bill 2170, which will require colleges to expand approaches such as corequisites that maximize the chances students will complete their gateway math courses within two semesters. Lastly, in some places, such as Georgia and Ohio, statewide math task forces that helped design the state's math pathway structures have also been instrumental in placement and corequisite reforms.

"I THINK WHAT AB 705 HAS TAUGHT US IS THAT, PROVIDED THE OPPORTUNITY, ALL STUDENTS CAN LEARN AT HIGH LEVELS."

Aisha Lowe,
California Community Colleges Chancellor's Office

STRATEGY

INSTITUTIONALIZING PRACTICES THAT FOSTER STUDENTS' MATH IDENTITY AND SENSE OF BELONGING

While classroom environments, particularly as they pertain to the delivery of curriculum and the interactions between students and faculty members, have critical implications for the success of racially minoritized students, instruction and support practices are often excluded from equity-focused college redesign efforts. For example, a study of California community colleges' equity plans found that only 14 percent included any focus on the classroom, while the vast majority focused exclusively on student services (Chase et al., 2020). In addition, a recent

analysis of implementation of postsecondary math pathways pointed to the absence of strategies for addressing students' classroom experiences as a possible explanation for why reforms have not gone far enough to eliminate equity gaps (Brathwaite et al., 2020).

Our interviewees reported alarming variations in course success rates across different sections of the same course in the same institution depending on the individual instructor. A particularly thorough analysis of De Anza College's statistics course shows that success rates varied by 68 percent depending on the section (Rosenberg et al., 2020). Furthermore, researchers found that the strongest predictor of students' course success is who they have as an instructor. The course instructor was more predictive of success than students' high school GPAs, ethnicity, or any other student or course-level characteristics. This was especially true for Black and Latinx students (Rosenberg et al., 2020).

Research has begun to explain these patterns. A 2019 study, for example, found that faculty beliefs about whether students' abilities are fixed or malleable were the most powerful indicator of performance for all students, but especially for students from Black or Latinx backgrounds (Canning et al., 2019). Similarly, research has shown that instructors with high expectations for minoritized students play an important role in student success and influence students' academic choices. This may partly be due to the fact that instructors who perceive particular students to be less capable provide less support, while instructors with high expectations are more likely to help students meet or exceed those expectations for succeeding in mathematics or pursuing a STEM field (Ortiz, 2020; Leyva et al., 2021).

"CREATING A SENSE OF BELONGING IN THE CLASSROOM IS NOT SOMETHING YOU DO IN ONE ACTIVITY. IT'S ONGOING AND EMBEDDED.... IT IS SHOWING UP A COUPLE OF MINUTES EARLY TO WELCOME STUDENTS; IT IS KNOWING THEIR NAMES, AND PRONOUNCING THEM CORRECTLY; IT IS ALL THE MICRO-AFFIRMATIONS YOU GIVE THEM WHEN YOU CELEBRATE THEIR SUCCESSES AND ALSO THE GOOD THINKING BEHIND THEIR MISTAKES."

Myra Snell,
California Acceleration Project

Strategies that improve the classroom environment should be integrated into the pedagogy, course content, instructor-to-student interactions, and structured student-to-student interactions. Instructors should engage methods that support identity acceptance and cultural relevance. Below, we discuss areas of equity-focused classroom instruction that can help close student equity gaps.

INSTRUCTION IS CONTEXTUALIZED AND CULTURALLY RELEVANT

Research has increased awareness that the decontextualized, abstract way mathematics is traditionally taught upholds dominant cultural norms, sending the message to minoritized students that they don't belong in mathematics classes, or in STEM fields (Agarwal, 2020; Wilkes & Ball, 2020; Adiredja & Andrews-Larson, 2017; Oppland-Cordell, 2014; McGee, 2016). Conversely, Black and Latinx students may be more motivated to participate in mathematics and see themselves as mathematicians when they are provided contexts that offer them opportunities to participate, engage in mathematical activities with relevance to their lives, and have their thinking affirmed (Miller-Cotto & Lewis, 2020).

