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Support for All? Confronting Racism and Patriarchy to Promote Equitable Learning Opportunities through Undergraduate Calculus Instruction

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Abstract
Undergraduate calculus instruction is a contributor to racialized and gendered trends of STEM persistence and disidentification with mathematics. However, the nature of instruction that promotes equitable learning opportunities for disrupting such negative outcomes and experiences among historically marginalized populations is underexplored. To fill this gap, this paper presents an analysis of 34 undergraduate Black and Latina/o students' perceptions of discouraging events and alternatives for supportive practices in calculus instruction to build theory of equitable practices. Our findings show how *supportive-for-all practices* – instructional practices supportive for all students (e.g., creating space for questions and mistakes, extending out-of-class support) – were perceived as necessary yet insufficient to cultivate equitable opportunities for classroom participation and access to content. Black and Latina/o participants' perceptions of instruction addressed how, without challenging broader influences of racism and patriarchy (e.g., stereotypes of mathematical ability), historically marginalized students have limited access to learning opportunities afforded by supportive-for-all practices. The present study, therefore, demonstrates how equitable calculus instruction requires race- and gender-conscious enactment of supportive practices, which challenges colorblind and gender-neutral assumptions of uniformity in students' experiences of instruction that leave structural forms of exclusion unchecked. We conclude with implications for practice and research.

Keywords Equity · Racism · Patriarchy · Supportive-for-all practices · Undergraduate calculus instruction

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Introduction

International research has explored features of calculus instruction that support students with the challenging transition into university mathematics (Ellis et al., 2014; O'Shea & Breen, 2021; Petropoulou et al., 2020; Pinto, 2019). This body of work fills a research gap in undergraduate mathematics education that González-Martín and colleagues (2017) described as "studies connecting teachers and students (teaching with learning)" (p. 1959). Findings conveyed how instructional practices facilitated students' mathematical enculturation. However, variation in students' instructional experiences across race, ethnicity, gender, and other dimensions of social difference was left implicit in analyses. With systems of oppression shaping inequitable access to mathematical content (Bressoud, 2021; Gerber et al., 2005) and experiences of marginalization in calculus (Oppland-Cordell, 2014; Sabbah & Heyd-Metzuyanim, 2021), the field lacks insights on calculus instruction that theorizes equitable distribution of support.

The present study fills this void by exploring variation in Black and Latina/o[1] students' perceptions of supportive instructional practices in U.S. calculus classrooms and their influence on equitable learning opportunities. Focusing specifically on U.S. Black and Latina/o students allowed us to examine instructional experiences for two underrepresented racial groups who have been historically denied access to high-quality mathematics education (Battey & Leyva, 2016; Martin 2009) and stereotyped as lacking mathematical ability (McGee, 2016). Our study, informed by the critical race tradition of educational research (Ladson-Billings & Tate, 1995; Lynn & Dixson, 2013), centers and validates racially minoritized students' perspectives on instruction as knowledge sources for disrupting racism and other interlocking systems of power (e.g., patriarchy) that shape inequitable experiences in undergraduate calculus.

We employed a critical view of equity in mathematics education (Martin, 2003) as the study's guiding theoretical perspective. This theoretical lens challenges dominant conceptions of equity in U.S. mathematics education framed as providing support *for all*, which homogenizes social differences and assumes uniformity of experience. In applying this lens, our study explored how Black and Latina/o students' perceptions of calculus instruction depict how practices deemed supportive for all students regardless of identity (or *supportive-for-all practices*) limited equitable learning opportunities. We address the following research questions:

1. What do Black and Latina/o students perceive as supportive-for-all practices in calculus instruction, and what are their perceived impacts on learning opportunities?
2. In what ways do Black and Latina/o students' perceptions address limitations of supportive-for-all practices in fostering equity?

[1] Participants from Latin American backgrounds in our study identified as either Latina women or Latino men, so we use those racial identity descriptors when referring to them. Elsewhere in the paper, when referring to people from Latin American backgrounds in general, we use the descriptor *Latin**. The asterisk in Latin* considers fluidity in gender identities across the Latin American diaspora (Salinas, 2020). Latin* responds to (mis)use of Latinx, a term reserved for gender-nonconforming peoples of Latin American origin and descent (Salinas & Lozano, 2019).

Our findings illustrate how supportive-for-all practices can leave unaddressed racialized and gendered influences (e.g., stereotypes of mathematical ability, exclusionary ideas of who belongs in STEM) that limit historically marginalized students' access to participation and content. Thus, student perspectives in our analysis suggest that equity-oriented calculus instruction requires confronting racism and patriarchy that reproduce oppression in mathematics education.

As a contribution to the present *IJRUME* special issue that challenges assumptions of uniformity in calculus education, our paper problematizes dominant orientations of equity in mathematics education that decouple instruction from systemic forces and homogenize student experiences. We place our analysis from the U.S. context in dialogue with international research in undergraduate mathematics grounded in sociocultural approaches (Nardi et al., 2014). Responding to the "need for more research considering social and institutional factors which intervene in the [calculus] teaching/learning processes" (Petropoulou et al., 2020, p. 370), our analysis situates instruction in sociohistorical contexts to theorize equity in calculus education, which is largely missing in the field (Adiredja & Andrews-Larson, 2017; Hagman, 2019; Larsen et al., 2016). We encourage readers to consider transferability of our findings to promote equity in calculus education across countries with social realities, both historical and in the present day, that overlap and differ from those in the U.S. context.

Literature Review

We review two sets of studies to situate our work in an international body of research on undergraduate calculus education[2]. The first set focused on instructional practices that supported students' transition into and persistence with university mathematics. Equity issues were not the focus. The second set of studies engaged equity in a more central way to explore historically marginalized students' calculus experiences, but instruction was not closely examined. Our literature review captures the international need for equity-oriented research on undergraduate calculus instruction. Where relevant, we note sociopolitical realities of cultural and structural racism varying across national contexts that shape issues of equity.

Supportive practices of calculus instruction

A major trend in research on undergraduate calculus instruction that supports transition into and persistence with university mathematics was carving opportunities for

[2] The nature of university calculus courses varies internationally (Petropoulou et al., 2020). In some countries (e.g., Greece, Israel), the courses have a theoretical focus on the behavior of real numbers, sequences and series, and real functions. Calculus courses in other countries (e.g., Ireland, U.S.) have a computational focus on continuous change in real numbers. Despite this variation in content, calculus plays a common role across national contexts as one of the first courses that students must take to be granted access to more advanced mathematics and STEM majors. We center this international role of calculus in our literature review while recognizing that course contexts specific to the nature of mathematical content across empirical studies differed.

student engagement in mathematical discourse (Ellis et al., 2014; Jaworski et al., 2017; Petropoulou et al., 2020; Rasmussen et al., 2019). Petropoulou et al. (2020) presents a case of a calculus instructor in Greece whose instruction involved eliciting students' observations as entry points for learning. Ellis et al., (2014) reported that U.S. students who perceived high frequency of whole-class discussion and eliciting of student thinking were more likely to persist with calculus.

