The Journal of Higher Education

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/uhej20

"It Seems like They Purposefully Try to Make as Many Kids Drop": An Analysis of Logics and Mechanisms of Racial-Gendered Inequality in Introductory Mathematics Instruction

Luis A. Leyva, R. Taylor McNeill, Brittany L. Marshall & Oscar A. Guzmán

To cite this article: Luis A. Leyva, R. Taylor McNeill, Brittany L. Marshall & Oscar A. Guzmán (2021) "It Seems like They Purposefully Try to Make as Many Kids Drop": An Analysis of Logics and Mechanisms of Racial-Gendered Inequality in Introductory Mathematics Instruction, The Journal of Higher Education, 92:5, 784-814, DOI: 10.1080/00221546.2021.1879586

To link to this article: https://doi.org/10.1080/00221546.2021.1879586

Published online: 15 Apr 2021.

THE JOURNAL OF HIGHER EDUCATION
2021, VOL. 92, NO. 5, 784–814
https://doi.org/10.1080/00221546.2021.1879586

Routledge
Taylor & Francis Group

"It Seems like They Purposefully Try to Make as Many Kids Drop": An Analysis of Logics and Mechanisms of Racial-Gendered Inequality in Introductory Mathematics Instruction

Luis A. Leyva[a], R. Taylor McNeill[a], Brittany L. Marshall[b], and Oscar A. Guzmán[a]

[a]Peabody College of Education & Human Development, Vanderbilt University, Nashville, Tennessee, USA; [b]Rutgers University, Graduate School of Education, New Brunswick, New Jersey, USA

ABSTRACT

Introductory mathematics courses, including precalculus and calculus, largely influence Black and Latin* students' persistence and sense of belonging in STEM. However, prior research on instruction in these courses for advancing more equitable outcomes is limited. This paper presents findings from a study of 18 Black and Latina/o students' perceptions of introductory mathematics instruction as a racialized and gendered experience at a large, public, and historically white research university. Sociological perspectives of logics and mechanisms of inequality guided an analysis of Black and Latina/o students' group interview responses on how instruction perpetuates racial and gendered oppression. Two logics were identified: (i) Instructors hold more mathematical authority than students in classrooms; and (ii) Calculus coursework is used to weed out students 'not cut out' for STEM. These logics, coupled with the influence of broader sociohistorical forces (e.g., cultural scripts of behavior, stereotypes), gave rise to mechanisms of inequality through seemingly neutral instructional practices that reinforce racial-gendered distribution of classroom participation and STEM persistence. Our findings inform implications for STEM higher education researchers and mathematics faculty to foster socially affirming STEM instruction, especially in introductory courses.

ARTICLE HISTORY
Received 30 June 2020
Accepted 19 January 2021

KEYWORDS
Calculus; instruction; logics; mechanisms of inequality; STEM; whiteness

A wealth of literature has documented how Black and Latin* [1]students experience racial and gendered oppression in STEM higher education (e.g., Carlone & Johnson, 2007; McGee, 2016), including mathematics (e.g., Oppland-Cordell, 2014). While such research has importantly captured patterns of classroom experiences that impacted students' identities and STEM persistence, instruction in introductory STEM courses like precalculus and calculus was not the focus. Introductory mathematics instruction contributes to disproportionate attrition in STEM majors among Black students, Latin* students, and white women across universities (Chang et al., 2011; Gasiewski et al., 2012; President's Council of Advisors on Science and Technology

CONTACT Luis A. Leyva luis.a.leyva@vanderbilt.edu

[PCAST], 2012; Seymour & Hewitt, 1997). However, there is a paucity of equity-oriented research on the gatekeeping function of calculus instruction to address its impact on Black and Latin* students. (Adiredja & Andrews-Larson, 2017; Larsen et al., 2016).

When STEM instruction has been taken up as the analytical focus (e.g., Ellis et al., 2014; Ferrare & Miller, 2020), Black and Latin* students' perspectives were not central to analyses and the unique impact of the mathematics discipline was left implicit. With disciplinary norms and values shaping instruction in higher education (Ferrare & Hora, 2014; Johnson, 2007), this research gap is important to address in understanding and disrupting instructional functions of whiteness and patriarchy[2] in STEM (Joseph et al., 2016; McGee & Bentley, 2017). In this study, we draw on critical race and feminist scholarship about mathematics (Hottinger, 2016; Martin, 2009) to capture how the discipline's exclusionary culture is operationalized through *logics* (i.e., a shared set of assumptions, norms, and values; Acker, 1990; Ray, 2019) that shape instruction as a racialized and gendered experience. Logics of the mathematics discipline and organizational contexts of higher education collide with socially constructed meanings of race and gender to produce inequitable educational opportunities through instruction (Leyva, 2017; Martin, 2009).

The present study addresses the lack of systematic inquiry on introductory mathematics instruction by exploring 18 Black and Latina/o students' perceptions of discouraging instructional events from precalculus and calculus classrooms at a large, public, and historically white research university. We characterize instruction as a function of logics, simultaneously disciplinary and organizational in nature, with mechanisms that reproduce racial and gendered inequalities. Our study addresses two research questions:

(1) What logics influence Black and Latina/o students' perceptions of discouraging practices in introductory mathematics instruction?
(2) What mechanisms of instruction rooted in these logics characterize racialized and gendered impacts?

Addressing these questions situates introductory mathematics in organizational and sociohistorical contexts to understand how racial-gendered inequalities among Black and Latin* students are reinforced through instruction.

Undergraduate STEM instruction

Our study extends research on undergraduate STEM instruction in two ways. First, the study's focus on mathematics classrooms adds discipline-specific understandings of how logics in introductory STEM instruction produce students' racialized and gendered experiences. Research has noted how logics of neutrality and innateness of ability frame or are disrupted

through STEM instruction (Ferrare & Miller, 2020; Johnson, 2007; Oppland-Cordell, 2014). For example, Johnson (2007) documented how constructions of scientific ability as innate framed discouraging instructional experiences for Black, Latin*, and American Indian women in introductory science. This logic coupled with racialized-gendered images of ideal science students produced pressure among women of color to perform at par with white men and discouraged them from asking questions, thus reinforcing a racialized-gendered distribution of scientific authority and support opportunities.

The ways that discipline-specific logics take form in mathematics instruction are yet to be extensively studied. One noteworthy exception is Oppland-Cordell's (2014) case study of two Latina/o students' positive mathematics identity constructions in an undergraduate calculus course that challenged logics about innate mathematical talent and what 'counts' as mathematically competent work. While this study importantly captured the socially affirming potential of calculus instruction, instructional practices were not as much of the analytical focus as Latin* students' shifts in identity and participation — a gap that our study addresses.

Second, our study builds on research detailing instructional practices that perpetuated or challenged the gatekeeping impact of STEM coursework, but left variation specific to students' racial and gender identities implicit (Ellis et al., 2014; Gasiewski et al., 2012). For example, Ellis et al. (2014) found that students in the same undergraduate calculus course experienced instructional practices related to STEM persistence (e.g., showing students how to work through problems) with differing frequency, which they argued to possibly reflect an inequitable distribution of learning opportunities. Without disaggregating findings by race and gender, it was left implicit how variation in student reports were indicative of an instructional mechanism that perpetuates racialized and gendered gatekeeping. Our study extends this work by detailing such variation across race-gender identities in how Black and Latina/o students experience instruction as a function of gatekeeping and other oppressive logics.

Logics and mechanisms of inequality

In what follows, we first unpack the concepts of logics and mechanisms of inequality that guided our analysis. Since sociological literature from which these concepts are derived focused on organizational spaces broadly, we then draw on research about mathematics to characterize discipline-specific logics, including how they intersect with educational resources to produce racialized and gendered mechanisms of inequality. These perspectives capture the simultaneously organizational and disciplinary nature of logics in mathematics

education, which provide a lens for exploring oppressive functions of introductory mathematics instruction.

The concept of logics originates from sociological theories of organizations as racialized and gendered spaces (Acker, 1990; Ray, 2019). Referring to them as *schemas*, Ray (2019) describes how these assumptions, norms, and values connect with resources to produce racialized organizational structures and practices, which are seemingly neutral and justified by racist ideologies (e.g., colorblind racism, meritocracy). Analogously, Acker (1990) theorized how logics of work organizations with no regard for workers' identities and outside commitments (e.g., women with roles of bearing children and caring for family) are rooted in the patriarchal ideology of gender neutrality and collide with job opportunities to produce gendered workplace structures (e.g., men disproportionately holding high-status, well-paid positions). As a result, racial and gendered logics (or schemas) shape mechanisms of inequality in organizational routines (e.g., hiring) that (un)consciously reinforce inequities (Ray, 2019). In education, Lewis and Diamond (2015) highlighted mechanisms of inequality in schools' enactments of seemingly neutral policies. Logics (or schemas) function to make mechanisms of inequality invisible in everyday institutional practices justified by oppressive ideologies.

Logics in mathematics

In a feminist cultural studies analysis of the mathematics discipline, Hottinger (2016) identified various shared assumptions and beliefs that: (i) mathematics is an objective, universal, and value-free discipline; and (ii) mathematical ability is innate, which shape a culture of competition between individuals. Hottinger argues that these exclusionary logics cause women to question their ability and belongingness in mathematics when they struggle to understand concepts or face discouragement from instructors. As a result, a gendered hierarchy of mathematical ability is socially constructed, which positions women and non-dominant masculinities at the bottom (Leyva, 2016, 2017). This hierarchy upholds misogyny by naturalizing gendered exclusion and masculinized norms in mathematical spaces through constructions of femininity as intellectually inferior.