Some examples of classroom equity practices that have been found to be effective include the use of instructional practices that reflect culturally relevant ways of knowing (Miller-Cotto & Lewis, 2020; Priniski & Thoman, 2020; Ortiz, 2020; Kroeper & Murphy, 2020; Adiredja & Andrews-Larson, 2017; Leyva interview, October 19, 2020), engaging students in active learning and discussion that invites them to grapple with problem-solving organically before diving into rules and formulas, and providing writing exercises for students to explore how math relates to their personal experiences and career goals (Priniski & Thoman, 2020).

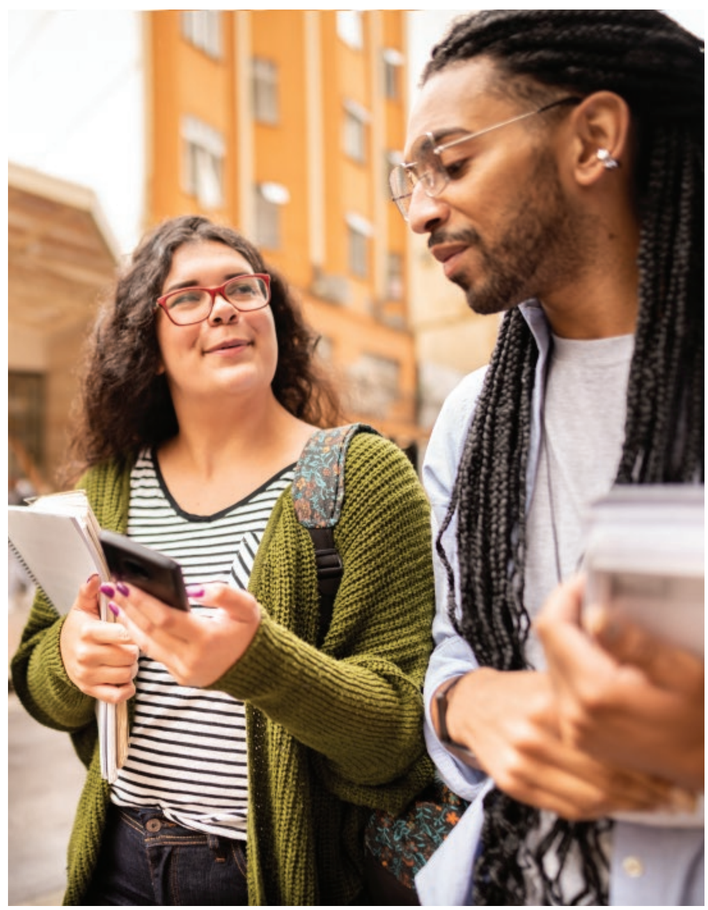
INSTRUCTORS EDUCATE IN WAYS THAT MITIGATE SYSTEMIC RACISM AND THEIR OWN IMPLICIT BIASES

Instructors can, and do, act out biases toward their students, however unconsciously and unintentionally. Researchers have found that students who are seen as deviating from social norms face greater social disadvantages, are socially punished, and receive fewer educational opportunities (Agarwal, 2020; Wilkes & Ball, 2020). Factors such as appearance, comportment, heritage, ethnicity, gender, sexual orientation, economic background, and current economic status all have been shown to influence the assessment of a given individual's aptitude for math (Agarwal, 2020; Wilkes & Ball, 2020; Voigt & Reinholz, 2020; , McGee, 2016; Leyva interview, October 19, 2020). Additionally, studies on incidents of bias on college campuses have found that students experience higher rates of bias in the classroom than in public campus spaces, and perceive more interactions as biased than faculty do, suggesting a lack of awareness among faculty of biased behavior (Boysen et al., 2009).