Another trend in this set of studies was instruction that facilitated enculturation into mathematics by way of beliefs and values (Liu, 2009; O'Shea & Breen, 2021; Sonnert et al., 2015) as well as norms of practice (Petropoulou et al., 2020; Pinto, 2019). Liu (2009) reported how Taiwanese students' engagement with a historical approach to instruction contributed to shifts in disciplinary beliefs aligned with those of mathematicians that account for knowledge as abstract, dynamic, and creative. O'Shea and Breen's (2021) study in Ireland showed how nonroutine tasks developed students' values of learning independently (e.g., working alone, thinking for themselves) and building conceptual understanding. Pinto's (2019) study of two teaching assistants' lessons in Israel highlighted how instructional practices for informal aspects of mathematics learning were used to develop students' engagement with disciplinary norms. One practice, for example, was the emphasis of certain words in the definition of a derivative to underscore the importance of precise meaning when reading and communicating in mathematics.

While this set of studies importantly identified features of calculus instruction that alleviated the challenging transition into university mathematics, findings largely centered instructors' and researchers' perspectives. Student reports about instruction were missing except in some studies (e.g., Ellis et al., 2014; O'Shea & Breen, 2021), which documented variation in how supportive practices were experienced. For example, O'Shea and Breen (2021) found that despite students' appreciation for non-routine tasks, some students found expectations to work independently and keep up with fast-paced instruction to be challenging. Ellis and colleagues (2014) noted that rates for reported instructional practices that supported calculus persistence differed between students who continued and switched out of STEM majors despite them being in the same classroom. The researchers interpreted disparities in peer perceptions of holding whole-class discussions, for instance, as signaling a possibly inequitable distribution of discussion opportunities, wherein an instructor may more readily involve students perceived as easier to engage (e.g., students answering quickly and correctly).

Variation across students' experiences of supportive practices revealed challenges in calculus learning (e.g., speed of instruction, lack of involvement in classroom discussions) echoed in the second set of studies reviewed below, which centered issues of equity. However, the lack of consideration for diversity and systemic forces in the first set of studies left implicit how these influences shaped differences in students' experiences of supportive instruction.

Historically marginalized students' experiences in undergraduate calculus

The second set of studies in our literature review explored historically marginalized students' experiences in undergraduate calculus, which shed light on how ideological

and structural forces rooted in systems of oppression reinforced inequities in mathematics education. One thread of findings revealed stereotypes as ideological influences that limited access to classroom participation (Oppland-Cordell, 2014; Sabbah & Heyd-Metzuyanim, 2021). In a study of Arab females' academic identities while attending a predominantly Jewish institution in Israel, Sabbah and Heyd-Metzuyanim (2021) found how gender stereotyping of males as more confident and competent than females in mathematics shaped female participants' identities of being academically unsuccessful that inhibited classroom contributions. One participant Lena never asked questions in calculus. This gendered dynamic was situated in the broader context of cultural racism rooted in the Israeli-Palestinian conflict that created tensions between Arab and Jewish students, thus alienating Arab females in classes. Similarly, Oppland-Cordell (2014) reported on how U.S. Latina/o calculus students' internalized stereotypes of mathematical superiority among Asian people, white[3] people, and men inhibited their sharing of ideas or prompted deferring to others' thinking when collaborating with peers holding these identities.

Another thread of findings was historically marginalized students' limited access to content due to structural barriers (Gerber et al., 2005; Jett, 2013; Leyva, 2016). Gerber and colleagues (2005) found that South African students who received calculus instruction in their home language of Afrikaans[4] outperformed students receiving it in their second or third language (English). With Afrikaans as the language of white supremacy in apartheid racism (Gosselink et al., 2017), this finding depicts structural racism through language in South Africa, such that instructional use of Afrikaans reinforced racialized power through inequitable access to content.

International use of calculus for sorting students into and out of STEM (Deeken et al., 2020; Ellis et al., 2014) is a structural barrier to mathematical persistence. Jett (2013) described how calculus was one of the most difficult courses for African American males even as mathematics majors at a predominantly Black college or university. Elsewhere (Leyva, 2016), the first author described how first-year Latina college women reconsidered STEM majors as calculus students at a predominantly white U.S. university. One participant attributed her reconsideration of computer science to calculus instruction that left her with unanswered questions and concerns about teaching herself content for future mathematics courses.

While the challenge of calculus impacts students across social differences, its discouragement of mathematical persistence is uniquely exacerbated for historically marginalized students navigating stereotypes of ability (McGee, 2016; Sabbah & Heyd-Metzuyanim, 2021) and working to overcome structural inequities (e.g., access to pre-college mathematics preparation; Bressoud 2021). Thus, calculus instruction can play an important role in challenging dominant ideologies and structural barriers that reproduce inequitable access to content and STEM persistence (PCAST, 2021). However, instruction was not the focus of equity-oriented research on historically

[3] The use of lowercase W for white racial identity and uppercase B for Black racial identity challenge symmetrical treatment of racial groups through language as a form of resistance against white supremacy (Appiah, 2020).

[4] Afrikaans was the primary language of the former South African apartheid until 1994 when English became the lingua franca, but first-language English speakers remained in the population minority at the time of the study.

marginalized students' calculus experiences, which leaves theorizing equitable calculus instruction as an area of needed study.

Theoretical Perspective: A Critical View of Equity in Mathematics Education

Martin's (2003) *critical view of equity* served as the present study's guiding theoretical perspective. Since our study took place in the U.S., we adopted this equity perspective developed with the backdrop of structural racism in U.S. education. Amidst post-slavery racial integration of schools during the 1950's-1970's, Black students attended predominantly white schools where they could no longer learn from Black teachers who taught with social justice orientations (Joseph, 2017; Tillman, 2004). Thus, Black students navigated teachers' white gaze that positioned them as culturally deprived or academic failures. Concurrently, a movement for Latin* educational equity was underway to resist anti-immigration sentiments in school policies that privileged English-speaking students and disproportionately slotted Latin* students into low-tracked classes (González, 2011). These deficit views of Black and Latin* students' ability influence mathematics teaching in the present day, which reduce the challenge of learning opportunities and reinforce racialized access to content (Berry, 2008; Gutiérrez, 2013; Leyva, 2016). Such inequities are also gendered with masculinized constructions of mathematical ability that limit women and girls being recommended for advanced courses (McGraw et al., 2006) as well as marginalize embodied femininity (Gholson & Martin, 2019; Leyva, 2017).