Similarly, Martin's (2009) critical race analysis of mathematics education identified logics of mathematical ability as a marker of superior intelligence and the hierarchal knowledge structure of mathematics. These logics collide with societal meanings of race to shape a racialized distribution of resources for mathematics learning and participation. Racialized achievement rates due to these inequitable structures coupled with the logic of innate ability result in the construction of a racial hierarchy of mathematical ability, which positions white and Asian people at the top while Black and Latin* people are at the bottom (Martin, 2009). This hierarchy preserves white supremacy and

antiblackness by naturalizing racist inequities through dehumanizing constructions of racially minoritized people as intellectually inferior (Battey & Leyva, 2016; Martin, 2019).

Mechanisms of inequality in mathematics education

Mathematics culture, including logics of the discipline, provides a lens to understand how instruction constructs mathematical success in racialized and gendered ways (Hottinger, 2016; Martin, 2019). Colorblind, gender-neutral approaches to instruction are rooted in logics of mathematics as a neutral, value-free discipline and mathematical ability as innate, which obstruct instructors' perceptions of how systemic forces create seemingly neutral practices that are oppressive to historically marginalized students. We look across two studies in undergraduate mathematics (Leyva et al., 2021; Rodd & Bartholomew, 2006) to illustrate this theoretical point.

Rodd and Bartholomew's (2006) longitudinal study of undergraduate women's mathematics experiences found women were less likely than men to take up instructors' invitations to ask and respond to "proper questions," or mathematically rich questions that motivate instruction. The researchers interpreted this dynamic as rooted in constructions of femininity as incompatible with mathematical ability described earlier. While instructors' calls for participation were gender-neutral in nature, this gendered influence shaped women's inhibited participation, especially with increased stakes of asking questions deemed "proper." Thus, the logic of mathematics as a gender-neutral space collided with gendered constructions of mathematical participation to fuel an instructional mechanism of inequitable opportunities for women's classroom contributions.

Similarly, Leyva and colleagues (2021) reported on Black and Latina/o students' experiences of marginalization from a seemingly neutral instructional behavior in undergraduate calculus (namely, ignoring a student's raised hand twice) as a function of instructors' racial stereotypes about mathematical ability. Students raised a mechanism of inequality in their reflections on instructional experiences that limited their access to participation and support. Thus, the logic of mathematics lacking social relevance that shapes colorblind approaches to calculus teaching collided with racial stereotypes of ability to structure a racialized distribution of opportunities for participation and instructor support.

Findings in Rodd and Bartholomew (2006) and Leyva et al. (2021) portray the simultaneously disciplinary and organizational nature of logics that shape instruction as a racialized and gendered experience. Students' instructional experiences pointed to a logic of instructors holding more authority than students to motivate instruction and structure participation, which is fairly typical across undergraduate classrooms. Disciplinary beliefs of mathematical

knowledge as hierarchal exacerbate this organizational structure, creating racialized and gendered distributions of authority unique to undergraduate mathematics classrooms. Ideologies of gender neutrality and colorblindness justified instructors' neglect of sociopolitical inequities, leaving exclusionary constructions of mathematical participation and ability unchallenged. As a result, whiteness and patriarchy were preserved through mechanisms of inequality.

Logics and mechanisms of inequality provide a theoretical foundation for the present study to account for disciplinary and organizational forces in introductory mathematics instruction. In response to calls for mathematics education research with nuanced inquiry of race and gender (Hottinger, 2016; Martin, 2009), this study brings Black and Latina/o students' perceptions of precalculus and calculus instruction to the fore in revealing how logics inscribed with whiteness and patriarchy shape mechanisms that reinforce inequities. Our study also contributes to higher education research that explores relations between disciplinary logics and organizational behaviors, such as curriculum development (e.g., Garibay et al., 2020) and graduate admissions (e.g., Posselt, 2015), by detailing how another institutional practice, namely instruction, reproduces structural inequalities.

Methods

The present analysis comes from a larger study that examines features of instruction in undergraduate precalculus and calculus perceived as supportive or marginalizing among students across race-gender identities. Prior to this analysis, we collected student reports of discouraging instructional instances from which stimulus events were developed for use during individual and group interviews. Here, we focus on an analysis of group interview data. We position Black and Latina/o students' perspectives as sources of knowledge to improve understandings of racialized and gendered aspects of instruction to inform equitable instructional experiences (Gutiérrez, 2013).

Context and participants

The study took place at a large, public, and historically white research university in the northeastern United States. Precalculus and calculus courses consist of a lecture (90–100 students per section) during which teaching faculty and part-time instructors introduce content. The courses also include a recitation (25–35 students per section) during which doctoral students and adjunct faculty address questions and administer quizzes. Lectures are held in large classrooms or halls with tiered seating, and recitations are held in smaller classrooms.

Recruitment and data collection took place during the 2018–2019 academic year. The university's undergraduate population was 40% white,

24% Asian, 12% Latin*, 9% Black, 3% multiracial, and 12% some other race. This population was 53% female[3] and 47% male. During fall 2018, all students enrolled in precalculus and calculus were invited to express interest in participating by completing a survey that collected information about their race, gender,[4] and course enrollment.

The team planned to recruit four participants across eight race-gender identities (Black woman/man, Latina woman/Latino man,[5] Asian woman/man, white woman/man). Students were selected to participate on a first-come, first-served basis. All participants were in their first or second year at the university. Given the centrality of race and racism in students' experiences of oppression in undergraduate mathematics (McGee & Martin, 2011; Oppland-Cordell, 2014), our analysis focused on the 18 recruited Black and Latina/o participants. This analytical sample enabled us to better understand the nature of instruction that contributes to undergraduate mathematics as racialized and gendered. Elsewhere (Battey et al., accepted; Leyva et al., 2021; McNeill et al., in press), we explore variation in perceptions of instruction across other race-gender identities considered in the larger study. Table 1 presents participant information, including race-gender identities and fellow participants for group interviews.

Data collection

Four semi-structured group interviews were completed with 1–2 interviewers. Each 90-minute interview was audiotaped and transcribed. To the best of our ability, each participant was paired with at least one other participant of the same race-gender identity. Such pairings mitigated feelings of tokenization and created space for varied perspectives among participants with shared

Table 1. Participant profiles.

Group Interview	Pseudonym	Race-Gender Identity
1	Tina	Black woman
	Veronica	Black woman
	Isabelle	Latina woman
	Laura	Latina woman
	Melanie	Latina woman
2	Giselle	Latina woman
	Brian	Latino man
	Daniel	Latino man
	Juan	Latino man
	Wilson	Latino man
3	Antonio	Latino man
	José	Latino man
	Deondre	Black man
	Korbin	Black man
	Wayne	Black man
4	Isaac	Black man
	Felicia	Black woman
	Scarlett	Black woman

identities. We also tried to match interviewers' and participants' identities. A Latina woman interviewed women of color in group interview 1, a Latino man interviewed Latina/o students and men of color for group interviews 2 and 3, and a Black woman interviewed Black participants for group interview 4. This was an attempt to increase participants' comfort with discussing issues of race and gender, though we recognize that the presence of someone with the same identity does not guarantee such comfort.

Interviews centered around four stimulus events, including an instructor: (i) cutting off a student who acknowledged a mistake on the board to justify it (*instructor mistake*), (ii) accusing a student of not owning a calculator (*calculator accusation*), (iii) not honoring a student's request to review a certain problem (*unreviewed problem*), and (iv) advising an entire class to drop down a course level or not take Calculus 2 if they cannot complete steps of a problem quickly (*course drop*). Appendix A presents text for the events. We purposefully selected events that capture variation in instructor behavior, people involved (e.g., entire class, instructor-student interaction), frequency of occurrence, and potential reactions. Such variation allowed for broader discussions of instructional practices as racialized and gendered.

To develop stimulus events, whenever possible, we preserved phrasing from reports of discouraging instructional instances. These reports were solicited from student participants who were not involved in group interviews during earlier stages of the larger study. We removed language about race and gender, which allowed interviewed participants to consider if their event perception changed when different combinations of involved individuals' race and gender were posed. One event (*unreviewed problem*) was modified to be more supportive, allowing for engagement with events that ranged from likely discouraging to likely encouraging.

The group interview protocol consisted of four sets of questions for each event. Because these questions structured ways to explore the nature of instructional events, interviewers played a central role in asking them and ensuring all participants had opportunities to respond. Thus, the nature of group interviews was more conducive to our inquiry than that of focus groups, where interviewers have a more backgrounded role (Patton, 2014). At the start of interviews, interviewers remarked that there were no right or wrong answers and that differences in perspectives were welcome. The first set of group interview questions asked participants to describe what they saw happening in the event, if and how they had experienced something similar in class, and how frequently similar events occur in introductory mathematics. Second, participants were asked how each event would make them feel as a student in the classroom and why. We also asked participants how they believed students with their race-gender identities and different identities might experience each event, along with their reasoning.