Biased social messages, or "cues," can cause Black and Latinx students to contend with "stereotype threat," the fear of being judged negatively by others due to belonging to a particular group, and math anxiety, the fear of not performing well in math class (Miller-Cotto & Lewis, 2020). Because both can interfere with students' academic performance and make it less likely that they connect positively with mathematics (Brathwaite et al., 2020; Maloney et al., 2013), they should be mitigated at the source, by addressing systemic bias (McGee, 2016).

Grading and assessment can also be a locus of bias. "Threatening situational cues in STEM settings, such as the diagnosticity of a test, can cause URM [underrepresented minority] students to become concerned about being judged in terms of ability stereotypes, resulting in a loss of motivation, intellectual underperformance, and larger racial achievement gaps in STEM classes" (Canning et al., 2019). Timed math tests that focus solely on right-or-wrong answers, for example, privilege speed over depth, "position correctness as more valuable than mathematical thinking" (National Council of Teachers of Mathematics, 2018, p. 31), and reinforce "the sort of 'fixed mindset' that interferes with students' motivation" (Daro & Asturias, 2019, p. 23). Practices that elicit student thinking and allow students to revise their answers provide more opportunities for students to learn—and demonstrate their learning.

Of course, the messages students receive may be influenced by the fact that STEM faculty are far less racially diverse than their students. In addition to addressing the mindsets of current faculty, increasing the diversity of math faculty is an important strategy over the longer-term: Research finding that exposure



to Black faculty improves the STEM persistence rates of Black students (Price, 2010) provides additional impetus for diversifying the ranks of math professors (which also requires improving ensuring equity in postsecondary math opportunities).

INSTRUCTORS SUPPORT EFFECTIVE USE OF STUDENT SOCIAL NETWORKS

While the benefits of student social networks, such as study groups and learning communities, have been well documented (Hsu et al., 2008; Fullilove & Treisman, 1990; Adiredja & Andrews-Larson, 2017), facilitating student interactions within and outside the classroom requires awareness of racial dynamics and the skill to foster inclusive environments (Esmonde & Langer-Osuna, 2013).

Uri Treisman observed that Black students with high math failure rates tended to study alone, whereas Black students who were placed in collaborative learning contexts ultimately exceeded both white and Asian students in achievement, and their failure rates dropped to zero (Fullilove & Treisman, 1990; Hsu et al., 2008; Boaler, 2019). Yet, in what has been called "unproductive positioning" in group work, white students can reinforce and act out racial bias toward peers of color (Wilkes & Ball, 2020). Interventions that can mitigate inequities include setting up classroom expectations that convey clear rules of student engagement, and proactively structuring group work in ways that mitigate acting out bias (Leyva interview, October 19, 2020; Wilkes & Ball, 2020, Esmonde & Langer-Osuna, 2013).

"I SAY [BRING] RACE AND GENDER INTO THE CONVERSATION IN OUR CLASSROOM SPACE, BECAUSE... IF WE CAN BRING IT AND FOLD IT INTO THE CONVERSATION, THE INSTRUCTOR IS ACTUALLY ABLE TO WORK WITH STUDENTS TO DISRUPT THE FUNCTIONS OF THOSE RACIAL AND GENDERED PROCESSES, THUS MITIGATING SOME OF THE NEGATIVE IMPACTS OF THESE INSTRUCTIONAL PRACTICES IN THE CLASSROOM."