In response to mathematics education reform of the early 2000s in pre-college grades, Martin (2003) critiqued the framing of equity as ensuring access to high-quality learning opportunities for all students. While racialized disparities in achievement and persistence motivated this reform, the *for all* rhetoric in major educational policy documents [e.g., *Principles and Standards for School Mathematics* (NCTM, 2000)] erased racially minoritized students and their educational realities (Martin, 2003). This colorblind, gender-neutral conception of equity signaled "uneasiness or unwillingness to grapple with the complexities and particularities of race, minority/marginalized status, differential treatment, underachievement in deference to the assumption that teaching, curriculum, learning, and assessment are all that matter" (Martin, 2003, p. 10). Thus, Martin (2003) called for the uptake of a "critical view of equity" (p. 7) to guide changes in policies and practices that explicitly confront systemic forces of oppression, which shape inequitable opportunities to learn and build a sense of belonging in mathematics.

During a plenary at the 2019 Conference on Research in Undergraduate Mathematics Education in the U.S., Dan Battey (2019) invoked Martin's (2003) critical view of equity to similarly critique *for all* discourse on equitable instruction in undergraduate mathematics. Highlighting language in sections of the Mathematical Association of America's *Instructional Practices Guide* (2017), Battey (2019) argued that lack of criticality in an equity stance toward reform disallows consideration for variation in how students across social differences experience instruction. Therefore, with a critical view of equity, undergraduate mathematics educators disrupt colorblind

and gender-neutral instructional approaches that problematically assume uniformity in students' experiences and leave broader oppressive influences unchallenged. This orientation to equitable reform is crucial in U.S. undergraduate calculus, where pre-college educational inequities are exacerbated and contribute to racialized-gendered attrition in STEM majors (Bressoud, 2021).

Inquiry-Based Mathematics Education as a Starting Point for Equity. To depict the promise of framing our analysis of supportive-for-all practices in a critical view of equity, we apply this theoretical perspective to U.S.-based research on instruction in the tradition of Inquiry-Based Mathematics Education (IBME). We use IBME research as an illustrative case that captures the need for and importance of exploring undergraduate calculus instruction as situated in broader sociopolitical realities to foster equitable learning. Our rationale for focusing on IBME research is twofold. First, IBME is a widely-engaged approach to reform in undergraduate mathematics toward promoting equitable outcomes of achievement and persistence (Laursen & Rasmussen, 2019), which is analogous to educational reform efforts that Martin (2003) critiqued. Second, practices of IBME, such as eliciting student thinking and fostering engagement with disciplinary practices, exemplify supportive-for-all practices highlighted in our literature review on calculus education and therefore relevant to our analysis.

IBME is centered around four pillars: (i) students' deep mathematical engagement, (ii) student collaboration, (iii) instructor inquiry of student thinking, and (iv) equity (Laursen & Rasmussen, 2019). These pillars organize instruction intended to support all students through *equal* opportunities to access content, participate in mathematics learning, and build disciplinary identities. However, as shown in research discussed below, such supportive-for-all practices in IBME without a critical view of equity overlook historically marginalized students' racialized and gendered experiences in mathematics, thus making equitable learning an elusive outcome.

With a focus on gender, Johnson and colleagues (2020) documented no differences between women's and men's performance in non-IOL[5] courses, but men significantly outperformed women in IOL courses. These findings contrast those in Laursen et al. (2014) that reported significantly lower gains in cognitive and affective outcomes (e.g., understanding of concepts, attitudes toward mathematics) among women compared to men in non-IBL courses, but no such gender-related differences in IBL courses. In interpreting this contrast, Johnson and colleagues (2020) argued that an inquiry approach is "far from a guarantee of equitable instruction" (p. 514). The authors conjectured that unchecked misogynist influences (e.g., microaggressions during peer collaboration) possibly shaped oppression in women's instructional experiences to further explain gendered disparities of performance.

In analyzing Latina/o students' racialized-gendered instructional experiences in an IBL classroom, Brown (2018) conveyed how inattention to realities of structural exclusion reinforced oppression through instruction. Findings showed how a Latina was excluded from groupwork with three male peers and a Latino student's use of Spanish slang was invalidated as discourse for mathematics learning. Thus, inquiry

[5] IOL (inquiry-oriented learning) and IBL (inequity-based learning) are two traditions of IBME in undergraduate mathematics (Laursen & Rasmussen, 2019).

practices of fostering collaboration and engagement with disciplinary norms enacted without a critical orientation to equity fell short in resisting oppressive forces (e.g., gender stereotypes of ability, racialized constructions of mathematical discourse) that limited Latina/o students' access to participation and content.

IBME research highlighted here illustrates how supportive-for-all practices through inquiry are necessary yet insufficient to promote equity from a critical perspective, which requires confronting broader sociohistorical forces that collide with instruction to reinforce systemic inequities. Thus, inquiry instruction is a starting point for equity (Battey & McMichael, 2021; Tang et al., 2017). More broadly, a framing of equity to provide support *for all* students through instruction in undergraduate mathematics, including calculus, can reinforce dominant conceptions of mathematics learning as a colorblind and gender-neutral endeavor that leave unchallenged structural exclusion (Joseph et al., 2016; Leyva, 2021; McNeill et al., in press). In contrast, instruction that confronts how undergraduate mathematics is situated in broader systems of oppression, including racism and patriarchy, works toward disrupting colorblind and gender-neutral assumptions of uniformity in students' instructional experiences to advance equitable learning.

Methods

The present analysis comes from a larger study of racialized and gendered features of undergraduate calculus instruction. We (the author team) and fellow members of the study's research team completed several analyses about historically marginalized students' perceptions of instruction as potentially racialized and gendered. Major findings from our prior work shed light on inequitable mechanisms of instruction (e.g., creating differential opportunities for classroom participation; Leyva, Quea, et al., 2021); logics in mathematics that organize seemingly neutral yet oppressive instruction (e.g., instructors hold all authority in classrooms; Leyva, McNeill, et al., 2021); and student experiences of managing cognitive and emotional labor from racialized and gendered instructional instances (e.g., grappling with uncertainty about bias in instructor behaviors; Battey et al., 2022). While these findings were based on historically marginalized students' perceptions of discouraging aspects in calculus instruction, the present study complements these insights with an analysis focused on *supportive* features.

Student populations in our prior work consistently included Black and Latina/o students, with some analyses (Battey et al., 2022; Leyva, Quea, et al., 2021) also considering white women's perspectives. To ensure consistency with our theoretical perspective (a critical view of equity) that centers racism in U.S. mathematics education while attending to related systems of oppression (e.g., patriarchy), our present study focused on Black and Latina/o students' perceptions of calculus instruction. We, thus, followed the critical race tradition of educational research (Ladson-Billings & Tate, 1995; Lynn & Dixson, 2013) that analytically foregrounds racially minoritized perspectives. This tradition disrupts social science methodologies that uphold 'objectivity' or 'validity' by relying on large samples as well as comparing racial majority and minority groups. Such methodologies function as scientific racism that

centers whiteness by positioning the racial majority as legitimizing structural oppression (Ladson-Billings, 2013; Zuberi & Bonilla-Silva, 2008). Informed by the critical race tradition, our study validated Black and Latina/o students' perceptions and experiences of instruction as knowledge sources for dismantling racism and related systems of oppression in undergraduate mathematics.