Third, participants were asked if and how their perceptions of each event would differ based on the race and/or gender of instructors and students involved. Fourth, participants were asked what, if anything, they would have preferred the instructor to have done instead along with their reasoning. Group interview questions, thus, captured variation in how participants perceived events in terms of frequency, impact, and relevance of race and gender. Interviews' semi-structured nature allowed for probing about logics across event perceptions, including how they shaped racialized and gendered impacts.

Data analysis

We engaged a grounded theory approach to data analysis (Charmaz, 2014). The central goal was to theorize how mechanisms of inequality rooted in exclusionary logics shape introductory mathematics instruction as a racialized and gendered experience. We adopted an open, axial, and selective coding scheme to analyze group interview data (Strauss & Corbin, 1998). Theoretical perspectives about organizational spaces outlined earlier as well as critical race and feminist research about mathematics informed the coding.

Coding

A pair of team members inductively coded each interview transcript. This paper's four authors (1 Black woman, 2 Latino men, and 1 white non-binary person) were involved in coding. One member of each pair matched the participant's racial and/or gender identity to have at least one insider perspective. Each coder independently coded the transcript to identify logics and related mechanisms of inequality. Open codes flagged the influence of beliefs, norms, values, and practices to address the first research question about logics that shaped perceptions of instruction as discouraging. Axial codes, which are used to refine and build relationships between open codes in grounded theory (Strauss & Corbin, 1998), flagged mechanisms of inequality associated with logics (captured in open coding) that participants invoked to describe racialized and/or gendered impacts. Selective codes, which are used to conceptually thread together open/axial code relationships in grounded theory (Strauss & Corbin, 1998), flagged broader sociohistorical forces (e.g., stereotypes, cultural scripts of behavior) that were raised to qualify how mechanisms of inequality rooted in exclusionary logics are racialized and/or gendered. Axial and selective coding address the second research question about mechanisms of inequality. Figure 1 provides examples of codes that emerged in our analysis.

Building theoretical explanation. Relationships between open, axial, and selective codes build our theoretical explanation for how mechanisms of inequality rooted in exclusionary logics shape introductory mathematics instruction as

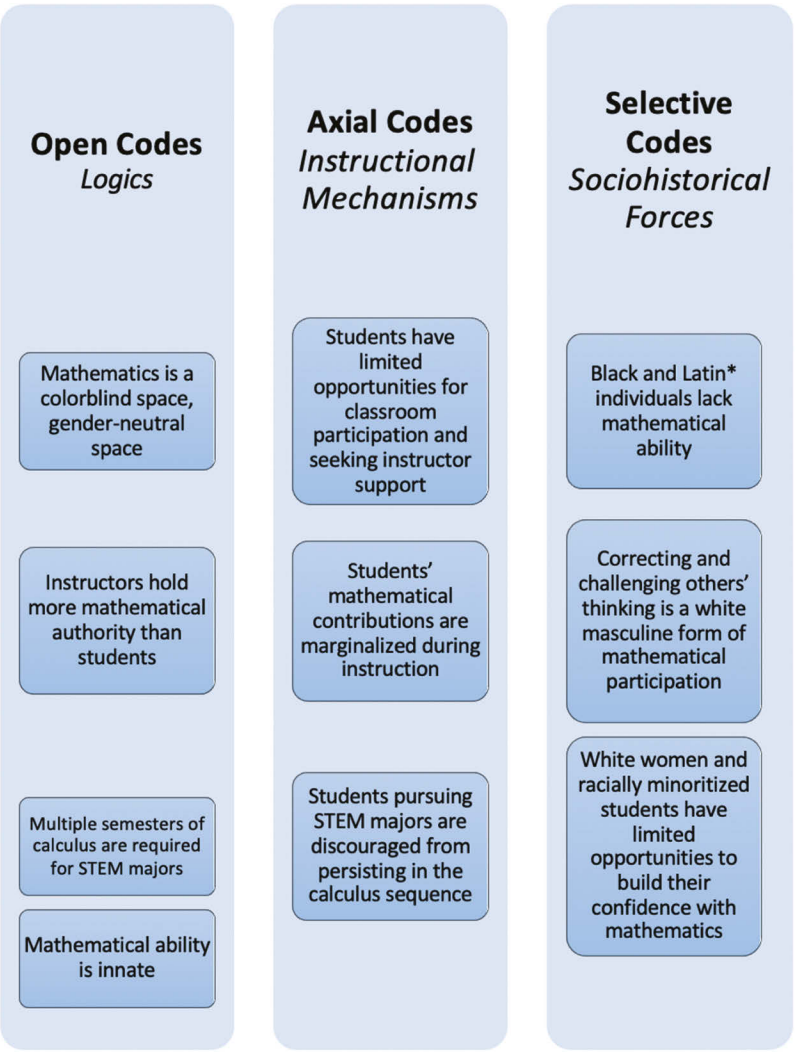

Figure 1. Examples of open, axial, and selective codes.

racialized and gendered. We demonstrate these connections using a coded interview excerpt — a response from Isabelle (Latina woman) about the role of race in the *instructor mistake* event. The event features a student correcting an instructor who copied a number incorrectly on the board. Rather than thanking the student as the instructor did when others volunteered corrections, the instructor interrupted the student to justify the mistake. Figure 2 presents the codes applied to this excerpt.

Open coding, accounting for logics, flagged Isabelle's appeal to the logic that introductory mathematics instructors hold more mathematical authority than students. Axial coding, accounting for mechanisms of inequality, flagged Isabelle's discussion of limited opportunities for participation among Latin*

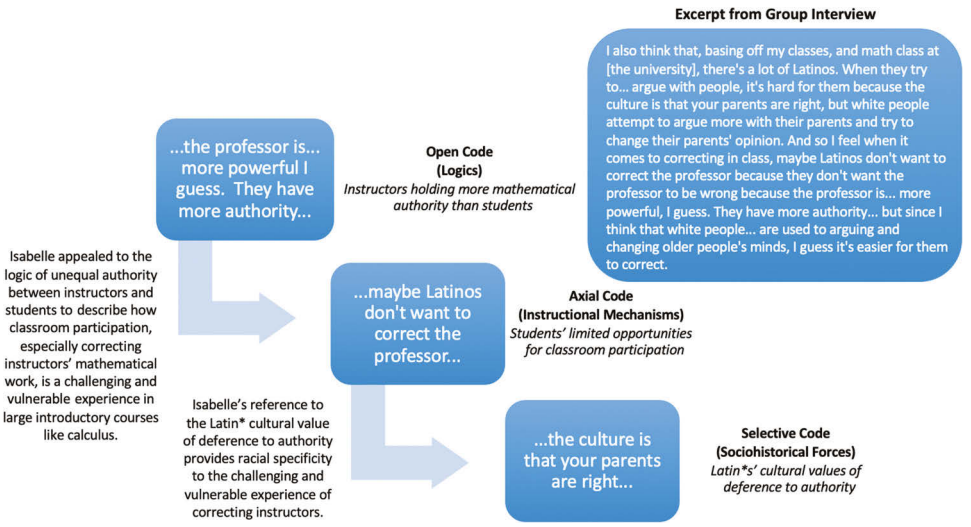

Figure 2. Example of applying the coding scheme.

students. Isabelle's invoked logic of disparities in authority (open code) collided with the resource of classroom participation, producing an instructional mechanism that made correcting instructors a challenging and vulnerable form of participation for Latin* students (axial code). Selective coding, accounting for sociohistorical forces, flagged Isabelle's invoked value of deference to authority in Latin* culture when describing the event's impact on Latin* students' participation. Thus, the selective code related to open and axial codes by specifying the racialized nature of this mechanism of inequitable participation rooted in an exclusionary, colorblind logic of authority.

After independent coding, paired coders met and reconciled coding differences through discussion. Coders met as a whole group to reconcile coding across the various pairs assigned to transcripts. A final transcript for each interview was created with reconciled codes. Our codes were synthesized into broad categories of logics and mechanisms of inequality, which are used to organize the presentation of our findings.

Study design summary

Figure 3 visually summarizes our study design. Black and Latina/o participants' perceptions of instruction (Figure 3b) are the main units of analysis. These perceptions were generated during data collection through group interview responses to questions about stimulus events from introductory mathematics instruction (Figure 3a). Data analysis revealed mechanisms of inequality (Figure 3d) rooted in logics of introductory mathematics (Figure 3c) and shaped by sociohistorical forces (Figure 3e). Connections between logics, sociohistorical forces, and mechanisms of inequality provide