Luis Leyva
Vanderbilt University

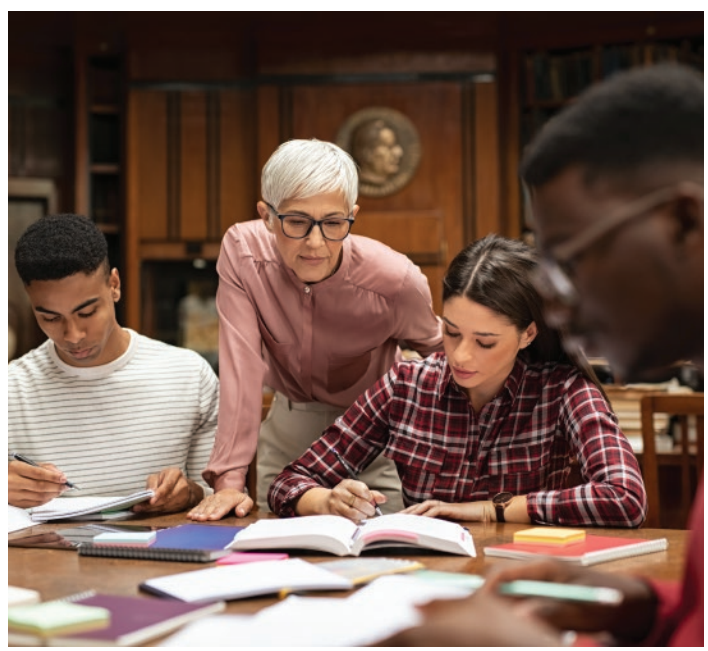
MAKING IT HAPPEN:
THE IMPORTANCE OF FACULTY DEVELOPMENT AND SHARED OWNERSHIP

Faculty professional development and shared ownership of courses are two important levers for institutionalizing effective and equity-focused classroom practices.

Professional development opportunities should be discipline specific, ongoing, and focused on both improving instruction and addressing faculty implicit bias or equipping faculty to confront racism in their classrooms (Kroeper & Murphy, 2020; Wilkes & Ball, 2020; Leyva, et al, 2021). Having instructors engage in reflective teaching, meaning they regularly reflect on their interactions and teaching decisions, has also been shown to help curb bias (Brathwaite et al., 2020; Joseph et al., 2016; Boysen et al., 2009). To ensure equity, such professional development must apply to grading and assessment practices, in addition to classroom pedagogy.

"ACADEMIC FREEDOM DOES NOT MEAN THAT EVERY FACULTY SHOULD DECIDE WHAT TO INCLUDE IN THE COURSE, WHAT THE TEST LOOKS LIKE, AND HOW MANY STUDENTS SHOULD PASS."

Ricardo Moena
University of Cincinnati



Ongoing, extensive, and contextualized professional development requires funding and skilled facilitation. Yet, faculty professional development is often underfunded and limited to occasional workshops and conferences. When communities of practice exist, it is difficult to find skilled facilitators who would keep the conversations productive and focused on effective and equitable practices.

"WE NEED TO BRING STUDENT VOICES TO THE FORE IN ORGANIZING PROFESSIONAL DEVELOPMENT WORKSHOPS. I THINK IT SHOULD COME FROM THE CLASSROOM AND BE SPECIFIC TO MATH. [FOR EXAMPLE], EVENT JOURNALS ALLOW US TO CAPTURE SOME OF THE NUANCE OF WHAT HAPPENS TO STUDENTS, THAT THEY FEEL AFFIRMED OR DISAFFIRMED IN CERTAIN MOMENTS."

Luis Leyva
Vanderbilt University

Another lever for institutionalizing effective and equity-focused instruction, assessment, and grading practices is shared ownership of courses across multiple faculty members. Though not specifically analyzed for equity, one well-regarded example of shared ownership of math instruction is the CUNY Start program at the City University of New York. CUNY Start's use of standardized course content and instruction has led to positive outcomes (Bickerstaff & Edgecombe, 2019; Cormier & Bickerstaff, 2020).

"YOU'RE NEVER GOING TO EQUALIZE THE QUALITY OF INSTRUCTION COMPLETELY, BUT WHAT YOU CAN DO IS ESTABLISH STRUCTURES THAT MAKE IT AS EASY AS POSSIBLE FOR INSTRUCTORS TO DO THE QUALITY INSTRUCTION, AND THAT CAN BE THROUGH… COURSE GUIDES THAT THE INSTRUCTORS ARE ASKED TO FOLLOW, INSTITUTIONALIZING THE POLICIES OR PRACTICES THAT ARE REALLY IMPORTANT… THINGS LIKE REQUIRING STUDENTS TO VISIT THE TUTORING CENTER AT LEAST ONCE IN THE BEGINNING OF THE SEMESTER."

