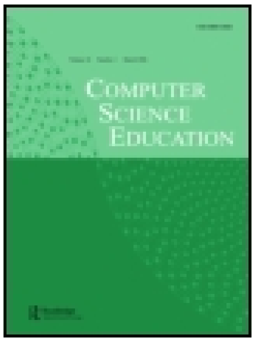

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Racial hierarchy and masculine space: Participatory in/equity in computational physics classrooms

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ABSTRACT

Background and Context: Computing is being integrated into a range of STEM disciplines. Still, computing remains inaccessible to many minoritized groups, especially girls and certain people of color. In this mixed methods study, we investigated racial and gendered patterns of equity and inequity in high school physics classrooms incorporating computational modeling, with an emphasis on group work.

Objective: The objectives of this study were: 1) to document equity patterns in student participation and how they vary based on group composition by race and gender; and 2) to understand how discourses of race and gender influence group interactions.

Method: We used the EQUIP web app (https://www.equip.ninja) to analyze quantitative patterns in student participation. We then identified video of three group sessions and analyzed how discourses of race and gender mediated classroom interactions.

Findings: Data show that racial hierarchies were prominent, with White students dominating group interaction and Black and Latinx students experiencing substantial marginalization. While there was evidence of gender equity in many groups – particularly those with greater proportions of girls – we show how computing and physics were still maintained as masculine spaces.

Implications: Teachers of computing should intentionally structure learning environments to attenuate the impact of White supremacy and patriarchy. More research is also needed on how power operates in computing education at the level of classroom interaction.

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Race; gender; equity; computer science; STEM education; mixed methods

White supremacy and patriarchy remain pressing problems that precipitate racial and gender inequity in computing education (Ensmenger, 2012; Margolis et al., 2008). One way of conceptualizing these inequities is in terms of representation: that is, who gets access to computing and who does not. And yet, representation and access constitute but one aspect of inequity. The field must also grapple with learners' racialized and gendered experiences *within classrooms* as they engage in the process of learning computing. In other words: what happens to racially and gender minoritized students *after* they enter

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the classroom? To date, less is known in computing education research about how equity and inequity play out in everyday classroom interaction.

We focus our inquiry at the intersection of two major trends in the field: collaborative learning and the integration of computing into other STEM disciplines. The K-12 Computer Science Framework (2016) positions "collaborative computing" as a core practice, explaining that by 12th grade students should be able to "create common goals, expectations, and equitable workloads." With respect to computing integration, physics has become an important context as computation has been central to understanding many aspects of the physical world (e.g. discovery of the Higgs boson (ATLAS Collaboration, 2012)). Additionally, like computing education, physics is a field with a long history of marginalizing people of color and women (National Science Board, 2018).

In this article, we engage this problem space by investigating racial and gendered patterns of participation that emerged as high school physics students collaborated in small groups on computational modeling tasks. Researching equity and inequity as interactional phenomena requires a multifaceted perspective on social markers like race and gender. Typically, equity-focused research and rhetoric across STEM education conceptualizes social markers as demographic variables. While this perspective can be useful in illuminating certain kinds of inequities (e.g. course enrollment patterns, test performance), reducing experiences of oppression to static categorical variables can obscure the nuanced ways that forces like White supremacy and patriarchy organize people's everyday lived experiences.[1]

More than demographic variables, race and gender are discursive in nature, in the sense that they dynamically materialize in the form of narratives about the tendencies and capacities of people, particularly those with bodies that differ from the bodies of people in power (Butler, 1990; Goldberg, 1993). For example, racial narratives about intelligence can be deployed between peers as they work together on a group task, and gender narratives about computing ability can influence whose ideas a teacher legitimizes. This perspective illuminates how social markers like race and gender function as sociopolitical constructions, rather than fixed traits that people are born with. The broader point is that learning environments are not neutral spaces; they are subject to the same power dynamics that organize society (Philip, Bang, & Jackson, 2018). Capturing these dynamics – especially when they are not explicit in classroom talk – is a central challenge for the field.

Using a mixed methods approach, we examine both the nature of equity patterns in students' group work, as well as processes by which those patterns may have emerged. Specifically, these research questions oriented our study:

(1) What racial and gendered patterns in students' verbal participation emerged as they collaborated on computing tasks in small groups, and how did these patterns vary across different compositions of groups by race and gender?
(2) How do classroom interactions in small groups – as mediated by material resources, spatial arrangements, and racial and gender narratives – amplify and attenuate racial and gender inequity?

Our analysis of the first question was supported by a web app called EQUIP (https://www.equip.ninja), a classroom observation tool designed to generate quantitative analytics on equity patterns in student participation disaggregated by social markers (Reinholz

& Shah, 2018). Building on those findings, we used qualitative analysis to explore the second question, with a goal of illustrating some of the moment-to-moment processes by which race and gender can both marginalize and support minoritized learners. We conclude by discussing pedagogical implications of our findings and reflecting on distinctions between equity and justice in relation to the broader purposes of computing education.

Literature review

Dominant discourses of equity in computing education – and STEM education broadly – have emphasized structural concerns, including diversity, access, and inclusion (Lewis, Shah, & Falkner, 2019). While broadening access for girls and non-Asian students of color has become a focal point of research and practice, there have been significant challenges. For instance, Margolis et al. (2008) found substantial resource inequities between schools in Los Angeles in terms of the types of computing instruction being offered. Even within a racially diverse school with a robust computing program, they found that computing became "marked territory" for White and Asian boys, thereby limiting minoritized students' access to computing. And yet, scholars have made important contributions to attenuate racial and gender inequity by identifying effective institutional strategies, such as developing peer groups among minoritized students (Miliszewska et al., 2006) and implementing equity-oriented pedagogy and curricula that leverage cultural resources and interests (Goode & Margolis, 2011; Pinkard et al., 2017).