Study context

Our study took place in a large, public, and historically white research university in the northeastern U.S. during 2017–2019. The undergraduate population in 2018–2019 was approximately 40% white, 25% Asian, 10% Latin*, 10% Black, 5% multiracial, and 10% some other race. Students, given only binary male/female options in institutional reporting, were about 50% male and 50% female. Each section of a precalculus or calculus course consists of: (i) a lecture that meets in large halls (60–90 students) where content is introduced and (ii) a recitation that meets in smaller classrooms (20–30 students). Approximately 4000–5000 students are enrolled in precalculus and calculus each semester. Adjunct faculty typically teach lectures in a traditional, frontal manner with limited input from students. Doctoral students and adjunct faculty typically teach recitations where students ask questions about content, work on problem solving sets, and take quizzes.

Student participants were recruited from Precalculus and Calculus I courses (see Leyva, McNeill, et al., 2021 and Leyva, Quea, et al., 2021 for more details on recruitment). Instructors were not informed if any of their students were recruited. The present analysis focuses on the 34 recruited Black and Latina/o students whose enrollment spanned over 30 course sections. All participants except one were in their first or second year at the university.

Table 1 Individual interview participants

Race-Gender Identity Group	Participant Pseudonyms
Black women	Jasmine, Nadine, Regina, Uzma
Black men	Dwayne, Ife, Parker, Quinton
Latina women	Angelica, Beatriz, Delma, Victoria
Latino men	Adrian, Andres, Carlos, Leonardo

Table 2 Group interview participants

Group Interview	Participant Pseudonyms & Race-Gender Identities
1	**Black women**: Tina, Veronica **Latina women**: Isabelle, Laura, Melanie
2	**Latina woman**: Giselle **Latino men**: Brian, Daniel, Juan, Wilson
3	**Black men**: Deondre, Korbin, Wayne **Latino men**: Antonio, José
4	**Black women**: Felicia, Scarlett **Black man**: Isaac

Participants and data collection

The data collection team conducted 16 individual interviews (Table 1) followed by four group interviews with the remaining 18 participants (Table 2). Individual interviews were used for deep exploration of Black and Latina/o students' individual perceptions of instruction. Group interviews allowed for capturing broader variation in perceptions across race-gender groups.

Interviews were structured around 4–5 stimulus events of instruction. Appendix A and Appendix B contain the full text for stimulus events used during individual and group interviews, respectively (see Online Resource 1). Stimulus events were developed from participants' journaling of discouraging moments in precalculus and calculus classrooms. To allow for open-ended interpretations of stimulus events, we removed student reactions from journaling as well as details about involved individuals' race and gender[6]. See Leyva, Quea, et al. (2021) for additional details about developing the stimulus events.

Table 3 presents brief descriptions of the stimulus events, which vary in terms of potentially oppressive features, whole-class and individual interactions, and frequency of occurrence. Since the *dismissed student* and *unreviewed problem* events

Table 3 Overview of stimulus events

Event Name	Brief Description of the Event
Calculator Accusation	An instructor accuses a student of not owning a calculator that a university program provides to students from low-income backgrounds.
Course Drop	An instructor advises an entire Calculus I class to drop down a course level or not take Calculus II if they cannot complete steps for a problem quickly.
Dismissed Student	An instructor laughs and repeatedly says "no" without an explanation in response to a student's question about the reasoning for an algebraic step in solving a problem. The student apologized for asking the question and the instructor moved on.
Instructor Mistake	A student volunteered a correction of an instructor's work on the board. The instructor cut off the student, replying "Yeah, I know" and raised excuses for it.
Unreviewed Problem	After an instructor responded to a student's question and asked if others had a question, another student asked the instructor to go over a question. The instructor replied, "Sorry, I don't have time to go over another domain question right now. But if you come to my office hours, I can go over another problem with you."

[6] The research team for the larger study inadvertently left pronouns (he/him and she/her) signaling instructors' and students' binary gender identities in some events used for individual interviews. Despite this oversight, we asked participants if their event perceptions changed if instructors' and students' gender identities were different.

both address classroom participation, we chose one event (*unreviewed problem*) for group interviews and modified the text to be more supportive in nature (as presented in Table 3). This modification allowed for participants' engagement with stimulus events that ranged from likely discouraging to likely encouraging.

Interviews were semi-structured, audiotaped, and transcribed. Individual interviews (60–90 min) and group interviews (90 min) were conducted by 1–2 team members. To the extent possible, we paired participants with at least one interviewer who shared racial and/or gender identities as an attempt to build comfort for discussing racism and misogyny. Interviews probed variation in Black and Latina/o students' perceptions of stimulus events, including their nature, frequency, impact, and alternatives for supportive practices. Participants were not provided with prior insight on the interviews' content to avoid biased responses. For more details about interview protocols, see Leyva, McNeill, et al. (2021) and Leyva, Quea, et al. (2021).

Data analysis

The author team (1 Black woman, 1 Asian woman, 1 Latino man, and 2 white women) analyzed interview data to address our research questions. Two team members were assigned to each interview transcript. Like the interviews, we tried to match one member of each coding pair with interviewed participant(s) by race to have at least one insider perspective for analysis. Open codes (Strauss & Corbin, 1998) were applied to instances of participants suggesting supportive-for-all practices to counter discouragement from stimulus events and expand learning opportunities, addressing our first research question. These practices broadened access for all students to classroom participation (e.g., *welcoming students' questions*, *positively recognizing corrections from students*) and support (e.g., *extending support during office hours*).

Next, building off our prior work described earlier, we conducted a secondary analysis to flag instances where participants invoked racial and/or gendered influences that limit access to participation and support through supportive-for-all practices (captured in open codes). Axial codes were applied to these oppressive influences, such as *racial stereotypes of mathematical ability* and *gendered ideas of who belongs in STEM*. Most axial codes were race-specific or gender-specific, given that participants were asked about the role of race and gender separately. At times, however, participants invoked influences that alluded to both race and gender.

Our analytical goal through axial coding was not to make claims that distinguish features of calculus instruction as being exclusively racialized, exclusively gendered, or both. Considering how functions of racism and patriarchy are concurrent and overlapping, the disentangling of these two systems would be challenging and beyond the scope of our analysis. The study was also not designed to examine issues of race-gender intersectionality (Crenshaw, 1991), or unique forms of oppression shaped by interlocking systems of racism and patriarchy. Rather, our goal with axial coding was to generally account for influences, which were in some way tied to race and/or gender, that constrained equity through supportive-for-all practices.