Amy Getz
Charles A. Dana Center

STRATEGY

ACTIVELY RECRUITING AND PROVIDING SUPPORT FOR BLACK, LATINX, AND OTHER STUDENTS TRADITIONALLY UNDERREPRESENTED IN STEM PATHWAYS

Among academic disciplines, STEM fields stand out for their degree of racial inequality (Riegle-Crumb et al., 2019). Part of the work of creating diversified math pathways is to ensure that all students who are potentially interested in STEM fields can pursue them. There are many possible explanations for the underrepresentation of Black and Latinx students in STEM, including:

- **Placement practices in K-12 schools:** Middle schools and high schools disproportionately track underrepresented students out of advanced math courses that would prepare them to enter STEM fields or access more selective colleges (Gao & Johnson, 2017; National Council of Teachers of Mathematics, 2018; Daro & Asturias, 2019).

- **Bias from staff and faculty:** Advisors and faculty who counsel students about major and career, may unconsciously send messages to students that they don't have the potential to perform well in a particular course or program (Brathwaite et al., 2020; Bickerstaff interview, October 7, 2020; Leyva interview, October 19, 2020).

- **Stereotype threat and math anxiety:** Both stereotype threat and math anxiety can result from messages students receive as early as elementary school (Maloney et al., 2013). By the time students arrive in postsecondary education, these messages may have taken a significant toll, and Black and Latinx students pursuing STEM fields continue to encounter racial bias (Brathwaite et al., 2020; McGee, 2016; Oppland-Cordell, 2014; McGee & Martin, 2011).

- **Inadequate major and career exploration opportunities:** Focus groups with community college students reveal few opportunities, and a great need, for understanding the competencies involved in various majors and careers, as well as the connection between majors and careers (Dadgar et al., 2017; Burdman & Purnell, 2020).

- **Remedial and other prerequisites:** Such courses lengthen the STEM sequence and create financial and other barriers to participation for low-income and minoritized students (Xu & Dadgar, 2017; Scott-Clayton & Rodriguez, 2012; Venezia et al., 2010).

While ideally the work to address these barriers should begin at the K-12 level, there is much that postsecondary institutions can do to attract more underrepresented students to STEM paths and support their success.

EXPANDING CAREER EXPLORATION OPPORTUNITIES

In the absence of opportunities for career exploration, there is a risk that students from disadvantaged backgrounds will select short-term credentials that require less time and money to complete or "default" into a liberal arts pathway, interviewees said. Students often express the desire for in-depth career exploration, to help them understand which careers different majors lead to and the competencies needed for each career. Most community colleges do not offer such experiences (Dadgar et al., 2017). Yet, community colleges in the guided pathways movement are clustering programs of study based on competencies into meta-majors. Meta-majors create an opportunity for organizing and expanding career exploration opportunities around student interest, but few colleges have utilized them in this way.

An exceptional example of in-depth career-exploration opportunity that is available to all students is LaGuardia Community College's dedicated career exploration class, which is offered to all incoming students and is differentiated based on students' general areas of interest. The class allows students to develop research skills by shadowing and interviewing individuals in real jobs and writing about their experiences. Additionally, the class setting creates an opportunity for students to receive ongoing career-exploration mentorship from a faculty member (Dadgar, 2018).