Within physics education – the context of the current study – ensuring access to computing course work remains an important avenue for equity-based research and practice. Findings from a recent report by the American Institute of Physics (2020) found the prevalence of long-term systemic issues (e.g. a sense of belonging, leadership structures, physics identity) in physics and astronomy contribute substantially to the underrepresentation of African Americans in these fields. Still, a complementary emphasis is needed on the dynamics of equity and inequity *within* classrooms. Computing and physics education research has tended to focus almost exclusively on cognitive processes at the expense of the sociopolitical contexts of learning (Traxler et al., 2016; Vakil, 2018). In recent studies, though, scholars have embraced more critical perspectives by going beyond questions of access and representation to investigate minoritized students' experiences, their sense of belonging, and identity development in the learning process (e.g. Hyater-Adams et al., 2018; Johnson et al., 2017; Lewis et al., 2019). For example, Rosa and Mensah (2016) collected narrative accounts from Black women physicists that revealed the prevalence of racialized and gendered obstacles to learning physics and how these Black women navigated and overcame them. Their personal narratives highlighted barriers against Black women physicists in informal social settings (e.g. study groups), despite their active participation in institutional communities such as summer research programs. These studies not only corroborate the need for institutional support (e.g., recruitment and funding opportunities) for students from minoritized social marker groups, but they also reveal the unique challenge of social isolation that minoritized learners face as they learn computing and physics among historically dominant White and Asian men and boys (Johnson et al., 2017; Rosa & Mensah, 2016).

Sociopolitically attuned perspectives on equity also acknowledge that STEM education is rife with false narratives about the academic ability and intellectual capacity of minoritized people (Shah, 2019; Camacho & Lord, 2011; McGee & Martin, 2011; Shah and Lewis, 2019). Computer scientists are often portrayed as geeky, socially inept White men (Ensmenger, 2012). These narratives are also relational, in that they implicitly position minoritized groups (e.g. women, certain people of color) as less capable and unfit to join the community of professional scientists (Shah, 2017). Drawing on the social psychological concept of "stereotype threat," Lewis et al. (2016) argue that narratives like the "geeky computer scientist" stereotype – in conjunction with other narratives that falsely suggest women's inferior quantitative abilities – can undermine the performance of women in STEM. These narratives can confine minoritized learners to restrictive gender roles (Barthelemy et al., 2016), and also erode their sense of belonging, which is a significant factor for academic success (Lewis et al., 2016). Although the prevalence of these false narratives and their detrimental effects on minoritized learners have been documented in computing and physics education, how these narratives manifest in moment-by-moment interactions during computing activities remains under-examined. In this study, we were particularly interested in documenting racial and gender equity patterns at the classroom interactional level, as well as the processes by which racial and gender narratives organize social interaction in computing learning settings.

Conceptual framework

Inequity in learning settings has multiple facets. In this study, we focus on a particular aspect of inequity: participation. *Participatory equity* is a "condition where opportunities to participate – and participation itself – are fairly distributed among all students involved in a learning interaction" (Shah & Lewis, 2019, p. 428). Participatory equity for minoritized students is critical not only because participation matters for learning (Sfard, 1998), but also because public participation can lead to students being positioned with identities as academically capable (Gresalfi et al., 2009). Analytically speaking, the construct of participatory equity is useful because it orients investigations of inequity toward the social interactional level. It frames equity and inequity not as absolute binaries, but rather as conditional states that are fluid from moment to moment.

From a sociocultural perspective, whether participatory inequity is amplified or attenuated is contingent on the artifacts and resources available in the learning setting, and how participants take them up and deploy them as they engage in cultural practices (Nasir & Cooks, 2009; Vygotsky, 1978). In computing contexts, for example, which students do and do not have physical access to their group's laptop in a given moment of social interaction can mediate how students interact with each other, and thereby prove consequential for participatory inequity (Shah & Lewis, 2019). Any bid to monopolize a group's material resources is certainly an exercise of power, but the dynamics of equity and inequity cannot be reduced to only what seems to be happening locally in a given classroom.

Learning settings are also mediated by the power dynamics that organize society writ large (Esmonde & Booker, 2016; Philip et al., 2018). Ideologies of race, gender, and other social markers also organize the local interactions that take place in classrooms (Langer-Osuna, 2011; Shah & Leonardo, 2016). To illustrate, consider the common scenario in collaborative learning situations where a student's ideas get ignored by the rest of the group. A purely local analysis might attribute this to personality conflicts between the students, for example. While this certainly might be the case, it is also true that students are human beings marked by sociohistorical labels and group memberships. This means that the effect of sociohistorical forces like anti-Blackness, patriarchy, and ableism – as well as their intersections – cannot be ruled out. As researchers, we must ask whether that student's idea was dismissed *because* they were, for example: Latinx, a girl, a Latinx girl, a disabled Latinx girl, and so on.

Power, White supremacy, and patriarchy in collaborative learning

Collaborative learning (e.g. group work, pair programming) can be a promising space where students engage in equitable and democratic participation (Sengupta-Irving, 2014). However, participatory equity in collaborative learning settings does not occur automatically – it requires educators' vigilant efforts to fairly organize the learning environment, as well as to possibly intervene in student-student interactions to counter marginalization (Shah & Lewis, 2019; Vakil & McKinney de Royston, 2019). Importantly, narratives about dominant and minoritized groups are readily available to students as they interact with peers in small groups. For example, they can shape whether girls are treated as "leaders" or as "bossy" (Langer-Osuna, 2011). They might inadvertently bias how a teacher interacts with their students, as well as which students receive a teacher's attention.

Participatory equity is, then, a function of how those narratives get deployed during interactions between group members. Because we live in a historically White supremacist and patriarchal culture, supposedly "neutral" forms of classroom participation do not exist; these global forces set the conditions for oppressive narratives to become entangled with everyday classroom life. Of course, due to social norms and also people's legitimately good intentions, oppressive narratives may not be explicitly invoked in classroom settings. However, this does not mean they are not in play. As we discuss later, this poses a unique methodological challenge.

This article focuses on two social markers (race and gender) and two related oppressive systems (White supremacy and patriarchy). Race and gender are both sociopolitical constructions; racial categories and gender categories are created and destroyed in concert with shifting political and cultural exigencies (Butler, 1990; Goldberg, 1993). With respect to gender, although binary conceptualizations remain dominant (boys and girls), we recognize a more fluid model where people have agency to identify as they choose in a field of gender positions. Still, the history of patriarchy in both computing and physics sensitized us to focus on the small-group participation of girls in their own right, as well as in relation to boys in their groups.