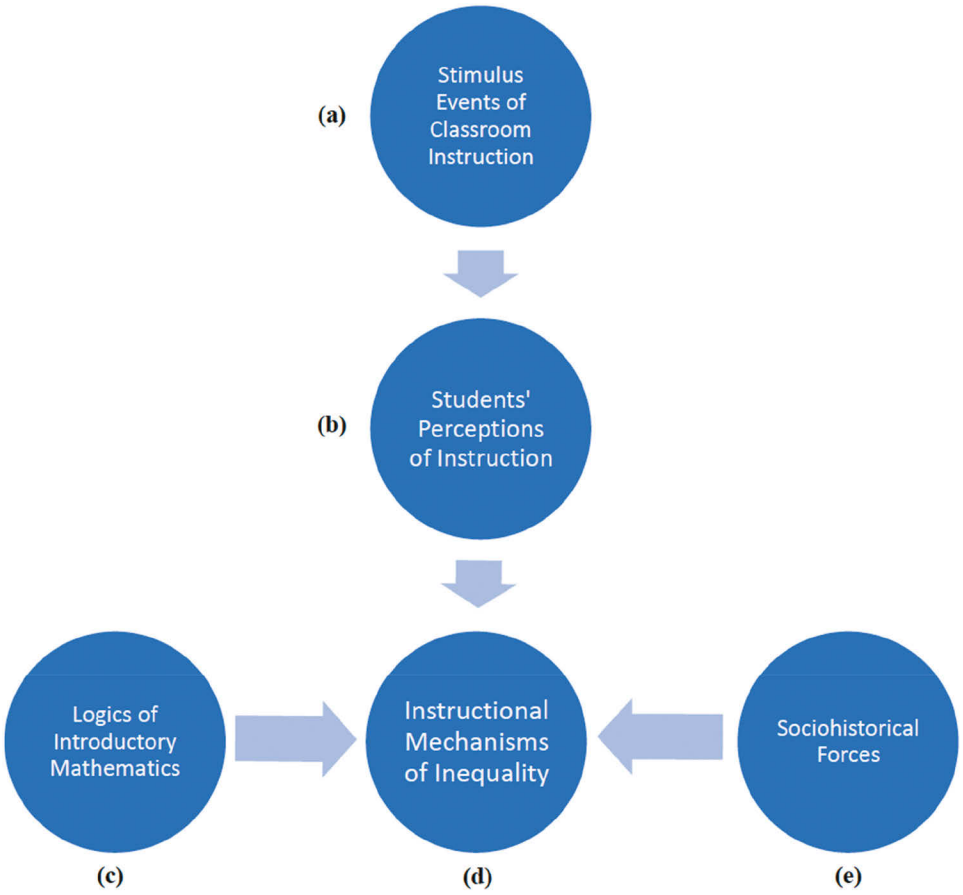

Figure 3. Summary of study design.

a theoretical explanation for introductory mathematics instruction as a racialized and gendered experience for Black and Latin* students.

Positionality

Our team, with a wide range of expertise on racial and gender equity in STEM higher education and mathematics education, consists of 4 faculty members, 7 doctoral students, 5 undergraduate research assistants, and 1 graduate research assistant. The team includes 3 Black women, 1 Latina woman, 4 Latino men, 2 Asian women, 1 white non-binary person, 4 white women, and 2 white men. Team members built on each other's backgrounds to approach the analysis with a collective positionality that addresses "dangers seen, unseen, and unforeseen" (Milner, 2007, p. 388) in educational research. A seen danger was avoiding critical examination of instruction's racialized and gendered functions. We addressed this danger through constant recognition of instruction as a function of systemic influences as well as awareness of our areas of privilege and oppression that can bias analysis.

The team also recognized the unseen danger of not attending to how differences in our experiences as raced and gendered individuals impact our approaches to the research. We addressed this danger by ensuring, to the extent possible, that interviews and coding were completed in pairs that included team members who did and did not self-identify with participants' race and/or gender. Such pairs allowed for the presence of multiple perspectives when following up on interview responses and developing analytical claims from coding. Team members who did not similarly self-identify were more readily able to bracket their lived realities from those of participants while still approaching the research with a lens of criticality. Team members who similarly identified, while having an insider perspective beneficial to understanding race- and gender-specific issues, consciously bracketed their experiences apart from those of participants. Finally, the team attended to the unforeseeable danger of generating findings that position introductory mathematics instruction as a uniform experience among Black and Latin* students. Our sample addressed this danger by capturing variation in student perceptions within and across multiple race-gender identities.

Findings

We organize findings in two sections, each focusing on Black and Latina/o participants' perceptions of a different instructional event illustrative of how a logic shaped instruction and its impact. These two logics include: (i) Instructors hold more mathematical authority than students; and (ii) Calculus courses weed out students 'not cut out' for STEM success.

The first half of each section addresses the first research question. We elaborate on how each logic rooted in ideologies of colorblindness and gender neutrality shaped students' perceptions of seemingly neutral instructional practices as discouraging. The second half of each section addresses the second research question. We highlight mechanisms of inequality across students' perceptions that create the discouraging impact as racialized and gendered. These mechanisms are: (i) limiting opportunities for classroom participation and (ii) communicating lack of ability and belongingness in STEM. We describe sociohistorical forces that students invoked to qualify the racialized and/or gendered nature of mechanisms of inequality.

Instructors hold more mathematical authority than students

The logic of instructors holding more mathematical authority than students shaped perceptions of the *instructor mistake* event. This event features a student correcting an instructor who copied a number incorrectly on the board. Rather than thanking the student as the instructor did when others volunteered corrections, the instructor interrupted the student to justify the mistake. All participants except one perceived the event as discouraging, and

13 deemed it racialized and/or gendered. Though this type of event was not seen frequently in classrooms, participants found it represented complex power structures that shaped norms of classroom participation and made correcting instructors a challenging, vulnerable endeavor.

Participants perceived situations similar to the event as discouraging participation due to dismissive, undermining responses from an instructor as the authority. In addition, perceptions of the event as racialized and/or gendered point to a mechanism that limits participation from race- and/or gender-minoritized students. Participants invoked sociohistorical forces (e.g., racial and gendered norms of behavior) that made correcting instructors — a challenge to the classroom distribution of mathematical authority — less accessible to Black and Latin* students. Thus, while the instructional behavior in the *instructor mistake* event is seemingly neutral due to the logic of authority that organizes it, a mechanism of inequitable opportunities for participation transpires when accounting for racial and gendered influences.

"You put yourself in a vulnerable situation because you try to correct the teacher and the teacher has power over you." Nearly half of participants (Antonio, Giselle, Isaac, Isabelle, Juan, Laura, Melanie, and Wayne) discussed the vulnerability associated with correcting an instructor as the figure of mathematical authority. Isabelle and Melanie (both Latina women) explained that the *instructor mistake* event would produce discomfort.

Interviewer: Would you describe this event as uncomfortable if it happened to you?

Melanie: Yeah.

[. . .]

Isabelle: Yeah . . . In a big class, you put yourself in a vulnerable situation because you try to correct the teacher and the teacher has power over you . . . so when you try to correct them, I'm putting myself out there because in big classrooms it's really hard to participate.

[. . .]

Melanie: Personally, I'm shy and when you're in a big lecture hall and there's everyone there and when you try to answer a question, you try to participate. Because for me, I'll ask a question or I'll answer it, but then either if you get it wrong or if you get that kind of acknowledgment like, 'Yeah, I know,' it just pushes that person or anyone who feels like that, back in their shell and doesn't motivate them to actually ask questions.

Isabelle alluded to instructors' power and authority, shaping vulnerability when correcting them and participating. Melanie reasoned how such authority makes instructor responses potentially discouraging for participation.

Other participants (Isaac, José, and Wayne) similarly described how students may limit their participation following something like the *instructor mistake* event. José (Latino man) argued that the instructor's response would shoot down confidence that students may be developing for classroom participation:

> I think for people who don't speak up as much in class, if they were looking to participate, for example, they just see an easy fix to say, 'Hey, Professor, I'm trying to fix this.' And they [instructors] respond with that, I think it's like a shot down, 'Oh, I'm trying to participate a little bit and he [the instructor] just gives me this answer. Oh, okay.' Now, you don't feel as eager to say anything in the class, participate as much. I think that just really shot down your confidence.

Wayne (Black man) explained how other students would be less inclined to ask questions and correct an instructor, "People are not gonna be as inclined to raise their hand and say something, point something out at you [the instructor], and ask a question even if they need it." José's and Wayne's responses demonstrate the influence of the logic regarding authority in introductory mathematics classrooms, in which instructors' dismissive or undermining responses to student contributions discourage participation.

"Because I'm a woman or maybe because I am a person of color . . . my opinion doesn't matter as much as somebody who shares the same race and gender as the professor." Participants' responses to the *instructor mistake* event capture how sociohistorical forces (e.g., cultural scripts of behavior, racial and gendered biases) collide with the logic of authority to shape an instructional mechanism that limits race- and/or gender-minoritized students' participation. Deondre (Black man) asserted that Black and Latin* students' experiences of structural racism in academic spaces make instructor respect for their contributions critical in introductory mathematics, but such respect was not expressed by the instructor in the event.

> It's very reasonable for a student to be acknowledged . . . when you're dealing with a higher-level math course. . . . For a minority student, it's probably a lot more tough to be in an academic environment. I can speak from personal experience . . . Therefore, professors should treat minority students with a lot of . . . respect for what they're trying to do 'cause it can be very difficult.

This event response captures how the logic of authority grants instructors the power to acknowledge student contributions. Deondre's perspective also identifies how instructors' consciousness of racial obstacles faced among Black and Latin* students should attune them to the racialized impact of waving off their offered corrections like in the event. Thus, the logic of

authority coupled with instructors' lack of racial consciousness reinforces racism through Black and Latin* students' limited opportunities to have their contributions acknowledged.

Laura (Latina woman) perceived the event as racialized and gendered due to instructors' biases about ability that shape double standards for whose contributions get taken seriously.

Laura: If the teacher is white and the first student who was accepted was white and then the second person was a person of color, I might look at it as a little weird. But again, it could be coincidental, but if it's like an ongoing theme and pattern in that, then yeah.

[. . .]

Interviewer: If it were a white professor and a minority student, let's say. Why would it be weird? I know you used the word 'weird.'