ACTIVE RECRUITMENT OF BLACK AND LATINX STUDENTS INTO STEM AND IMPLICIT BIAS TRAINING FOR STAFF WHO INTERACT WITH STUDENTS

Interviewees said that institutions should take responsibility for actively recruiting Black and Latinx students into STEM pathways, to counter educational structures that discourage participation (Henfield & Byrd, 2014). Ideally, such engagement would begin with partnerships when students are still in high school. Faculty could speak with Black and Latinx students about majoring in STEM, or peer mentors could be used to invite students to STEM clubs or other peer-supported opportunities that promote Black and Latinx participation in STEM pathways. For example, at the University of Texas at Austin, Black and Latinx work-study students who are STEM majors are hired to visit math classrooms and speak with other students about majoring in a STEM field (Treisman interview, October 21, 2020). Strategic implementation of dual-enrollment programs, which allow high school students to enroll in college-level courses, can also be an opportunity to expose students to STEM pathways.

Additionally, institutions can ensure that all students with potential interest in STEM fields can access those pathways, by training staff, faculty, and advisors who interact with students, with a goal of instilling a growth mindset and minimizing implicit bias.

"STUDENTS NEED TO HEAR AN AFFIRMING AND CONSISTENT MESSAGE FROM ALL WHO ENGAGE THEM AT OUR INSTITUTIONS. THE MESSAGE NEEDS TO BE: YOU CAN DO COLLEGE, AND HERE IS HOW WE WILL HELP YOU DO IT."

Myra Snell
California Acceleration Project

ALIGN RESOURCE-INTENSIVE SUPPORTS WITH STUDENT NEEDS

Interviewees agreed that colleges have limited resources and that high-touch supports should be prioritized based on students' needs. This would ensure opportunities and support for populations that have historically had lower rates of postsecondary success (Henfield & Byrd, 2014).

"ONE IMPORTANT METRIC FOR SUCCESS IS, REGARDLESS OF WHAT LEVEL STUDENTS ARE AT, WHEN THEY ENTER A COURSE, THEY END UP EXITING WITH EQUAL LEVELS OF SUCCESS—BECAUSE SUPPORTS ARE PROVIDED BASED ON NEED."

Ricardo Moena
University of Cincinnati

The most effective types of supports are holistic—addressing students' academic and nonacademic needs—and are provided to students proactively, so that access to supports is not contingent on students having the confidence or skills to navigate college (Dadgar et al., 2013; Karp et al., 2008; Scott-Clayton, 2015). Also, the most effective approaches take advantage of peer support, given that some students are more comfortable seeking help from peers (Thiry, 2019). One example is learning communities or peer networks (including same-race peer networks) in which students are recruited to study together, support one another, and access dedicated counselors and advisors who support academic and nonacademic needs.

Another example is embedding tutors in classrooms to offer support to students proactively. An evaluation of CUNY Start revealed that the use of embedded tutors led to an increase in the use of the tutoring center; similar results were found in those California community colleges that take advantage of embedded tutors (Bickerstaff & Edgecombe, 2019; Purnell & Burdman, 2020).

MAKING IT HAPPEN:
DEEPENING COLLEGEWIDE COORDINATION

To ensure diverse racial representation in all mathematics pathways, mathematics departments should collaborate closely with college officials responsible for student outreach, onboarding, and career-exploration and support services, to ensure that all students receive career exploration opportunities, and that Black, Latinx, and other students from racially minoritized backgrounds are actively recruited into STEM pathways and proactively supported to succeed. In addition, state systems and college leaders should prioritize funding for ongoing and contextualized implicit bias training for all staff who interact with students, and examine faculty and staff hiring and promotion policies to advance greater diversity.

RECOMMENDATIONS

Existing research and knowledge in the field validate the notion that redesigning postsecondary math pathways can be a strategy to enhance educational equity. Yet this won't occur unless institutions and states exercise leadership around solving for equity, as outlined below. Many of the recommended steps align with work that states and institutions may already be doing in the context of implementing other initiatives, such as creating guided pathways, establishing completion goals, reforming developmental education, and improving alignment and articulation across institutions and segments.