With respect to race, racism is also typically conceptualized in binary terms as a conflict between White people and people of color. However, Bonilla-Silva (2004) has proposed a tri-racial system consisting of "Whites" (e.g. European light-skinned ethnics, some multi-racial people, some "assimilated" people of color); "Honorary Whites" (e.g. East Asian people, South Asian people, Middle Eastern people, light-skinned Latinx people); and the "Collective Black" (e.g. Southeast Asian people, Black people, reservation-bound Native people) (p. 933). Bonilla-Silva explains how this tri-racial order complicates traditional "us vs. them" framings, as "Honorary Whites" serve as a buffer between "Whites" and the "Collective Black." That is, the relative privilege and status enjoyed by this intermediate group undermines accusations of racism by people of color who do not qualify. Still, this perspective underscores that White supremacy remains the dominant form of racism.

In our analysis, we did not use Bonilla-Silva's scheme to strictly sort students according to the three groupings he proposes. Rather, we found this sociological perspective on race and racism useful in a broader sense, in the ways it allowed us to distinguish varying degrees of participatory inequity that different groups of students of color in our data experienced – specifically, Asian, Middle Eastern, and mixed race students on the one hand, and Black and Latinx students on the other. We return to this point in the Findings.

Method

This mixed methods study took place in a Midwestern U.S. state three years after the adoption of its new K-12 science standards, mostly consisting of the Next Generation Science Standards. With *computational thinking* being one of the eight scientific practices new to the state's standards, this project provided a five-day summer workshop (June 2018) focused on the equitable integration of computation into high school physics classrooms. Most of the workshop focused on the development of teachers' own computational skills and computational activities for their students, with approximately 15% of the time focused on equitable participation. Computational activites were created using VPython in either Glowscript or Trinket and ranged in physics content from simple one-dimensional force and motion for 9th grade students to advanced electromagnetic topics for Advanced Placement II students. In general, these activities asked students to edit "minimally-working code" (Irving et al., 2017), or code that requires several edits to produce a computational model that fully represents observational or experimental data. For example, for a projectile motion model, the minimally working code may show a horizontally launched object following a linear path across the screen. Students would then edit the code to model the object "falling."

In August teachers returned for a workday that provided training on EQUIP (Reinholz & Shah, 2018; https://www.equip.ninja). We also supported teachers in developing action research plans to study how equitably they were implementing computational activities in their physics classrooms. While each teacher implemented computational activities differently given their varied districts, courses, and school expectations, all computational activities had similar goals and originated in the summer workshop.

This study focuses on the classrooms of eight teachers from different school districts across the state. These teachers agreed to engage in regular action research during the 2018–2019 school year, as well as to attend workdays organized by the research team to support their action research and their learning of computation. On average, teachers attended three of four workdays between October and May. Teachers focused their action research on several students in their classrooms from racially and gender minoritized groups. Video data were collected during small group work involving these students as they worked on computation-related physics tasks. Teachers used these videos to notice and interpret patterns of equity and student engagement. This work became the basis for developing action plans to address inequities that surfaced.

Teacher and student participants

All eight participating teachers identified as White. The average number of teaching years for the cohort was 19.75, with only one teacher reporting under 10 years of experience. Most teachers reported minimal to no equity-related professional development since the start of their teaching careers. All participating schools were predominantly White (57.-6–88.5% of the student body), with five of the eight schools above 80% White. School size varied greatly, from 139 to 2050 total students in grades 9–12. Six of the eight schools were public and two were private, parochial schools.

Across the eight participating physics classrooms, 60 students were recorded working in small groups at least once on computation-related activities. Teachers identified students' social markers either by surveying students about their self-identifications or by making their own determinations based on their knowledge and experience with their students. By gender, students were identified as: 26 boys, 34 girls, and none outside the traditional gender binary. By racialized social markers, students were identified as: Asian (5), Black (4), Black-White multiracial (2), Latinx (7), Middle Eastern (2), Middle Eastern-White multiracial (1), and White (39). In certain cases, teachers racially identified students using nationality markers (e.g. Egyptian, Mexican). Because our goal was a racial analysis of participation patterns in the context of longstanding societal narratives about racial groups commonly racialized in the U.S. context, we recategorized these students using predominant categories of racialization (e.g. Middle Eastern, Latinx). We recognize that drawing hard lines between categories for malleable social markers like race and gender is a fraught enterprise without one "right" way. However, aligned with Gutiérrez's (2002) notion of "strategic essentialism," we take this approach in the service of illuminating inequities that too often remain invisible.

Data sources and data collection procedures

This study leveraged two primary data sources: video recordings of small group work and quantitative analytics generated by EQUIP from each recording. We elaborate on each in turn.

Group sessions

Teachers arranged students into small groups of 2–4. Generally, two small groups of students were video recorded in each teacher's classroom. These small groups were selected for recording because they had at least one minoritized student in the group and also granted permission for recording. A *group session* refers to a video recording of a single group working during a single class period. Because the composition of the groups changed throughout the year, mostly due to student absences, the 60 participating students were arranged into 27 unique groupings. By design, the observed groups were diverse in their racial and gender composition, and therefore should not be taken as indicative of the diversity in the broader school contexts. Most students (41) were recorded more than once, but not more than three times; the mean number of recordings per student was 1.93. A total of 38 group sessions were recorded (15 racially diverse, 8 gender diverse, and 15 were both racially and gender diverse), with a typical length of 30 minutes per session.

EQUIP analytics

As a research tool, EQUIP has been used reliably to capture students' verbal participation by race and gender in diverse classroom settings (Reinholz & Shah, 2018). While EQUIP can be customized to capture various, nuanced aspects of students' and teachers' discourse, here we focus only on the *total number of contributions*[2] from a given student because this was readily tracked by teachers in all classrooms (whereas customized dimensions of classroom discourse differed across classrooms).

As a professional development tool, EQUIP provides visual representations of the distribution of classroom participation, which teachers can reflect upon to improve their teaching practices. As part of their action research, teachers used EQUIP to code group sessions recorded in their classrooms. To do so, the teachers created their classrooms in EQUIP, which involved: 1) choosing discourse dimensions (i.e. which features of participation to focus on); 2) choosing social marker categories (e.g. race, gender); and 3) creating a student roster. Once the classroom was set up, teachers used EQUIP to code group sessions and generate analytics. Notably, these analytics only describe how participation is actually distributed; they cannot prescribe how it *should* be distributed. Thus, the analytics provided teachers grist for meaning making, as they reflected on equity and inequity with support from the research team. We trusted the teachers' codes because we engaged in planning and debriefs of EQUIP with teachers multiple times during the school year. Given the teachers' extensive training on using EQUIP, and their multiple rounds of EQUIP data collection and analysis, the teacher codes became an important source of data for this study.