Open-axial coding relationships convey how oppressive influences limit equitable learning opportunities through supportive-for-all practices of calculus instruction, thus addressing our second research question. Figure 1 presents an example of this

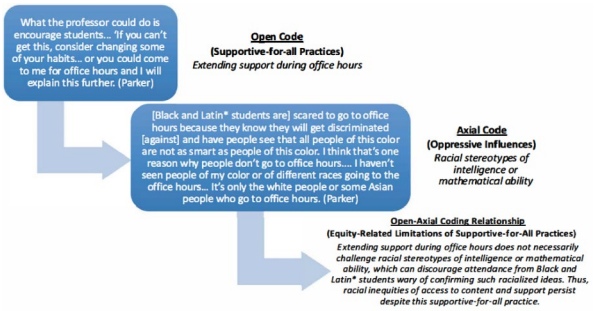

Fig. 1 An illustrative example of open-axial coding relationship

relationship specific to our analysis of Parker's (Black man) responses to the *course drop* event (an instructor advising a class to drop down or not continue with calculus if they cannot solve a problem quickly).

Our theoretical perspective guided analytical interpretations. In applying a critical view of equity, we elucidated how colorblindness and gender neutrality in supportive-for-all practices fell short in disrupting racial and gendered inequities in learning opportunities.

Analytical interpretations and conclusions from our study cannot be generalized to all Black and Latina/o calculus students, given that our work is based on 34 students at one U.S. university. Rather than sample-to-population generalizability, our study aims for analytic generalizability -- a qualitative research process of generalizing to theory (Firestone, 1993; Maxwell & Chmiel, 2014). Our account of calculus instruction as a racialized and gendered experience offers a theoretical explanation of equity-related limitations in supportive-for-all practices. This explanation sheds light on mechanisms reinforcing inequities in calculus education that can be further explored in future work with goals of generalizing to populations.

Positionality

Through reflection about ourselves as individuals and in relation to others, we addressed the "dangers seen, unseen, and unforeseen" (Milner, 2007, p. 388) of not attending to how our lived experiences as varyingly raced and gendered people influence our research. Completing interviews and coding in pairs, with inclusion of at least one insider perspective specific to race and/or gender, created space for multiple interpretations of participants' views while also bracketing our lived experiences. Exploring racialized and gendered influences on participants' perceptions of instruction avoided the danger of colorblind, gender-neutral analyses that leave unchallenged the status quo of calculus education justified by dominant assumptions of uniformity in student experience.

The research team also attended to the unforeseen danger of essentializing Black and Latina/o students' perceptions of calculus instruction. For engaged reflection and representation that disrupt notions of calculus instruction as a monolithic experience, we infused participant voices in the findings to show variation in their perspectives. Our participant-centered reporting of findings, informed by the critical race tradition (Lynn & Dixson, 2013), allowed for a self-to-system research approach that inter-

rogates systemic oppression in calculus instruction and theorizes educational equity through historically marginalized students' individual experiences.

Findings

We organize our findings around two themes of supportive-for-all practices in calculus instruction raised across Black and Latina/o participants' interviews: (i) creating space for questions and mistakes; and (ii) extending out-of-class support. Each theme looks across responses for two stimulus events that were most illustrative for each set of practices. We begin by presenting participants' suggestions for supportive-for-all practices and their impact on learning opportunities, which addresses our first research question. Next, we highlight participant perspectives on how racialized and gendered influences can limit underrepresented students' access to learning opportunities provided through supportive-for-all practices. These findings address our second research question to illustrate how supportive-for-all practices are necessary yet insufficient in confronting how calculus education is situated in broader systems of racism and patriarchy to foster equitable learning.

As an equity-oriented study of calculus instruction, we underscore that the central focus of our analysis is how *social contexts* of U.S. undergraduate calculus shape instructional experiences. We emphasize this point as equity-oriented research in mathematics education faces a pervasive critique of decentering content, which reinforces dominant conceptions of mathematics as neutral and the gatekeeping use of mathematics to frame what 'counts' as disciplinary work (Martin et al., 2010). This critique has been succinctly referred to as the "where is the math" question (Heid, 2010). To explicitly address potential "where is the calculus" critiques of our analysis, the exposition of our findings highlights how unique aspects of undergraduate calculus (e.g., large class sizes, fast-paced instruction) contribute to the significance of supportive-for-all practices and their equity-related limitations in this context.

Creating space for questions and mistakes

The first theme of supportive-for-all practices is creating space for questions and mistakes. Given that questions and mistakes are often perceived as signs of lacking mathematical ability, participants viewed instructors explicitly valuing such contributions as reducing risk associated with them and thus broadening opportunities for participation. These practices were largely raised in response to the *dismissed student* and *instructor mistake* events. Participants saw such practices as particularly valuable in undergraduate calculus given that classroom participation can be a uniquely vulnerable experience due to variation in high school mathematics backgrounds, large class sizes, and judgments made about one's STEM potential.

Responses that involved welcoming and engaging questions were specific to the *dismissed student* event, where an instructor laughed at and repeatedly declined to answer a student's question about a procedural step in problem solving. To address the event's potentially discouraging impact, participants called for instructors to provide explanations (Adrian, Brian, Giselle, Isaac, Laura, Wilson) and show respect

for questions (Isaac, Jasmine, Veronica). Some saw such practices encouraging participation in the form of asking questions during and after class (Adrian, Jasmine, and Laura). Adrian (Latino man), for example, argued that the instructor should have offered the inquiring student an explanation during or after class. He shared an example from his calculus lecture when the professor explained how negative numbers become positive when dividing a binomial by -1 after a student asked a question about this procedure. Adrian reasoned that providing explanations prevent calculus students from feeling like their questions are undermined for being "too simple" because they relate to algebra or precalculus. Instead, this practice can make students feel "encouraged to go see the professor more often in office hours or email the professor directly instead of just asking questions in lecture."

Jasmine (Black woman) described showing respect for students' questions and taking them seriously as explicitly valuing needs for support and affirming peers with similar questions, "It [taking questions seriously] values the student that's asking the question and it also adds value to any other student who maybe wants to ask a similar question." Instructor respect for one student's question, thus, can bring peers to feel validated and comfortable about posing similar questions, which broadens access to participation. Jasmine further argued that this supportive practice would contribute to a marked change in her calculus experience, wherein mathematics preparation during high school is assumed to be uniform even though "everyone's from different educational backgrounds" and some students "had stronger math classes coming from high school." She perceived this assumed uniformity shaping her calculus instructor's tendency to "skip steps [so] it's not clear how you go from point A to point B" as well as his judgmental "you should know" attitude to questions. In this way, Jasmine viewed taking questions seriously as adjusting the pace of calculus instruction to prioritize understanding over content coverage.