Laura: Well, again, it depends a lot on the other student, the student that came before the one, because it's a direct comparison.

Interviewer: Okay, so the pattern thing.

Laura: If, for example, there's a white professor . . . and the student who corrected him before was a white male and he was like, 'Yeah, you're right,' and then I do the same thing and he's like, 'Yeah, I know,' I might take that as a-

Interviewer: What would that imply?

Laura: Yeah, it would just imply that because I'm a woman or maybe because I am a person of color that my opinion doesn't matter as much as somebody who shares the same race and gender as the professor, or they don't take them as seriously or just assume that I'm wrong, so they don't really look at themselves.

Laura's perspective illustrates how varying responses to student corrections can reflect the function of a double standard rooted in instructors' racial and gender biases that go unchecked. Such biases shape expectations for whose contributions are assumed to be correct and who can hold mathematical authority, which upholds social constructions of a racial-gendered hierarchy of mathematical ability. Laura described how, as the student in the event, such racial-gendered trends in responses would make her feel that her contributions as a Latina woman are undervalued. Thus, Deondre's and Laura's responses illustrate how the colorblind, gender-neutral logic of authority underlying the *instructor mistake* event intersects with sociohistorical forces to create a mechanism of racialized-gendered inequalities in participation.

Isabelle (Latina woman) argued that correcting instructors is a form of participation more challenging for Latin* than white students due to the cultural value of deference to authority.

> Basing off my classes, and math class at [the university], there's a lot of Latinos. When they 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. I guess it's easier for them to correct.

This response illustrates how cultural scripts of behavior can produce tensions among Latin* students about challenging instructor authority that white peers may not share. These scripts intersect with the logic of authority to racialize authority, producing differential opportunities for mathematical participation in the form of correcting.

In addition, Isabelle perceived men to experience fewer tensions than women about correcting instructors. Reflecting on who might be unphased by the *instructor mistake* event, Isabelle referred to men in her calculus lecture who regularly correct the professor, "In my class, mostly boys, they don't really care … My professor's a woman … She makes mistakes sometimes, so a lot of people correct her, but it's mostly the boys and the boys are like, 'Really? Are you sure?'" With challenging others' mathematical thinking as a masculine form of participation (Leyva, 2017; Rodd & Bartholomew, 2006), men hold privilege in being able to challenge authority, as reflected in Isabelle's gendered reading of her classroom experience and the stimulus event. Uninhibited participation from men contrasts Isabelle's vulnerability about correcting professors described earlier, signaling gendered opportunities to challenge instructor authority. Isabelle's perspective illustrates how the seemingly neutral practice of dismissing student contributions rooted in the logic of authority collides with racial and gendered behavioral norms, yielding a mechanism that reinforces a racialized-gendered distribution of participation.

Weeding out students 'not cut out' for STEM success

The logic of weeding out students 'not cut out' for STEM success shaped Black and Latin* participants' perceptions of the *course drop* event. In the event, an instructor makes the following statement to an entire class, "If you don't know how to do these steps quickly, you might want to consider dropping down to a lower class or consider not taking Calculus 2." Thirteen of the 18 participants across all race-gender identities experienced moments like the event at least once or regularly in precalculus and calculus. Participants perceived the event and similar instructional instances as functions of mathematics departments'

weedout logic for building rigor, which discourages persistence in mathematics coursework required for STEM majors. Our findings highlight how this logic intersects with exclusionary ideas of who is able and belongs in mathematics to produce a racialized instructional mechanism of communicating that Black and Latin* students lack ability and do not belong in STEM. Thus, the weedout logic organizes a seemingly neutral and frequently occurring instructional behavior, justified by ideologies of colorblindness and meritocracy, to fuel a mechanism of inequitable STEM access.

"It seems like they purposefully try to make as many kids drop out of [math]." Over half of participants spanning race-gender identities (Brian, Daniel, Deondre, Felicia, Isaac, Isabelle, Giselle, Laura, Scarlett, and Wilson) perceived the *course drop* event to illustrate institutional practices rooted in the weedout logic. Daniel (Latino man) described his calculus instructor making a similar comment that "took a shot at [his] self-esteem" as a mathematics student, which he perceived as demonstrating the department's "very rigorous" ways. Assessment was another example, "Math here is very ridiculous . . . One professor that I have now . . . Her tests are very, very hard . . . Out of the two exams so far, the class average has been a 30 [percent] and a 35 [percent]." Daniel's references to exceedingly difficult exams and severely low class averages exemplify the mathematics department's maintenance of high rigor. Agreeing with Daniel's perspective, Brian described how departmental pursuits of rigor contribute to mathematics faculty's weedout practices that uphold exclusionary access to content.

> It seems like they [mathematics faculty] purposefully try to make as many kids drop out of it. It's like they want to create this idea that the math here, it's like, 'Oh, if you got this far, you're elite,' but that also shuts out so many other kids who want to learn that stuff . . . You can't push everyone that hard.

Daniel's and Brian's responses demonstrate how the weedout logic functions through departmental practices to build rigor and perpetuate elitism. Rigor, a standard for disciplinary quality in academic departments, is a meritocratic construct giving rise to practices that reproduce inequities (Riley, 2017). Daniel's and Brian's reflections on how students are demoralized and shut out from continuing with mathematics due to departmental practices, including grading structures and gatekeeping discourse in instruction like in the event, capture these inequities. Further, these practices perpetuate cultural constructions of mathematical knowledge as hierarchal and accessible to select individuals with innate ability.

Some participants (Brian, Felicia, Giselle, and Isabelle) also perceived the *course drop* event to represent how speed is valorized through fast pacing of precalculus and calculus instruction. As a result, mathematical ability gets constructed narrowly as being fast, reinforcing notions of innate ability and contributing to instruction rooted in a weedout logic. Felicia (Black woman)

related the event to her struggles in keeping up with precalculus instruction and feeling discouraged when her instructor made similar remarks.

> When I was taking pre-calc . . . I remember going to her [the instructor] personally and telling her, 'There are some things that I forgot, but can you please be patient with me?' I'm expressing that I might need extra help . . . It was moving at a very fast pace. And she was saying things like that, too . . . That was very discouraging for me . . . She was making me feel as though I can't do it. And for myself, I knew if I had extra time, I would go to her, study. I could do it. But it was right off the bat. You're expressing that you might not think that I'll be able to make it.

Here Felicia conveys how fast-paced instruction and her instructor's similar comment about dropping down a course level were demoralizing because they communicated disbelief in her ability to succeed in precalculus. The valorizing of speed as a form of rigor and indicator of innate ability discouraged Felicia's pursuits of a business major, which required precalculus. Felicia critiqued the lack of support from her instructor and her academic counselor who made similar remarks about pursuing a challenging major, "As somebody who's supposed to be directing me on what I wanna do, whether it's a teacher or a counselor, why can't you support me in what I wanna do because I know I can do it?" Felicia's response shows how the *course drop* event exemplifies a valorizing of speed rooted in the weedout logic, shaping instructional interactions that discourage mathematical persistence.

"I do think race and gender play a role . . . I would analyze that statement and think, 'Oh, should I not take STEM?" Half of participants (Daniel, Deondre, Giselle, Isaac, José, Juan, Korbin, Wayne, and Wilson) raised exclusionary ideas of who is able and belongs in mathematical spaces to explain how the *course drop* event can be a racialized and/or gendered experience. Several responses capture how the seemingly neutral event rooted in the weedout logic intersects with broader sociohistorical forces to shape an instructional mechanism that relays messages of minoritized students lacking ability and not belonging in STEM. Wayne (Black man) described how the event can communicate racialized ideas of who belongs in calculus, "If the professor was white and it was a class full of minorities, then I'd feel the professor saying . . . 'None of you belong in here.' An all-minority class and one white professor doesn't necessarily happen too much." The event rooted in a weedout logic taking place in an introductory mathematics classroom with mostly Black and Latin* students, which is not the norm, would bring Wayne to interpret the instructor remark implying the students do not belong.

Wilson (Latino man) also reasoned that high enrollment of underrepresented students in introductory mathematics prompted the instructor to make the comment with a weedout logic.

> I couldn't think why race or gender would be really important in this scenario, but then I guess … maybe that's what gave him [the instructor] the urge. Seeing if there was a lot of women or … a lot of people of color, then he felt the need to say this.

Wilson described the racial and/or gendered undertone in the instructor's remark, especially if there was strong representation of women and students of color who are negatively stereotyped and underrepresented in mathematical spaces. In terms of impact, Wilson questioned belonging in precalculus after hearing a similarly demoralizing comment, "In that moment, it did bother me. I was [sic], 'Shit. My God, maybe I'm in the wrong spot.' … Maybe it's something that doesn't need to be said at all. Just brings people's self-esteem [sic] for no reason." Wilson's event response illustrates how exclusionary ideas of who belongs in mathematical spaces collide with the weedout logic in instructors' remarks to position race- and/or gender-minoritized students in vulnerable ways. Thus, Wayne and Wilson collectively show how underrepresented students may interpret such remarks as communicating racialized and/or gendered messages of not belonging in precalculus and calculus.