The first round of coding took place at the October workshop, with support from the EQUIP team. Subsequently, teachers coded their videos independently. All teachers coded at least one group session, with the average being 4.9 sessions coded per teacher. The average number of total verbal contributions per group session was 131.8.

Quantitative data analysis

Social marker units (SMUs)

To analyze the group sessions for patterns of racial and gender in/equity, we defined our unit of analysis as a *Social Marker Unit (SMU)*. An SMU corresponds to a single social marker category within the context of a group session. To illustrate, suppose a group of four students has the following social markers represented: a Latinx girl, an Asian boy, an Asian girl, and a White boy. In terms of race, there would be three SMUs – one for each racialized group represented: Latinx, Asian, and White. The Asian SMU would contain both Asian students together. In terms of gender, there would be two SMUs: boy and girl. For the 30 group sessions with racially diverse groups, there was a total of 67 race-SMUs (37 for students of color, 30 for White students). For the 23 group sessions with gender diverse groups, there was a total of 46 SMUs (23 for girls, 23 for boys).

Equity differential

To analyze quantitative equity patterns for the SMUs, we developed a metric called the *equity differential*, which we define as the percentage point difference between observed and expected participation for a given group session. Formally, the equity differential is calculated as follows:

$$\text{equity differential} = \frac{\#\text{of contributions for the SMU}}{\text{total }\#\text{of contributions in group session}} - \frac{\#\text{of students in SMU}}{\#\text{of students in group}}$$

Consider a group of four students with two women. If women made 35 out of 100 total contributions during a group session, their *observed* participation would be 0.35. But since two of the four group members are women, their expected participation would be 0.50. Thus, the equity differential for women in this group session would be –0.15. This indicates that the percentage of their participation was 15 percentage points *less than expected* based on demographics. A positive differential indicates an SMU participated more than expected based on demographics, while a negative differential indicates that an SMU participated less than expected.

The equity differential has a range of 1 (or 100%), and the scale is centered on the expected participation for an SMU within the group session. Thus, the center of the scale depends on the number of students in the SMU and in the group session (see Table 1). Consider two groups of 4 students each: group A has a Latinx SMU with 1 student, and Group B has a Latinx SMU with 3 students. In Group A, Latinx students are only expected to participate 25% of the time, so even if they never participated at all, their equity differential could at most fall to –0.25. In contrast, in Group B, because Latinx students are expected to participate 75% of the time, if they never participated, the differential would be –0.75. In this way, the total lack of participation from Latinx students in Group B would be a greater sign of inequity than in Group A because there are more Latinx students in Group B.

We considered an equity differential to be *small* if its magnitude was less than 0.1, and *large* if it was greater than or equal to 0.1. We considered 0.1 a large change because in the context of a group with 4 students and an SMU size of 2, this would represent a 20% deviation from the expected participation in a particular direction, which we hypothesize would be evident even without a formal quantification (i.e. students would be readily aware of it). Because a differential could be positive or negative, this gave us four groups, which we color-coded as follows: red is less than or equal to –0.1; pink is from –0.1 to 0 (excluding zero); yellow is from 0 to 0.1 (including 0); and green is greater than or equal to 0.1. This color-coding system is used for all graphs in the Findings.

Qualitative data analysis

Quantitative data cannot speak for themselves (Gillborn et al., 2018). To give greater context to our quantitative data, as well as to gain insight into the *processes* undergirding the EQUIP analytics, we also use qualitative methods to analyze social interactions from select group sessions. As we were interested in documenting and understanding the

Table 1. Range of equity differential based on group composition.

Number of Students in Group	SMU Size	Expected Participation	Maximum ED	Minimum ED
2	1	0.50	0.50	–0.50
3	1	0.33	0.66	–0.33
3	2	0.66	0.33	–0.66
4	1	0.25	0.75	–0.25
4	2	0.50	0.50	–0.50
4	3	0.75	0.25	–0.75

racial and gender dynamics of both equity and inequity, we initially selected seven group sessions that captured this variation: four race-SMUs having large negative equity differentials, and three gender-SMUs having positive equity differentials. After multiple viewings of these group sessions, we focused on episodes in three of these group sessions that illustrated how racialized and gendered interactions can amplify or attenuate participatory inequity.

For each episode, and consistent with our conceptual framework, we analyzed social interactions in terms of both the material aspects of group work (e.g. physical access to a laptop, spatial arrangement of group members) and students' verbal and nonverbal expressions. Our analysis was informed by a concern for power in the form of "who" questions (Philip et al., 2018), such as: who has access to the laptop from moment to moment, and whose ideas are taken up or ignored? We interfaced these "who" questions with the racialized and gender markers of the students in the group. This allowed us to make claims about racial and gender equity and inequity. Of course, White supremacy and patriarchy are rarely explicitly vocalized in formal spaces like classrooms. Indeed, this is one of the challenges in doing empirical work on inequity in social settings. To account for this issue, we analyzed each episode in relation to dominant racial and gender narratives about minoritized groups prevalent in society. Synchrony between such narratives and the classroom interactions were suggestive of how White supremacy or patriarchy might be organizing social activity.

Quantitative findings

Racial patterns: White students dominating group work

Figure 1 shows the distribution of equity differentials across race-SMUs only for students of color (N = 37). We found negative differentials for 22 of these SMUs (59%), of which 11 were large and negative (less than or equal to −0.1), indicating that students of color participated less than expected. In contrast, only 4 SMUs (11%) had large positive differentials. Overall, data suggest mostly inequitable participation patterns for students of color.

We also examined equity differentials for all race-SMUs (N = 67) disaggregated by each racialized marker category, including White students (see Figure 2). For White SMUs, 21 of 30 differentials (70%) were positive. There were 9 negative differentials for White SMUs, but none of them were large and negative. In contrast, for Latinx SMUs 13 of 16 differentials (81%) were negative, and none were large and positive. The 10 Black SMUs indicated slightly greater equity: half of the differentials were positive, and half were negative. Among the negative differentials, however, 4 of the 5 were large. With respect to Asian SMUs, 4 of 7 differentials were negative, although two Asian SMUs had large positive differentials. Finally, although there were only a few Middle Eastern SMUs and Mixed-Race SMUs, these were the only racialized marker groups for which all of the equity differentials were positive.