STATES SHOULD:

1. **Take a leadership role in coordinating cross-discipline and cross-institutional efforts to align curriculum**

   State-level coordination across institutions and disciplines can create seamless transfer of students from two- to four-year colleges, greater integration of skills across disciplines, and greater alignment of curricula with career competencies.

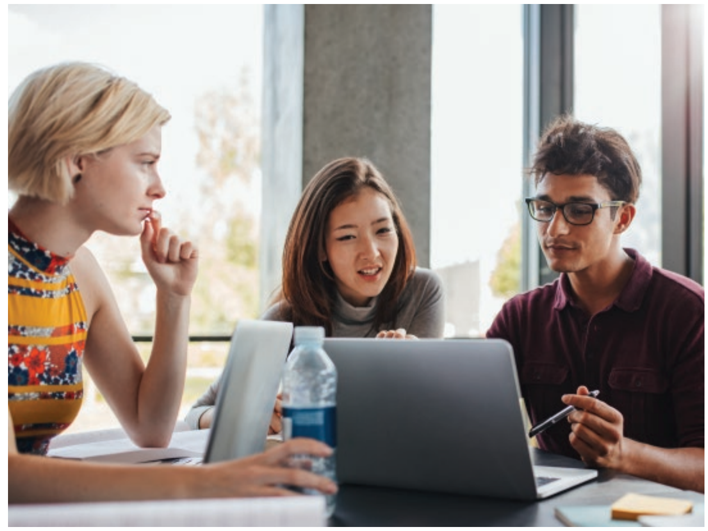
   State-level efforts can ease the burden on individual colleges to collaborate across departments and coordinate across segments. Additionally, state-level facilitation can relieve some of the power dynamics that exist in alignment and articulation conversations between two- and four-year institutions or between K-12 schools and postsecondary institutions.

2. **Disincentivize the offering of prerequisite remedial courses to avoid tracking students**

   Prerequisite remedial courses disproportionately track Black and Latinx students out of college-level courses. Whether it is through legislative action, governing bodies, or postsecondary system leadership working closely with colleges, remedial offerings should be replaced with evidence-based alternatives, such as corequisite courses or embedded supports.

3. **Provide funding and opportunities for effective professional development for faculty and other individuals interacting with students; invest in racial diversity of faculty**

   Effective professional development is ongoing, equity focused, well facilitated, and tailored to the specific discipline or individual's role in interacting with students. Colleges often report not having enough funds to provide ongoing professional development to all faculty and staff. Additionally, many colleges cannot require faculty or staff to attend professional-development offerings, hindering the effort's effectiveness. Finally, investing in a more racially diverse faculty composition can further support the success of students of color.



4. **Support research on equitable math instructional practices in the higher-education environment and incorporate equity into access and success metrics**

   Since much of the existing research on equitable instruction focuses on K-12 settings, further research in the postsecondary setting is needed to better understand the impact of faculty mindset about student ability, instructional practices, and assessment and grading on the success of students from marginalized backgrounds. Furthermore, states should invest in examining the sources of the high rates of variation in student success across math courses by instructor and use findings to institutionalize high-quality and equity-focused instruction.

   The following benchmarks should be considered when examining colleges' success in equitable design and implementation of math pathways:

   - High rates of participation and success in gateway math courses, such as Statistics, Quantitative Reasoning, and Calculus.

   - Demographics of students successfully completing specific gateway math courses, including Calculus, that closely represent institution or state demographics.

   - Demographics of students attaining degrees and credentials in fields requiring Calculus that closely represent the institution or state demographics.

INSTITUTIONS SHOULD:

1. **Create opportunities for cross-functional and cross-departmental collaboration**

   To ensure that students can develop the critical-thinking and problem-solving skills that are relevant to their majors and careers requires mapping course content backward from relevant major and career competencies. This can happen only in collaboration with other departments. Additionally, refining requirements in collaboration with advisors, counseling faculty, or student-services professionals ensures that students receive the right messages about the most appropriate courses for them.