Another strand of event responses, largely in response to the *instructor mistake* event (an instructor cutting off a student volunteering a correction to justify a mistake), concerned normalizing mistakes in calculus instruction. Suggested practices for normalizing mistakes included thanking or recognizing students for corrections (Giselle, Laura, Jasmine), owning up to mistakes (Delma, Isaac, Ife, Regina), stating that everyone makes mistakes (Angelica, Melanie, Quinton), and leveraging mistakes as learning opportunities (Felicia, Isabelle). Some participants (Angelica, Laura, Quinton, Regina) argued how these practices expand space for vulnerable forms of participation, such as correcting instructors and sharing incorrect thinking in calculus.

As an example of leveraging student mistakes as learning opportunities, Isabelle (Latina woman) shared how her calculus teaching assistant made comments like, "No, but good thing you said that. That's exactly the *right* wrong answer I want you to say because I don't want you to make that mistake in the exam." Similarly, Laura (Latina woman) noted that her precalculus instructor awarded points to students who caught his mistakes, which she perceived as motivating this form of participation. She also noted, "In a big lecture, it's hard to encourage students to want to participate at all. Now, kids are always raising their hands in class, trying to get a point for anything." Laura saw positive recognition of students' corrections as particularly beneficial in large classes like calculus where students may be less inclined to participate.

Quinton (Black man) argued how engaging students' corrections with humility by stating that everyone makes mistakes, including faculty, encourages participation. He reflected on safe learning environments with past instructors, including in calculus, who responded to corrections with comments like, "Thank you. I made a mistake. I make mistakes, too… Everyone is learning." Such instructor humility shaped his most meaningful learning experiences in calculus, "The best calc professors come in with the ideas, they see what ideas the students are having… [and] guid[e] you to the right way." Quinton contrasted this approach with traditional methods of training students to recognize correctness of answers through association and reinforcement. In this way, Quinton's positive experiences disrupted a dominant logic in undergraduate mathematics that instructors hold all authority and are the sole arbiters of determining whether students are right or wrong (Leyva, McNeill, et al., 2021), which makes offering corrections a vulnerable form of participation. Resistance to authoritarian norms is significant in U.S. calculus as an introductory course setting the tone for student expectations of university mathematics.

Addressing our first research question, findings in this section convey how Black and Latina/o students perceived welcoming or engaging questions and normalizing mistakes as supportive instructional practices that expanded participation opportunities for all. Event responses captured the value of these practices in calculus with large enrollments and wide variation in students' mathematical preparation, which contribute to the vulnerability of asking questions and making mistakes in the classroom. As the next section depicts, access to classroom participation broadened through these supportive-for-all practices can be inequitably distributed when broader forces of racism and patriarchy are left unchallenged in instruction.

Racialized and Gendered Opportunities for Classroom Participation. Black and Latina/o participants invoked racialized and gendered influences (e.g., stereotypes of ability, exclusionary ideas of who belongs in STEM) to describe how historically marginalized students may experience instructional instances like the *dismissed student* and *instructor mistake* events in oppressive ways. We now highlight how participants viewed these unchecked influences as exacerbating vulnerability of asking questions and offering corrections in calculus classrooms for historically marginalized students. These perspectives depict how supportive-for-all practices of welcoming questions and corrections do not guarantee equitable classroom participation.

While Jasmine (Black woman) acknowledged how respecting students' questions generally expands opportunities for participation, she also addressed how gendered ideas of who is capable or belongs in mathematics limit women's access to asking questions in calculus. For example, in response to the *dismissed student* event, Jasmine described how women manage tensions rooted in gender stereotypes of ability concerning how their questions would be received by calculus classmates, especially men, "They [women] don't want to come across as a silly schoolgirl asking questions that the rest of their male peers already know the answers to… When you do that [dismiss a woman's question], it makes it seem like this is the wrong field for you." Here, an instructor's dismissiveness can be experienced as confirming that women are less mathematically able than their male peers and thus do not belong in mathematics. As Jasmine's response highlights, the impact of hearing messages that mathematics is the "wrong field" for women through dismissed questions can be strong in calculus,

given that experiences in this course influence students' decisions of STEM persistence. Thus, the supportive-for-all practice of welcoming questions, without disrupting the influence of gender stereotypes of ability in mathematics, may not alleviate the vulnerability women feel about asking questions.

In relation to normalizing mistakes, Isabelle (Latina woman) and Jasmine (Black woman) perceived this supportive-for-all practice as expanding opportunities to correct instructors, while also arguing how such challenging of authority may be varyingly accessible across race and gender. Both participants shared these ideas in response to the *instructor mistake* event.

Isabelle discussed how even with instruction that normalizes mistakes, correcting instructors can be difficult for Latin* students due to cultural scripts of respecting authority.

> Based off my classes, and math class at [university name]… when they [Latinos] try to argue with people, it's hard for them because the culture is that your parents are right. But white people attempt to argue more with their parents and try to change their parents' opinion… When it comes to correcting in class, maybe Latinos don't want to correct the professor because they don't want the professor to be wrong because the professor is more powerful. They have more authority... White people are used to arguing and changing older people's minds. It's easier for them to correct.

Here, Isabelle addresses how cultural norms of showing deference and not questioning authority may inhibit Latin* students from correcting calculus instructors. As a result, the expectation that encouraging corrections alone is sufficient to motivate participation is inscribed in whiteness, thus making this learning opportunity less accessible to Latin* students. Isabelle's perspective shows how normalizing mistakes must be engaged with consciousness of different cultural views on authority to promote equitable participation involving corrections.

Likewise, Jasmine noted that while saying one is "open to being corrected by everybody" expands space for such participation, racialized-gendered ideas about who is capable and belongs in mathematics can produce inequitable access to correcting instructors. Although offering corrections in undergraduate calculus where "professors with degrees that [have] gone to school, et cetera, don't want to be corrected by this 18-year old in their intro class" is already a vulnerable experience, Jasmine described how this is compounded for historically marginalized students whose corrections may be deemed unwarranted challenges to instructors' authority.

> Math is supposed to be a white, Asian, male type area and anyone who doesn't fall into that, it [the correction] just seems like a challenge or like 'You're encroaching on space that doesn't belong to you or that society says doesn't belong to you.'… Women and minority STEM applicants, etc., don't feel supported in that sense.

Jasmine's mention of unsupported STEM applicants points to the unique influence of calculus on the vulnerability of correcting instructors and STEM persistence. To

illustrate, she shared an experience of offering a correction that felt taken as "overstepping [her] bounds" as a Black woman in her calculus lecture, bringing her to stop participating in this way and feeling "shut down" as a future computer scientist. Jasmine interpreted this experience as being rooted in deficit views, "People don't expect me to be as smart as them or they'll talk to me in a way like, 'How much experience do you have?'" This perspective conveys how the supportive-for-all practice of making space for corrections does not necessarily disrupt racialized-gendered ideas of who is mathematically able to offer corrections. Historically marginalized students are left grappling with concerns about corrections being received negatively, thus limiting access to participating in this way despite calculus instructors' expressed openness to corrections.