The imbalanced color-banding in Figure 2 is noteworthy, particularly in terms of how closely it mirrors Bonilla-Silva's (2004) tripartite racial hierarchy: White SMUs at the top; Asian, Middle Eastern, and mixed race SMUs in the middle (i.e. so-called "Honorary Whites"); and Black and Latinx SMUs at the bottom (i.e. the "Collective Black"). The greater

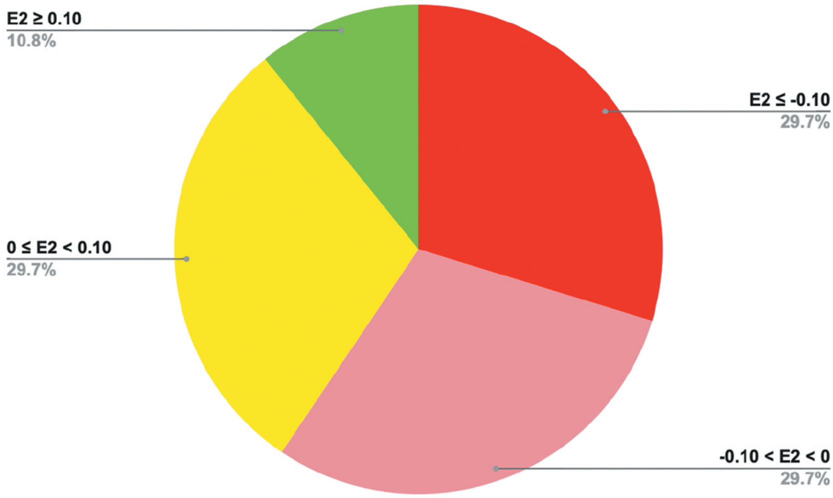

Figure 1. Distribution of equity differentials for race-SMUs involving students of color only.

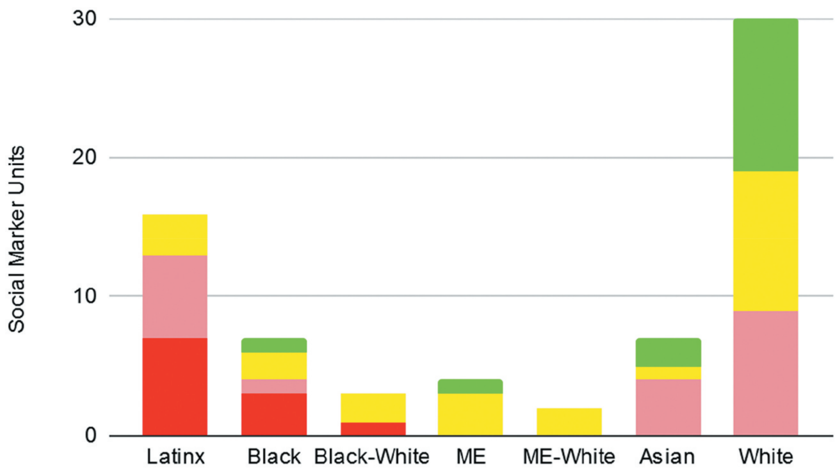

Figure 2. Distribution of equity differentials for all race-SMUs by racialized marker category.

percentage of green banding for White SMUs and greater percentage of red banding for Black and Latinx SMUs indicates that White SMUs participated mostly at the expense of SMUs consisting of the Collective Black. Given that all racially diverse group sessions included at least one White student, this underscores the zero-sum nature of verbal participation opportunities in the context of collaborative learning.

Finally, we explored the possibility of a relationship between equity differentials and the ratio of students of color in a group relative to White students. We hypothesized that we would find more positive equity differentials in SMUs where the proportion of students of color relative to White students was higher for that group session. The data did not show clear evidence to support or reject this hypothesis (see Figure 3). In the four SMUs where students of color were most outnumbered in the group session (1:3), their

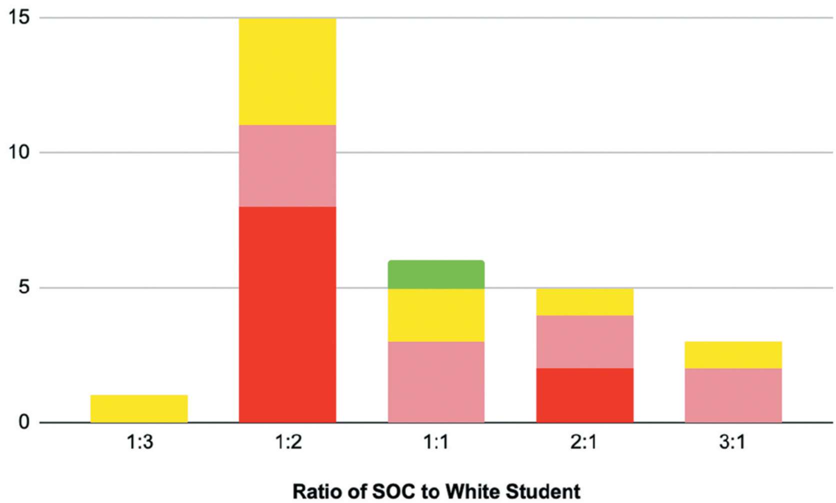

Figure 3. Distribution of equity differentials for all race-SMUs by ratio of racial representation.

equity differentials were all positive. However, in the SMUs where they were slightly less outnumbered in the group session (1:2), 55% (10 of 18) had large negative equity differentials less than −0.10. Although data indicate greater equity for students of color in groups with a 1:1 ratio, we hesitate to draw strong conclusions from this finding due to the small sample. Indeed, the fact that we documented so few instances where students of color either equaled or outnumbered White students in their group session (only 8 SMUs) might itself indicate effects of structurally racist factors that limit the enrollment of students of color in high-status STEM courses like physics.

Gendered patterns: more girls in a group, more gender equity

Overall, data indicated more gender equity in the group sessions we studied. Figure 4 shows the equity differentials for gender-SMUs for girls (N = 23). We found 15 of 23 (65%) for girls were non-negative (one was equal to 0), with 6 of these having large positive equity differentials. Still, 5 of 23 SMUs (22%) had large negative differentials – not an insignificant portion, and also close to the 30% of equity differentials in that band for SMUs of students of color.