Stereotyping of mathematical ability was also raised as a racialized and/or gendered feature of the *course drop* event. Participant responses reflect how the intersection of stereotypes with the weedout logic contributes to a mechanism of relaying racialized-gendered messages of ability. Deondre (Black man) used the example of the event taking place in a course section for a university program that supports financially disadvantaged students (pseudonym XYZ), who are mostly Black and Latin*, to show how the remark may stem from stereotyping.

> If this was an XYZ course … that [race] would definitely play a huge role … The professor may be thinking the students don't have the capacity or the ability to learn the material, or sort of like the bias against their intelligence. Or, if there were more females than males in the class, even though … they're underrepresented in STEM.

Like Wayne and Wilson, Deondre views strong representation of race- and/or gender-minoritized students prompting the instructor's weedout remark, but he also explicitly addresses it as a function of internalized stereotypes about intelligence often associated with mathematical ability.

Deondre, furthermore, described how this remark inscribed with stereotypes and a weedout logic is an instructional mechanism that relays racialized-gendered messages of who can succeed in STEM. Below Deondre acknowledges that students who lack confidence in their academic ability are vulnerable to the racialized-gendered impact of the instructor's remark.

> I do think race and gender play a role … I would analyze that statement and think, 'Oh, should I not take STEM? Should I not pursue this generally because I don't know this one thing?' And someone who's not confident and is suffering from whatever kinds of lacks of confidence in their academic work, that could be hugely impactful. It shouldn't be the way to approach it generally at all, especially in a high-level course like this.

Educational inequities, often resulting from the influence of stereotypes, limit opportunities for race- and/or gender-minoritized students to develop academic confidence, including in mathematics (Leyva, 2016). Such racialized-gendered opportunities may play a role in Deondre's argument in how the event can cause minoritized students lacking academic confidence to question their ability for pursuing STEM. Thus, Deondre's response illustrates how stereotyping intersects with the weedout logic to shape an instructional mechanism of delivering exclusionary messages of who has STEM potential that impacts student persistence.

Juan (Latino man) raised constructions of ability and intelligence rooted in stereotypes to explain the potentially racialized impact of the *course drop* event. Due to Black and Latin* students being positioned as less intelligent than white students, Juan perceived the instructor as being more likely to make the remark about dropping down a course level if Black or Latin* students were slow at completing the mathematics problem than if white students were slow at it.

> Say, there was a white group who is doing it slowly and then say there's a Hispanic or Black group doing it slowly, I feel like he's going to say that [remark] only if that one group of Hispanics or Blacks were doing it slowly. But if the white group was doing it, I feel like he wouldn't come down harder as much … Because STEM is a rigorous thing … It's like you have to be smart for that … Hispanics and Blacks are usually targeted as not as bright as whites.

Here Juan interprets the instructor remark as a function of racial stereotyping about intelligence. The valorizing of speed as an indicator of mathematical ability is also evident here, further illustrating the role of speed as a form of rigor tied to the weedout logic. In characterizing STEM as a "rigorous thing" for which students must be smart, Juan shows how slow problem solving and racial stereotypes of ability give rise to the instructor's remark that positions Black and Latin* students as lacking rigor for STEM. Juan also recalled feeling disparaged after hearing a similar comment from his precalculus instructor, which communicated a lack of trust in his ability, "I felt put down. It just shocked me … Yeah, I know I'm not doing it quickly, but I know how to do it. Just because I'm not doing it fast enough to your liking, I'm not stupid." Juan's event response captures how the weedout logic underlying the instructor's remark collides with stereotypes of ability to shape a racialized mechanism that relays exclusionary messages of who is capable or smart in STEM.

While Wilson and Deondre pointed to gender, participants largely described the *course drop* event as having a racialized impact on students' sense of STEM ability and belongingness. In particular, our findings capture how the instructor's remark in the event, while a function of a colorblind weedout logic, fuels a mechanism that reinforces racialized messaging of who is able and belongs in STEM. Furthermore, with constructions of mathematical ability as an indicator of intelligence, it is important to underscore how

mathematics figures into this mechanism that perpetuates racialized notions of intellectual inferiority and exclusion in STEM.

Discussion

We conclude with a discussion of the study's scholarly significance and limitations. This is followed by elaborating on implications for research, policy, and practice in higher education.

Scholarly significance

Detailing instructional mechanisms of inequality

Our findings identify mechanisms of inequality in introductory mathematics instruction rooted in exclusionary logics of mathematics culture and higher education. These insights build on research that characterize disengaging, unsupportive instruction in introductory courses as a major influence on STEM attrition, but left racialized and gendered features of instruction unexamined (Ellis et al., 2014; Gasiewski et al., 2012). Colorblind, gender-neutral logics of authority and weeding out students organized instructional practices that were not explicitly racist or sexist. However, when coupled with sociohistorical forces (e.g., stereotyping, cultural values), mechanisms of inequality transpired that had discriminatory impacts. Thus, our study makes a novel contribution in characterizing such mechanisms to expand our understanding of introductory mathematics instruction as racialized and gendered.

Innovating methods for equity research in STEM higher education

Relatedly, our study makes a methodological contribution through use of stimulus events, which allowed participants to reflect on potentially discouraging instructional practices that they may or may not have similarly experienced. This methodological approach innovates upon previous studies on Black and Latin* students' undergraduate STEM experiences that only accounted for personally impactful incidents and with reported findings that were not necessarily specific to instruction (e.g., Carlone & Johnson, 2007; McGee & Martin, 2011). By soliciting multiple perspectives for the same events during group interviews, our study brings a systematic approach to uncovering how contextual factors (e.g., classroom demographics, patterns of instructor behavior) varyingly shape the racialized and gendered nature of classroom instruction — a largely understudied area. Furthermore, the hypothetical nature of stimulus events allowed participants to explore different interpretations based on contextual factors, all while eliciting their reasoning about how disciplinary and organizational forces limited possibilities for equitable instruction in introductory mathematics.

In terms of data analysis, use of logics and mechanisms of inequality as guiding perspectives filled the void of sociological inquiry about how mathematics uniquely contributes to postsecondary STEM as a racialized and gendered space (Ferrare & Hora, 2014; Posselt, 2015). Our grounded theory approach yielded a theoretical explanation for how mathematics and higher education structures created racialized and gendered experiences of mathematics instruction.

Interrogating discipline-specific dysconsciousness in STEM instruction

Our study also extends prior work through prioritizing critical inquiry of discipline-specific instruction, which is limited in higher education research (Ferrare & Miller, 2020; Tuitt et al., 2016). Our study meets this research need by interrogating instruction as a function of racial-gendered dysconsciousness[6] that inhibits equitable pedagogy (Haynes & Patton, 2019; McNair et al., 2020). Such inquiry is critical in mathematics — a discipline inscribed with racist, patriarchal logics of neutrality and objectivity (Hottinger, 2016; Leyva, 2021; Martin, 2009) — that engender instructional dysconsciousness. Thus, by focusing on mathematics courses, our study adds disciplinary specificity to critiques of introductory STEM instruction as racialized and gendered (Ferrare & Miller, 2020; Johnson, 2007) by shedding light on dysconscious practices rooted in logics that have racialized and gendered impacts.

Limitations

We recognize two limitations of our study. First, while group interviews were beneficial in fostering structured discussion of stimulus events across multiple perspectives, participants may have hesitated to share ideas that were personal or different. While we were purposeful in having participants complete interviews with one other participant with a shared race-gender identity, this was not always possible due to differences in availability. Interviewers' remarks about welcoming differences in perspectives as well as their efforts to ensure all voices were heard are ways that we attempted to create a relational space in interviews of encouraged participation despite limitations with identity matching.

Second, our study design was limited in examining how mechanisms of inequality shaped differences in Black and Latin* students' race-gender intersectionality (Crenshaw, 1991), or unique experiences of oppression and resistance at the juncture of racism and patriarchy. While soliciting participants' perspectives through stimulus event prompts allowed for systematic inquiry of introductory mathematics instruction, the hypothetical nature of events may have limited opportunities to reflect on instructional episodes central to the intersectionality of participants' experiences. This limitation was mitigated

through prompts asking participants to connect event reflections to personal experiences, grounding event perceptions in lived realities specific to their intersectional identities.

Implications for research

Our findings raise two implications for future research. First, future research can expand our inquiry by examining how organizational features differing across institution types (e.g., size, demographics, commitments to teaching, values for serving minoritized groups) varyingly perpetuate or mitigate the influence of logics on instructional mechanisms of inequality. Noting institutional variation in equitable instruction for introductory mathematics extends prior work that found how oppressive structures rooted in logics of STEM disciplines thrive in academic departments at minority-serving institutions or women's colleges, despite their socially-affirming institutional missions (see McGee, 2016). Further, the pervasiveness of the weedout logic across mathematics departments, which we found had an oppressive impact on students' sense of ability and belongingness in STEM, warrants multi-institutional, longitudinal research that explores variation in how this logic takes form instructionally and implicates STEM trajectories.