Addressing our second research question, findings in this section depict how supportive-for-all practices of creating space for questions, mistakes, and corrections are important yet insufficient to carve equitable opportunities for participation. Findings also show how undergraduate calculus, which has historically served as a gatekeeper to upper-level mathematics and STEM majors, uniquely contributes to racialized and gendered risks of participation with instructor responses impacting students' sense of mathematical ability and STEM potential.

Extending out-of-Class Support Opportunities

The second theme of supportive-for-all practices is extending out-of-class support during office hours and after class. Participants often alluded to the importance of out-of-class support due to limited time in calculus instruction for addressing students' struggles on top of covering content. Mostly in response to the *course drop* and *unreviewed problem* events, participants described how such support mitigates discouragement from calculus instruction, which is often fast-paced and thus valorizes speed (Hagman et al., 2017; Leyva, McNeill, et al., 2021; O'Shea & Breen, 2021). Out-of-class support was perceived as creating opportunities for students to work through struggles and strengthen their sense of mathematical competence.

Several participants (Amy, Beatriz, Brian, José, Nadine, Parker, Victoria) suggested practices of extending help during office hours and after class. Some of these participants (José, Nadine, Parker) perceived such support as encouraging students to closely engage with instruction and learn calculus content. For example, in response to the *course drop* event (an instructor advising a class to drop down a course level or not continue into Calculus II if they could not solve a problem quickly), Parker described how providing office hour support is important in calculus as an introductory course where struggles with content can prompt students to question their ability to succeed in upper-level courses needed for intended majors. He offered his experience in an introductory computer science course as an analogy for such discouragement that may arise in calculus, "I got a B+… I should have gotten an A, especially given that I want to major in this field and this is an intro class… I felt discouraged." As an alternative to the instructor behavior in the *course drop* event, Parker volunteered inviting students to office hours where they can develop strategies to overcome struggles, "What the professor could do is encourage students… 'If you can't get this, consider changing some of your habits… or you could come to me for office hours

and I will explain this further.'" Parker explained that office hour support is particularly encouraging in calculus where students are often pressured to keep up with the fast pace of interrelated, multi-step computations, or as he described, "There is a step on level two. If you don't get it, that means you can't get it." Office hour support, thus, disrupts dominant associations of speed with calculus success.

Reflecting on a more supportive response to student struggle in the same event, José (Latino man) similarly viewed office hour invitations as motivating because they allow students to take action in addressing their struggles and do not leave them questioning their ability.

> I think that's definitely a more encouraging message… 'Come to office hours,' than saying to drop to a lower class. I think it just gives students motivation to learn the material and look forward to doing something, instead of having that little dribble of self-doubt in your head like, 'Oh damn, am I able to do this?'

José's perceived encouragement in office hour help is rooted in a framing of students' success in mathematics as a matter of effort rather than innate ability. He further commented, "Instead of just saying, I guess, just dropping lower to a class [sic], you'd be like, 'Hey, you can work on this… I got some problems. If you work on this for a solid week, you should be good." José perceived office hours, along with supplemental resources to refine students' foundational skills, as alternatives to extending support during instruction given time constraints in calculus courses.

In response to the *unreviewed problem* event (an instructor declining a student's request to review a problem like one previously reviewed), Nadine (Black woman) described encouragement from instructors' support after class. She argued that, by offering such support when a student's question goes unaddressed due to time constraints, instructors avoid having students feel like their questions are insignificant. Nadine viewed such support after class as the "care part" of instruction that was critical for high-enrollment courses like calculus, "Especially in large classes, I feel like that [instructor care] just adds to this comfort. Like, yes, I can ask this professor a question and she makes it feel like she cares." She reasoned that after-class support offerings alleviate pressure of understanding content during class and motivate students to closely engage with instruction for generating questions to be asked later.

> I don't think that the way that [the instructor] handled that situation was correct. He could have said something like, 'Come to me after class. I have a few problems we can work through.' As a student sitting there, I'm like, 'Okay, I'll just star this because I know that I'm going to work on this with him. He didn't shoot me down'... I'm going to be paying a lot more attention to the questions he's going over because if I have a question, I know after class I can talk to him.

Nadine's suggestion of offering help after class is a supportive-for-all practice that challenges the valorizing of speed as a marker of mathematical ability though fast-paced instruction. Such support provides calculus students with an alternative outlet to ask questions, thus removing pressures of understanding concepts quickly and increasing students' engagement with content.

Further addressing our first research question, findings in this section highlight extending out-of-class support during office hours or after class as another set of supportive-for-all practices to counter potential discouragement through calculus instruction. These support offerings were perceived as particularly valuable in calculus where instruction is typically fast-paced and students are often left questioning their mathematical ability when they have lingering questions or are still developing foundational skills. The next section shows how this supportive-for-all practice does not guarantee equitable access to out-of-class support.

Racialized and Gendered Opportunities for Out-of-Class Support. While offering out-of-class help was perceived to challenge notions of mathematical struggle as insurmountable and disrupt the equating of speed with ability, participants invoked racial and gender stereotypes of ability to describe how historically marginalized students risk confirming such exclusionary ideas when seeking support, thereby reinforcing inequitable access to content. Below we highlight event responses from Nadine and Parker that address how gender and racial stereotypes, respectively, shape equity-related limitations of extending out-of-class help.

While Nadine (Black woman) recognized how offering to clarify student confusion after class reduces pressures of understanding calculus content quickly and encourages students to pay close attention to instruction, her response for the *unreviewed problem* event noted how gendered notions of mathematical ability can produce tensions for women about seeking such clarification.

> It was a female student, right? So, it's already difficult enough for me [as a female] to admit that your [the instructor's] explanation was not enough for me to get it. It's almost like I wasn't good enough, but I'm going to put myself out there and I'm going to ask again. For you to shoot my question down, it almost makes me feel like the professor's inadvertently saying, 'You should have understood the first time I explained it.'… Now, are my classmates thinking, 'Is she not smart enough to get it?', or does my professor not think I'm smart enough?

Nadine's emphasis on the vulnerability for women in this context relies on stereotypes of women lacking mathematical ability. In this way, taking up instructors' offers of out-of-class support runs the risk of 'outing' women as unable to keep up with the pace of calculus instruction and confirming gender stereotypes. Nadine's event response illustrates how extending out-of-class support, while supportive for all students, does not ensure equitable access to this supplemental learning opportunity when gender stereotypes of ability are left unchallenged in instruction.

Similarly, Parker (Black man) noted how despite encouragement from office hour support, Black and Latin* students risk confirming stereotypes of ability by seeking support.