As with race, we also explored how the gender composition of the group sessions might relate to the equity differentials we observed. Whereas racial patterns on this question were less clear, Figure 5 indicates a somewhat stronger relationship. All but one of the large negative equity differentials occurred in SMUs where girls were outnumbered by boys in the group session. Conversely, all of the large positive equity differentials occurred in the 16 SMUs where the number of girls were at least at parity with the number of boys in the group session (ratios of 1:1, 2:1, 3:1). Further, in these particular SMUs, 13 of 16 (81%) had positive equity differentials. Again, the small sample here (only 23 SMUs) requires cautious inference-making, but these data do corroborate similar findings in the literature (Dasgupta et al., 2015).

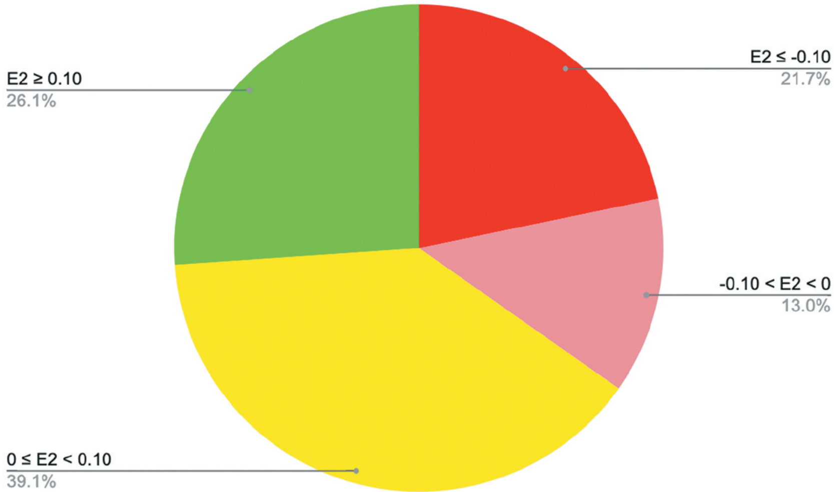

Figure 4. Distribution of equity differentials for gender-SMUs involving girls only.

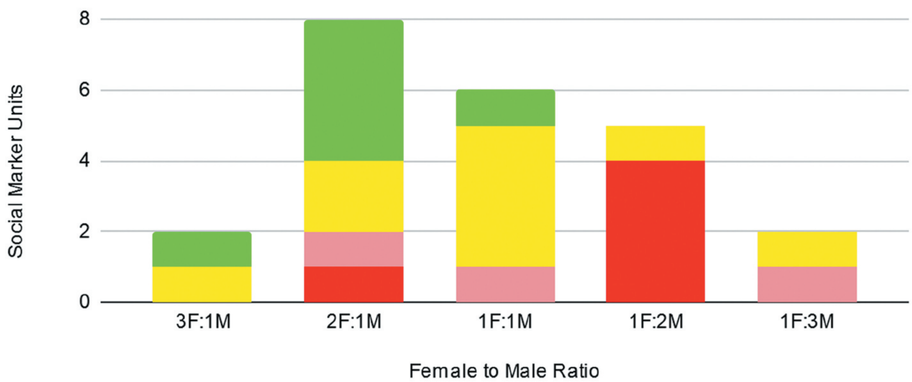

Figure 5. Distribution of gender equity differentials by ratio of gender representation in SMUs.

Qualitative findings

Building on the quantitative findings, we analyzed social interactions in particular group sessions. In general, we were interested in understanding the types of racialized and gendered interactions that contributed to both positive and negative equity differentials for students of color, girls, and girls of color. Here we focus on episodes from three different group sessions, which were selected with this range in mind. The first episode illuminates processes of racial marginalization, specifically related to how the racialized authority to legitimize ideas and academic language can amplify racial inequity. In contrast, the second episode shows how racial and gender inequity can be attenuated, specifically through anti-racist "off-task" talk and spatial arrangements that privilege girls' participation. Finally, the third episode demonstrates how patriarchy can still operate in groups with positive equity differentials, specifically through spatial arrangements and teacher moves that mark computing and physics as masculine spaces.

Episode #1: who gets to call it a "fish"?

The first episode took place at an all-girls Catholic school in a group with three students: Erin (White), Sam (White), and Lynn (Black). Each student had their own tablet-style laptop and was seated facing each other in a triangle formation. They often seemed to have a friendly rapport: laughing, engaging in non-content-related talk, and asking each other for help. However, Erin also had a tendency to cut-off group members and dominate the conversational floor. Perhaps as a result, Lynn's equity differential was less than −0.10 for this session.

Students were engaged in mathematical work (e.g. angle-distance calculations) that they would be using in physics-related tasks coming up in future weeks. Part of that day's work required students to use and manipulate a trigonometric identity, which involved the Greek letters alpha (α) and beta (β). Surprisingly, group discussion around this trigonometric identity – specifically that the letter α looked like a tiny fish – became a site of marginalization for Lynn, with potentially racial undertones. To preview this sequence of data: Erin (White) first introduces and legitimizes the substitution of "fish" for alpha, but later when Lynn (Black) says "fish," Erin sanctions Lynn.

We organize our analysis of this episode into three segments of interaction. In the first segment, Erin begins by reading part of the trigonometric identity and substitutes the word "alpha" for "fish" (i.e. using the α symbol):

1	Erin	Like on the bottom. Yea minus cosine A [alpha]. Cosine B [beta] minus cosine A. Minus cosine A. Cosine of fish or whatever [Erin chuckles; Sam and Lynn smile]. Ah plus all this.
2	Sam	Perfect. I have this. [Turns her tablet screen around to show her group.]
3	Erin	Wait hold on … how do you square that [looks at Sam's screen]. Plus, sine of B.
4	Lynn	Wait, why are you writing "fish" [on Sam's screen]?
5	Sam	Why am I writing "fish" [smiles]? –
6	Erin	– because that's the point – [head remains down looking at her tablet]
7	Sam	– yeah, because this is coordinate 1 and this is coordinate 2 [gesturing at tablet screen, talking to Lynn], and that's what the little, like … This is "x" from coordinate 1 and this is the "y" from coordinate, and this is the "y" from [unintelligible].