2. **Replace prerequisite remediation with corequisite supports**

   Colleges should universally replace remedial offerings with corequisite or embedded supports. When prerequisite courses are made available, Black, Latinx, and female students are more likely to enroll in them, even though doing so reduces their chances of subsequently completing a gateway course.

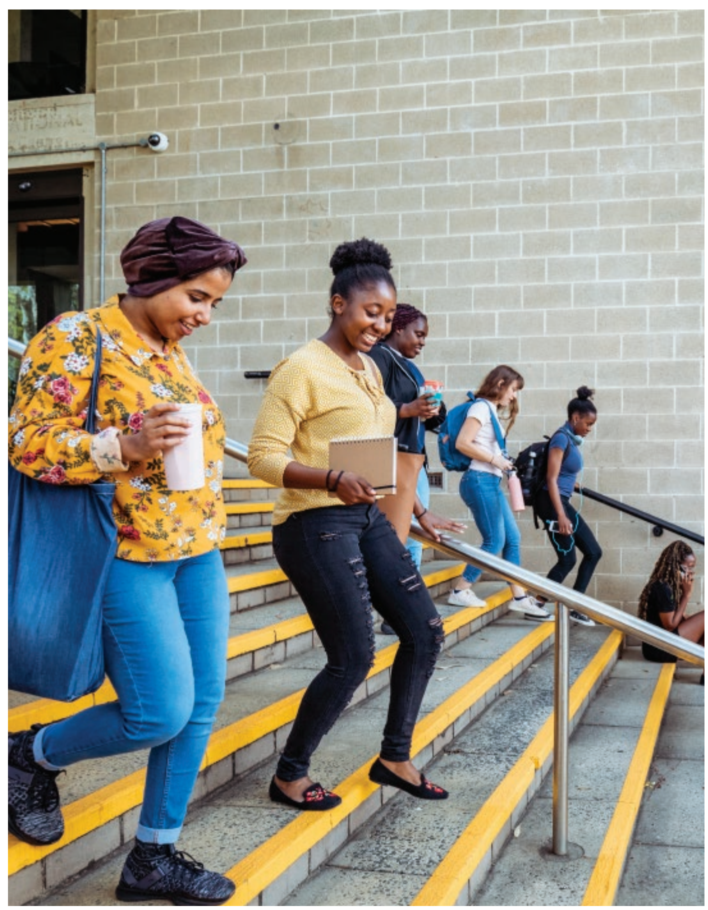
3. **Provide staff with ongoing, discipline-specific and well-facilitated professional development focused on equity and implicit bias, and institutionalize effective classroom practices though shared ownership of courses**

   Colleges should prioritize funding for ongoing and well-facilitated professional development or communities of practice that enable faculty to reflect on their own practices and learn about the experiences of marginalized student groups in their classrooms. Departments and institutions should create shared ownership of classroom success through various means, including course guides that promote equitable instructional and grading practices. Institutions should provide faculty with data on their course success rates disaggregated by race and gender, and they should provide safe spaces to discuss mindsets, policies, and practices that result in higher or lower success rates for marginalized student groups.

4. **Develop strategies to actively recruit Black, Latinx, and other marginalized student groups in STEM pathways and offer resources to ensure their success**

   Providing career exploration opportunities to all students and actively recruiting students who are underrepresented in STEM can ensure that students who are interested in STEM fields have the encouragement to pursue them. Institutions should also align resources with student needs and offer proactive and holistic supports to students who need them to succeed.

Postsecondary math pathways will not reach their highest potential—or ensure students can do so—unless they are implemented in equitable ways. To date, solving for equity in the implementation of postsecondary math pathways is an unfinished project. But the research for this brief suggests that the practices and strategies needed to ensure more equitable math outcomes are within the reach of postsecondary institutions and states, if they direct their resources toward the goal of racial equity.



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