> [Black and Latin* students are] scared to go to office hours because they know they will get discriminated [against] and have people see that all people of this color are not as smart as people of this color. I think that's one reason why people don't go to office hours…. I haven't seen people of my color or of dif-

> ferent races going to the office hours… It's only the white people or some Asian people who go to office hours.

Parker interpreted racialized trends in office hour attendance for his precalculus course as Black and Latin* students' avoidance of being stereotyped. An open invitation for office hour support does not guarantee equitable access to this resource, given how racial stereotypes collide with deficit judgments of ability that arise from seeking help in mathematics. Therefore, Black and Latin* students are left with limited access to office hour support, which Parker viewed as crucial for overcoming discouragement in an introductory course like calculus.

Further addressing our second research question, findings in this section depict how the supportive-for-all practice of extending out-of-class help, without directly challenging racial and gender stereotypes of mathematical ability, falls short in providing equitable access to such support. While Nadine's and Parker's event responses convey the value of such support in the unique context of calculus, they also point to the need for such offerings to come with racial and gender consciousness for historically marginalized students' vulnerability in seeking help.

Discussion

We drew two conclusions from our analysis, which we put into dialogue with prior research on calculus education. Each conclusion raises an implication for educational practice.

Equitable opportunities for participation in calculus classrooms and STEM persistence

Our first conclusion is the value of calculus instruction with equitable opportunities for classroom participation, which can positively impact historically marginalized students' sense of belonging in STEM. This conclusion relates to our findings about supportive-for-all practices of creating space for questions and mistakes. Our analysis confirms prior research that found practices of involving all students in classroom discourse – e.g., eliciting students' thinking (Laursen et al., 2014; Petropoulou et al., 2020; Sonnert et al., 2015), enculturation into disciplinary norms (Pinto, 2019), engagement in whole-class discussions (Ellis et al., 2014) – being beneficial for affective beliefs in mathematics and STEM persistence.

Our focus on equity issues extends this prior work by elucidating racialized and gendered influences (e.g., stereotypes of ability) that obstruct access to participation despite instruction that encourages all students to engage. Although similar influences were found to inhibit historically marginalized students' participation in undergraduate mathematics classrooms (Brown, 2018; Sabbah & Heyd-Metzuyanim, 2021), our findings nuance these insights by considering how instruction reinforces or disrupts such inequities. Furthermore, our study captures the significance of instruction with equitable participation opportunities specifically in calculus. We showed how dismissed contributions in calculus classrooms can lead Black and Latin* students to

question their ability and sense of belonging in mathematics, which conveys how equitable participation can disrupt pervasive STEM attrition associated with calculus.

An implication for educational practice related to our conclusion about equitable participation in classroom discourse is calculus instructors establishing norms of engagement with their students that redress racialized and gendered stigma. One example of a norm is engaging questions and mistakes as opportunities for collective learning rather than individual deficits of ability. To avoid a supportive-for-all approach to building norms, instructors can explicitly discuss their intentions in developing these norms for resisting pressures that historically marginalized students may feel about sharing accurate thinking and not asking 'simple' questions due to stereotypes of ability.

Equitable access to calculus content and positive mathematics identities

Our study's second conclusion is that equity-oriented support in calculus instruction disrupts conceptions of ability as innate and struggle as insurmountable in mathematics, thus expanding opportunities for positive co-constructions of social and disciplinary identities. Participants addressed how the fast pace of calculus instruction can leave students with unanswered questions and concerns about lacking ability to succeed in upper-level courses, which corroborates existing perspectives about calculus students being socialized to learn quickly and work through struggles on their own (Leyva, 2016; O'Shea & Breen, 2021). Findings in our study highlight how the supportive-for-all practice of extending out-of-class support challenges such narrow constructions of calculus success (e.g., equating ability with speed) and provides students with agency to work through struggles.

Based on the theorizing of equitable practices throughout our analysis, equitable access to content can be more readily ensured through race- and gender-conscious offerings of out-of-class support that attenuate historically marginalized students' tensions about confirming stereotypes of ability by seeking help. With systemic inequities shaping differential access to pre-college mathematics preparation (Bressoud, 2021; Hagman, 2019), equitable distribution of support plays a uniquely critical role in calculus as an introductory course in university mathematics. The present study extends prior work that depicts calculus as a structural barrier for STEM retention among underrepresented groups (e.g., Ellis et al., 2016; Jett, 2013), particularly by theorizing equitable support through instruction that disrupts such racialized-gendered filtering and fosters positive mathematics identities.

An implication for practice related to our conclusion about equitable access to out-of-class support is expanding the purpose of office hours. This implication is grounded in our findings that show how historically marginalized students grappled with racialized and gendered tensions about seeking out-of-class support due to concerns for confirming stereotypes of mathematical ability. Instructors can convey that office hours serve to not solely provide support for strengthening students' understanding of content, but also to create space for instructors to get to know students as whole people and build support networks among students (Gladstone & Soto, 2021). This instructional practice challenges the traditionally deficit framing of office hours as a space of compensatory support, which leaves historically marginalized students

concerned about confirming stereotypes of mathematical ability through their attendance (Ching & Roberts, 2021). This race- and gender-conscious expansion of office hours' purpose increases access to out-of-class support opportunities in calculus, all while disrupting socialization into mathematics as a solitary endeavor through supportive relations with faculty and classmates.

Implications for Future Research

Our analysis raises two implications for research. First, our findings are specific to calculus education in a large, public, and historically white research university, which leave room for research exploring instruction across different types of U.S. higher education institutions (e.g., small, liberal arts colleges; minority-serving universities). Multi-institutional insights can add nuance to conceptualizing equitable practices in calculus instruction by attending to various institutional factors (e.g., served student populations, commitments to teaching). Additionally, with our study based in the U.S., future research in different countries can adopt an analogously critical view of equity to explore supportive practices of calculus instruction that confront racialized and other sociopolitical realities in these respective contexts.

Second, our study provides a foundation for future research that more closely examines within-group variation in Black and Latin* calculus students' perceptions of equitable instruction to address issues of race-gender intersectionality. For example, stereotyping of Black men as aggressive and Latin* women as sassy in the U.S. may constrain the space that students who hold these intersectional identities can occupy in terms of correcting instructors and asking for support even when such behaviors are generally encouraged. This intersectional perspective, combined with our study's findings on the need for racial and gender consciousness in equitable calculus instruction, is promising for future research exploring features of instruction that disrupt interpersonal marginalization in groupwork noted in the literature on IBME and undergraduate mathematics broadly (Brown, 2018; Oppland-Cordell, 2014). Thus, future use of an intersectional lens can nuance understandings of social conditions under which calculus instruction disrupts broader influences shaping uniquely racialized-gendered experiences in undergraduate mathematics.

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