Initially, Erin used the English letters "A" and "B" to refer to the variables in the trigonometric identity (Turn 1). Soon after this, however, she switched into referring to alpha as "fish"; Sam and Lynn smiled but continued working. All three students at this point seem to recognize that something amusing has happened. In Turn 2 Sam rotated her laptop screen to share her work with the group. Erin commented on Sam's work and continued with her own (Turn 3), but in Turn 4 Lynn asked, "Wait, why are you writing "fish"? Given that both Erin's and Sam's responses (Turns 6 and 7) focused on mathematical substance and not the term "fish," we can reasonably assume that at this point in the interaction, the use of “fish” was considered normal and acceptable. However, one minute later, this group norm was destabilized during the second segment we analyze:

8	Lynn	Wait, does cosine of B and cosine of fish cancel out? But–
9	Erin	[Laughs]
10	Lynn	What wait they don’t? [Nervous expression and laughter]
11	Erin	[Laughs again] No, no, it’s just funny the way you say it: “cosine of fish.” I dunno.
12	Lynn	[Mumbles; raises and lightly thumps right hand on table]
13	Sam	Ok, I have this for the first one and I don’t know if it’s right.

This sequence marks a subtle but abrupt turn for the group. Whereas previous invocations of “fish” had gone uncensured, in this interaction Erin told Lynn that “it’s just funny the way you say it” (Turn 11). Erin did not clarify what she found “funny” this time. Because initially Lynn laughed (Turn 10) and Erin laughed throughout, one might assume that this was a harmless interaction. But after Erin’s rebuke, Lynn did not laugh and instead deployed a hand gesture that indicated some level of frustration (Turn 12). Indeed, a few seconds later, this third interaction occurs:

14	Erin	Wait, hold on, I’m almost done.
15	Lynn	I don’t know if that’s right. I have to do the other one.
16	Erin	Wait, cosine of just B …
17	Lynn	Minus cosine B *fish* [with tonal emphasis and eyebrows raised saying “fish”]

In spite of Erin’s earlier rebuke, Lynn persisted in her use of “fish” (Turn 17). The somewhat snarky tone and facial expression that Lynn used with “fish” in this instance differed markedly from her previous uses of the word. We interpret these signs as indicating that Lynn was annoyed that Erin had called her out for how she said “fish.”

Why does this episode matter? We argue that it illustrates a particular way that power is exercised in learning interactions: Whose language and ideas are considered legitimate, and who retains authority to decide legitimacy? Historically speaking, these questions in education have been racialized. Research in mathematics education shows that racist narratives positioning Black students as intellectually and academically inferior shape how Black students are perceived by their non-Black peers (McGee & Martin, 2011; Shah, 2017). Fueled by such narratives Black students often experience their contributions ignored or delegitimized by White peers. So even though race was not explicitly vocalized in this interaction, given its family resemblance to histories of Black students’ learning experiences, the racial implications of this episode cannot be ruled out.

Erin’s move to police Lynn’s use of “fish” was a power play. The Greek letter “alpha” connotes mathematical sophistication and using it signifies participation in high-status academic discourse. Erin’s decision to use “fish” – a less formal, lower-status register – is understandable and did not impede the students’ content learning. At the same time, though, it also reveals her privilege: she affords herself the right to do this "or whatever" (Turn 1). The problem is that within the racial politics of language, not all students share this right. Historically, students of color have been sanctioned when they use non-dominant or colloquial language, which are designated as deviant and inferior (Flores & Rosa, 2015). Given the evidence of their overall friendly rapport, it is doubtful that Erin intended racist harm. Still, we do not know what Erin meant in calling Lynn's use of fish "funny" (Turn 11). Erin also did not react when Sam, her White peer, said "fish." Why do Erin and Sam (both White students) have a right to use the informal register, but Lynn (a Black student) does not? Further, it is problematic for Erin to assume the authority to determine who holds this right. Overall, the point is this: while in the grand scheme of STEM education the matter of "fish" versus "alpha" is trivial, the power dynamics and racial context of this particular episode are consequential.

Episode #2: Dreamgirls, and a boy yields the floor

The second episode took place at a public urban high school where slightly more than half of students identified as White. This group involved four students: Dianna (Black girl), Laura (White girl), Pam (White girl), and James (White boy). Students were using a computation model to explore the force dynamics of a spring. Unlike the previous episode, equity differentials for this group session were positive for both the Black student's SMU (+.08) and the girls' SMU (+.15). Here we analyze data suggestive of several processes that may have attenuated racial and gender inequity.

All four students made substantive contributions with respect to the physics and coding content, albeit with varying frequency. Dianna and Pam were the most verbally and nonverbally engaged in the content, as they alternated between typing on the laptop and writing on whiteboards at the table. In contrast, neither Laura nor James ever attempted to use the laptop, although both did occasionally make substantive comments despite seeming mostly "off-task." For the first thirty minutes the group was stuck. While they had a breakthrough in the final ten minutes of class, it was clear they found the task difficult.

Rapport was strong in this group, as they often vacillated between content-related talk and personal talk. The latter spanned a range of topics: struggles with college applications, bus routes, and the possibility of one student's families being descendants of a signer of the Declaration of Independence. These kinds of conversations are often dismissed as "off-task" talk. However, our data suggest value in such talk, insofar as it fostered cohesiveness and comfort among group members, with potentially racialized and gendered subtexts. In particular, we argue that a running conversation about the movie *Dreamgirls* (2006), which threaded through all 50 minutes of the group work, had such benefits for this group.

Dreamgirls is the story of a group of young Black women navigating the U.S. music industry in the 1960s. Originally a Broadway musical, it was later adapted into an Academy Award-winning film. The students were discussing *Dreamgirls* because the musical was being produced at their high school. One student, Laura (White), was particularly upset that a White student might be cast in the lead role:

> Ok, I said I'll be mad if any White girl gets cast. But honestly, this is a story about the African – like three African American women, completely rooted in the African American community. You cannot change the characters' ethnicity.