Second, our study identifies the need for further research that characterizes how different cultures of STEM disciplines uniquely figure into Black and Latin* students' instructional experiences. Such work can build on scholarship that captured how dominant cultures of university sciences shape racialized and gendered mechanisms that impact access to content (e.g., Posselt, 2015), positive disciplinary identities (e.g., Carlone & Johnson, 2007), and social justice-oriented career development (e.g., Garibay, 2015). Future research can examine how these disciplinary forces influence instruction in different STEM classrooms and historically marginalized students' relationships with different STEM domains. For example, Carlone and Johnson (2007) found that cultural productions of scientific ability shaped racialized-gendered opportunities for faculty recognition of college women of color as scientifically competent — a central dimension of developing strong science identity. While their findings importantly captured recognition opportunities outside of instruction (e.g., out-of-class support from faculty, lab meetings), it was left implicit how STEM instruction reinforced or disrupted racialized-gendered recognition of scientific authority and how this varied across academic majors, which were predominantly biological sciences in their study. With the cultures of STEM disciplines like engineering and technology more readily valuing technical prowess over social issues compared to biological and environmental sciences (Garibay et al., 2020), we underscore the importance of future work that continues our discipline-specific inquiry to better understand socially affirming instruction for Black and Latin* students across STEM areas.

Implications for policy

Our findings raise two implications for policy. First, higher education policy should marshal institutions to reexamine infrastructures in mathematics departments that support the weedout logic. One possibility is reforming assessment policies (e.g., exam difficulty, grading on a bell curve) that function as mechanisms of academic hazing, separating those 'cut out' for STEM from those who are not. As the student quote in our paper's title highlights, instruction centered around such assessment approaches shapes students' perceptions of introductory mathematics as pursuits of academic survival and 'fit,' limiting opportunities for positive mathematics learning among historically underserved students. Thus, reform of weedout infrastructures like grading, which fail to account for educational inequities, can transform the exclusionary culture of mathematics departments to foster instructional approaches in introductory courses that develop rather than filter STEM potential.

Second, policy must motivate programmatic support that reprieves students from racialized and gendered constructions of mathematical authority. Such programming in undergraduate mathematics aligns with similar calls in STEM higher education research (e.g., McGee & Martin, 2011) about creating spaces of solidarity and critical dialogue about oppression in STEM education. An example is University of Arizona's five-day undergraduate calculus summer workshop for students of color embedded with "critical conversations," or structured dialogues on issues of race and gender related to mathematical success and pursuing STEM majors. This collaborative problem solving workshop led by faculty of color is a "counter/healing space where students get to see themselves and mathematics differently" (Anhalt, 2018, p. 51), carving opportunities to resist and redefine rigid logics of mathematical authority. Programs like this summer workshop provide Black and Latin* students with spaces that disrupt exclusionary distribution of authority in calculus instruction and foster meaningful participation with mathematics. Furthermore, these programs allow Black and Latin* students to collectively process burdensome instructional experiences, as evidenced in the cognitive and emotional burdens raised across participant responses to stimulus events (see also Battey et al., accepted), in addition to developing strategies for protecting their identities and mathematical success.

Implications for practice

Our findings raise two implications for practice. First, introductory mathematics instructors must critically examine and disrupt ways that their instructional practices subscribe to exclusionary logics and fuel mechanisms of

inequality. Because such practices can seem neutral, instructors must be conscious of how sociohistorical forces intersect with seemingly neutral logics to produce variation in how students experience them (Leyva et al., 2021; McNeill et al., in press). To illustrate, even when an entire class is subjected to the same discouraging instructional behavior like in the *course drop* event, minoritized students experience discouragement uniquely due to managing stereotypes of ability and messages of not belonging in STEM.

In addition, faculty can engage practices of critical instruction (McGee & Bentley, 2017), which create learning opportunities that develop students' critical consciousness of structural inequities as well as the sociohistorical significance of race and gender in mathematics learning. Critical instruction in introductory mathematics can take on different forms, such as co-constructing norms for participation to prevent racialized-gendered distribution of authority as well as facilitating brief discussions about stereotype threat and inequities of mathematical persistence.

Department leaders can offer professional development to build instructors' critical reflexivity in noting mechanisms of inequality in their practice and skills with critical instruction. These opportunities, such as peer teaching observations and video clubs, can be partnerships with faculty colleagues in education who have expertise in equity issues as well as staff members in offices for instructional improvement. Incentivizing these departmental initiatives fosters mathematics faculty commitment to dismantling logics in introductory courses that shape racialized and gendered mechanisms in taken-for-granted instructional practices.

Second, department leaders can commit to challenging racial and gendered inequities in classrooms by soliciting student feedback on experiences of identity-(dis)affirming instruction through routine evaluations of teaching. Evaluations can invite students' reflections on instances of instruction that disrupt or reinforce structural oppression, including limited access to classroom participation and recognition of mathematical competence. Much like how our study centered Black and Latina/o students' experiential knowledge to better understand inequitable functions of instruction, these evaluations can provide departments with student-centered insights about concrete examples of practices that positively and negatively impact historically marginalized students.

While studies have shown evaluations of teaching to reflect racial and gendered bias (e.g., Smith & Hawkins, 2011), which threatens career prospects of junior faculty of color and white women, these faculty groups have demonstrated strong advocacy for equity issues through their professional roles in higher education (Park & Denson, 2009). Thus, consideration of race- and gender-conscious instruction in teaching evaluations serves to not only disrupt inequities among minoritized students, but also valorize largely unrewarded work of pedagogical

inclusion among underrepresented faculty and hold their departmental colleagues accountable to doing the same. Department leaders can review evaluation feedback with cognizance of racial and gender bias, especially for minoritized faculty teaching courses with students who are predominantly white and men, to avoid reinforcing structural inequities in professional advancement. Evaluations should be taken seriously in annual review and promotion processes to incentivize instructors' development of critically-conscious, self-reflective instruction and reward faculty efforts to promote equity that may have previously gone unnoticed. Such feedback enables departments to provide instructors with support in cultivating equitable practices and prevent instructional mechanisms of inequality from going unchecked.

Notes

1. *Latin** is a term that encompasses fluidity of social identities. The asterisk considers variation in self-identification among people of the Latin American diaspora and origin (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). Participants from Latin American backgrounds in our sample identified as either Latina women or Latino men, so we use those identity descriptors when referring to them.
2. Whiteness is a set of ideologies (interrelated, commonly shared beliefs and values) that maintains white supremacy, the systemic maintenance of white people's social dominance and privilege in the U.S. (Leonardo, 2004). Patriarchy is a set of ideologies that maintains men's social dominance and masculine privilege (hooks, 2004).
3. The university reported gender as a sex-based binary (female and male).
4. The survey collected information about gender that was inclusive of cisgender, transgender, and nonbinary identities. For deep within-group comparison, all participants selected for the study self-identified as either cisgender women or cisgender men.
5. Because two Latino men participants did not confirm attendance via e-mail prior to the group interview, the team recruited two additional Latino men. On the day of the group interview, all four Latino men arrived and participated, leading to a total of six Latino men in the study.
6. Dysconsciousness refers to an unquestioned acceptance of dominant beliefs and norms that unintentionally perpetuates structural inequalities (King, 2015).

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the National Science Foundation [IUSE-1711712 & IUSE-1711553].

ORCID

Luis A. Leyva http://orcid.org/0000-0002-1704-0784
R. Taylor McNeill http://orcid.org/0000-0001-8884-6913
Brittany L. Marshall http://orcid.org/0000-0002-5162-779X

References

Acker, J. (1990). Hierarchies, jobs, bodies: A theory of gendered organizations. *Gender & Society*, *4*(2), 139–158. https://doi.org/10.1177/089124390004002002

Adiredja, A. P., & Andrews-Larson, C. (2017). Taking the sociopolitical turn in postsecondary mathematics education research. *International Journal of Research in Undergraduate Mathematics Education, 3*(3), 444–465. https://doi.org/10.1007/s40753-017-0054-5

Anhalt, C. (2018). *Access to mathematics: Opening doors for students currently excluded*. MSRI.

Battey, D., Amman, K., Leyva, L. A., Wolf McMichael, E., Hyland, N. & McClendon, C. (accepted). An analysis of racialized and gendered labor in students' experiences of pre-calculus and calculus instruction. *Journal for Research in Mathematics Education*.

Battey, D., & Leyva, L. A. (2016). A framework for understanding whiteness in mathematics education. *Journal of Urban Mathematics Education*, *9*(2), 49–80. https://eric.ed.gov/?id=EJ1124962

Carlone, H., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, *44*(8), 1187–1218. https://doi.org/10.1002/tea.20237

Chang, M., Eagan, M., Lin, M., & Hurtado, S. (2011). Considering the impact of racial stigmas and science identity: Persistence among biomedical and behavioral science aspirations. *The Journal of Higher Education*, *82*(5), 564–596. https://doi.org/10.1353/jhe.2011.0030

Charmaz, K. (2014). *Constructing grounded theory*. Sage.

Crenshaw, K. (1991). Mapping the margins: Intersectionality, identity politics, and violence against women of color. *Stanford Law Review*, *43*(6), 1241–1299. https://doi.org/10.2307/1229039

Ellis, J., Kelton, M., & Rasmussen, C. (2014). Student perception of pedagogy and persistence in calculus. *ZDM*, *46*(4), 661–673. https://doi.org/10.1007/s11858-014-0577-z

Ferrare, J., & Hora, M. (2014). Cultural models of teaching and learning: Challenges and opportunities for undergraduate math and science education. *The Journal of Higher Education*, *85*(6), 792–825. https://doi.org/10.1353/jhe.2014.0030

Ferrare, J., & Miller, J. (2020). Making sense of persistence in scientific purgatory: A multi-institutional analysis of instructors in introductory science, technology, engineering, and mathematics (STEM) courses. *The Journal of Higher Education*, *91*(1), 113–138. https://doi.org/10.1080/00221546.2019.1602392

Garibay, J. (2015). STEM students' social agency and views on working for social change: Are STEM disciplines developing socially and civically responsible students? *Journal of Research in Science Teaching*, *52*(5), 610–632. https://doi.org/10.1002/tea.21203

Garibay, J., Vincent, S., & Ong, P. (2020). Diversity content in STEM? How faculty values translate into curricular inclusion unevenly for different subjects in environmental and sustainability programs. *Journal of Women and Minorities in Science and Engineering*, *26*(1), 61–90. https://doi.org/10.1615/JWomenMinorScienEng.2020029900

Gasiewski, J., Eagan, M., Garcia, G., Hurtado, S., & Chang, M. (2012). From gatekeeping to engagement: A multicontextual, mixed method study of student academic engagement in

introductory STEM courses. *Research in Higher Education*, *53*(2), 229–261. https://doi.org/10.1007/s11162-011-9247-y

Gutiérrez, R. (2013). The socio political turn in mathematics education. *Journal for Research in Mathematics Education*, *44*(1), 37–68. https://doi.org/10.5951/jresematheduc.44.1.0037

Haynes, C., & Patton, L. (2019). From racial resistance to racial consciousness: Engaging White STEM faculty in pedagogical transformation. *Journal of Cases in Educational Leadership*, *22*(2), 85–98. https://doi.org/10.1177/1555458919829845

hooks, b. (2004). *The will to change: Men, masculinity, and love*. Atria Books.

Hottinger, S. (2016). *Inventing the mathematician: Gender, race, and our cultural understanding of mathematics*. SUNY Press.

Johnson, A. (2007). Unintended consequences: How science professors discourage women of color. *Science Education*, *91*(5), 805–821. https://doi.org/10.1002/sce.20208

Joseph, N., Haynes, C., & Cobb, F. (2016). *Interrogating whiteness and relinquishing power: Whitefaculty's commitment to racial consciousness in STEM classrooms*. Peter Lang.

King, J. (2015). *Dysconscious racism, Afrocentric praxis, and education for human freedom: Through the years I keep toiling*. Routledge.

Larsen, S., Marrongelle, K., Bressoud, D., & Graham, K. (2016). Understanding the concepts of calculus: Frameworks and roadmaps emerging from educational research. In J. Cai (Ed.), *Compendium for research in mathematics education* (pp. 526–550). NCTM.

Leonardo, Z. (2004). The color of supremacy: Beyond the discourse of 'white privilege'. *Educational Philosophy and Theory*, *36*(2), 137–152. https://doi.org/10.1111/j.1469-5812.2004.00057.x

Lewis, A., & Diamond, J. (2015). *Despite the best intentions: How racial inequality thrives in good schools*. Oxford University Press.

Leyva, L. A. (2016). An intersectional analysis of Latin@ college women's counter-stories in mathematics. *Journal of Urban Mathematics Education*, *9*(2), 81–121. https://eric.ed.gov/?id=EJ1124964

Leyva, L. A. (2017). Unpacking the male superiority myth and masculinization of mathematics at the intersections: A review of research on gender in mathematics education. *Journal for Research in Mathematics Education*, *48*(4), 397–433. https://doi.org/10.5951/jresematheduc.48.4.0397

Leyva, L. A. (2021). Black women's counter-stories of resilience and within-group tensions in the white, patriarchal space of mathematics education. *Journal for Research in Mathematics Education*, *52*(2), 117–151.

Leyva, L. A., Quea, R., Weber, K., Battey, D., & López, D. (2021). Detailing racialized and gendered mechanisms of undergraduate precalculus and calculus classroom instruction. *Cognition and Instruction, 39*(1), 1–34. https://doi.org/10.1080/07370008.2020.1849218

Martin, D. B. (2019). Equity, inclusion, and antiblackness in mathematics education. *Race, Ethnicity, and Education*, *22*(4), 459–478. https://doi.org/10.1080/13613324.2019.1592833

Martin, D. B. (2009). Researching race in mathematics education. *Teachers College Record*, *111*(2), 295–338. https://www.tcrecord.org/Content.asp?ContentId=15226

McGee, E. (2016). Devalued Black and Latino racial identities: A by-product of STEM college culture? *American Educational Research Journal*, *53*(6), 1626–1662. https://doi.org/10.3102/0002831216676572

McGee, E., & Bentley, L. (2017). The troubled success of Black women in STEM. *Cognition and Instruction*, *35*(4), 265–289. https://doi.org/10.1080/07370008.2017.1355211

McGee, E., & Martin, D. (2011). "You would not believe what I have to go through to prove my intellectual value!": Stereotype management among academically successful Black

mathematics and engineering students. *American Educational Research Journal*, *48*(6), 1347–1389. https://doi.org/10.3102/0002831211423972

McNair, T. B., Bensimon, E. M., & Malcom-Piqueux, L. (2020). *From equity talk to equity walk*: *Expanding practitioner knowledge for racial justice in higher education*. John Wiley & Sons.

McNeill, R. T., Marshall, B. L., & Leyva, L. A. (in press). *"I wish I could say 'You should not be here'": An analysis of instructors' and students' contrasting perceptions of a racialized and gendered gatekeeping practice in calculus*. Feature article for Mathematical Association of America (MAA) Notes.

Milner, R. (2007). Race, culture, and researcher positionality: Working through dangers seen, unseen, and unforeseen. *Educational Researcher*, *36*(7), 388–400. https://doi.org/10.3102/0013189X07309471

Oppland-Cordell, S. (2014). Urban Latina/o undergraduate students' negotiations of identities and participation in an Emerging Scholars Calculus I workshop. *Journal of Urban Mathematics Education*, *7*(1), 19–54. https://eric.ed.gov/?id=EJ1085785

Park, J., & Denson, N. (2009). Attitudes and advocacy: Understanding faculty views on racial/ethnic diversity. *The Journal of Higher Education*, *80*(4), 415–438. https://doi.org/10.1080/00221546.2009.11779023

Patton, M. (2014). *Qualitative research and evaluation methods: Integrating theory and practice*. Sage.

Posselt, J. (2015). Disciplinary logics in doctoral admissions: Understanding patterns of faculty evaluation. *Journal of Higher Education*, *86*(6), 807–833. https://doi.org/10.1353/jhe.2015.0030

President's Council of Advisors on Science and Technology (PCAST). (2012) . *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics*. The White House.

Ray, V. (2019). A theory of racialized organizations. *American Sociological Review*, *84*(1), 26–53. https://doi.org/10.1177/0003122418822335

Riley, D. (2017). Rigor/us: Building boundaries and disciplining diversity with standards of merit. *Engineering Studies*, *9*(3), 249–265. https://doi.org/10.1080/19378629.2017.1408631

Rodd, M., & Bartholomew, H. (2006). Invisible and special: Young women's experiences as undergraduate mathematics students. *Gender and Education*, *18*(1), 35–50. https://doi.org/10.1080/09540250500195093

Salinas, C., Jr. (2020). The complexity of the "x" in Latinx: How Latinx/a/o students relate to, identify with, and understand the term Latinx. *Journal of Hispanic Higher Education*, *19*(2), 149–168. https://doi.org/10.1177/1538192719900382

Salinas, C., Jr., & Lozano, A. (2019). Mapping and recontextualizing the evolution of the term Latinx: An environmental scanning in higher education. *Journal of Latinos and Education*, *18*(4), 302–315. https://doi.org/10.1080/15348431.2017.1390464

Seymour, E., & Hewitt, N. (1997). *Talking about leaving: Why undergraduate leave the sciences*. Westview Press.

Smith, B., & Hawkins, B. (2011). Examining student evaluations of Black college faculty: Does race matter? *The Journal of Negro Education*, *80*(2), 149–162. https://www.jstor.org/stable/41341117

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research: Grounded theory procedures and techniques*. Sage.

Tuitt, F., Haynes, C., & Stewart, S. (2016). *Race, equity, and the learning environment: The global relevance of critical and inclusive pedagogies in higher education*. Stylus.

Appendix A. Stimulus events for group interviews

Instructor Mistake

Our professor was finishing a problem, but when recopying the step in the problem, the professor wrote a number incorrectly. A classmate and I raised our hands to bring it up, but it took almost a minute or so before being acknowledged. As I was explaining what was wrong, the professor interrupted me and said "Yeah, I know," and gave a number of reasons for what was written on the board, even though it was clearly wrong. When the professor was corrected previously, the professor admitted being wrong and thanked the students, but did not do either when corrected by me.

Calculator Accusation

During a lecture, the professor demonstrated how students should mark their calculators for identification for the exams. The professor collected mine and used it as an example. My calculator had an "XYZ" tag on it because the XYZ program gave me the calculator. As the professor was doing the demonstration, they said "this calculator is not yours." I told the professor that those were not initials and that XYZ was a program that gave me the calculator.

Unreviewed Problem

After the professor finished responding to another student's question and asked if anyone else had a question, I raised my hand and asked the professor to go over a question related to the domain of a function. The professor said, "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." The professor then moved onto a different problem.

Course Drop

The professor asked the class to work on a problem that required multiple steps. After giving some time for the class to solve the problem, the professor said, "If you do not know how to do these steps quickly, you might want to consider dropping down to a lower class or consider not taking Calculus 2."