Dianna (Black), Pam (White), and James (White) either agreed with or did not challenge Laura's concerns about cultural appropriation and Black erasure. Dianna had not seen *Dreamgirls* and did not know the story; most of the *Dreamgirls* part of the group work involved Laura recounting the plot to Dianna. In fact, Laura was so passionate about this topic that she interrupted content-related group work on multiple occasions to talk about *Dreamgirls*. However, the group seamlessly alternated between content-related and non-content-related talk, mainly because Dianna would cut-off Laura and steer the group back toward the physics.

Clearly, race and gender were explicitly "in the air" as the students engaged in physics and coded in GlowScript. What were the functions or effects of the *Dreamgirls* conversation on the interactions between students, particularly Dianna? Interviewing Dianna might have shed light on this question, but in the absence of such data, we can offer reasonable speculations. It is possible that Laura's anti-racist framing of the casting controversy put Dianna's mind at ease (i.e. her White classmates were resisting cultural appropriation), which supported her content engagement. Certainly, we can imagine how an alternate scenario – where Laura and the other White students espoused a racist take on the controversy – might have made Dianna uncomfortable and taxed her cognitive load, thereby making it more difficult to learn.

In that sense, the anti-racist *Dreamgirls* conversation can be understood as a kind of indirect learning resource. Even apart from its racialized benefits for Dianna, this "off-task" talk may have helped the group to persist on a difficult task. We also note that no one challenged Dianna in her role as de-facto group leader. For many girls – and Black girls in particular – leadership in STEM settings can mean being pejoratively labeled as "bossy" (Langer-Osuna, 2011). In contrast, Dianna was often the intellectual center of the group's interactions.

The *Dreamgirls* conversation also has a gendered aspect: if the gender ratio had been reversed, would a group of Dianna and three White *boys* be discussing the racial politics of *Dreamgirls*? With respect to the broader gender dynamics of the group, certain moves were made – some more overt than others – to claim or cede physical and conversational space that contributed to the large equity differential. In terms of physical positioning, all three girls were seated within arms-reach of the laptop. However, because of the design of the tables, there was no room on an edge of the square table. Instead, James positioned his chair in line with a table corner but several feet away (since he could not sit comfortably on the corner itself). This meant that he was the only group member who could see but not touch the laptop. In terms of physical artifacts, Dianna and Pam alternated typing on the laptop and using the whiteboard on the group's table, but neither Laura nor James attempted to use the laptop. While this configuration did not seem intentional, James's relative lack of access to the table and to the laptop may have diminished his engagement.

Apart from the spatial organization of the learning environment, it was clear that Dianna and Pam were group leaders. Laura seemed indifferent to the task, but her copious verbal contributions about *Dreamgirls* further occupied the conversational floor by the girls. For his part, James facilitated the gender dynamic by his passivity. Although his occasional contributions made clear that he understood the material, James yawned frequently, rarely looked at the laptop screen, and got up from his seat a couple times to blow his nose and chat with a friend. James spoke only once during the final 20 minutes of class. The girls were in charge and James seemed okay with that. On a couple occasions, James actively positioned himself in a support role, offering to perform more mundane "secretarial" tasks typically delegated to girls, such as typing or reading off numbers from a paper to be entered into the students' GlowScript program. Whether conscious or not, James's participation did not reproduce this historically gendered division of labor. Thus, in both passive and active ways, James ended up attenuating gender inequity by *not* taking up space through his silence and passivity, thereby yielding the conversational floor to Dianna, Pam, and Laura.

Episode #3: seeking (male) oracles, and laptops as masculine property

The final episode took place at a public suburban school where nearly all students identified as White. This group consisted of two White girls (Cindy and Trish) and two White boys (Shawn and Mark). Students were tasked with coding a program to calculate frictional forces. During this group session, the students also frequently interacted with their teacher, a White woman named Ms. C, and a pre-service teacher interning with her, a White man named Carl. As in the previous two episodes, this group often engaged in playful banter, although there was less evidence of mutual respect for each other's competence with physics or computing. With respect to gender, the equity differential for the girls was positive (+.05). However, qualitative analysis revealed particular forms of masculinity that amplified gender inequity and complicate the story suggested by the quantitative data.

Four individual desks were pushed together, with the boys' two desks facing the girls' two desks. Shawn and Cindy were closest to the laptop, as it straddled their desks on the far edge. While the screen faced all of the students, Mark and Trish could only touch the keyboard if they reached past Shawn and Cindy, respectively. An extra desk was positioned next to Shawn and Cindy, on which an audio recorder and microphone were placed for data collection. During this session, Shawn and Cindy occupied most of the conversational floor. Much of Trish's talk was not content-related, and Mark barely spoke. In part, this pattern was a function of the students' relative physical access to the laptop. However, data also show that some of the interlocutors – Shawn, in particular, but the teachers as well – participated in ways that supported the kinds of patriarchal social arrangements typical of physics and computer science learning environments.

Overall, Shawn dominated the group's interactions. Even times when he solicited input from his group, Shawn usually set the direction for the group's problem solving. The laptop was initially angled in a neutral position directly down the centerline of the four desks, such that it was visible to all four students. However, multiple times Shawn moved the laptop onto his desk and angled it toward himself as he typed. At times Shawn became frustrated and disengaged, or stood up and visited another group. For example, ten minutes into the session after the group got stuck, Shawn leaned back in his chair and said, "Alright, I give up. We had a good run boys." Then, Cindy rotated the laptop 90° away from Shawn to face her and began to type. The rest of the group stopped looking at the laptop and began talking about breakfast foods they like and potentially dropping physics. After several minutes of this, the following exchange took place:

1	Shawn	Have we gotten anywhere?
2	Cindy	No, I'm –
3	Shawn	– I'm going to go spy on another group [Gets up and leaves; returns after 1 minute of conversing with a nearby group]
4	Shawn	Alright team, so I have consulted the Oracle.
5	Cindy	Is that Ms. C, or Luis, or . . .
6	Shawn	Yes. [Not answering the question; pulls laptop from Cindy and back toward him]
7	Cindy	Yes? (Laughs)
8	Shawn	And the Oracle said that the width is just 30. I don't know that –
9	Cindy	– Yeah we knew that, we just didn't know the height.

The "Oracle" refers to another boy in the class named Luis, who Shawn clearly perceived to be a computation expert. By seeking out this "Oracle" instead of persisting with his group, Shawn revealed his lack of faith in his groupmates' abilities. Later in the session, Shawn left the group again to consult the "Oracle," which prompted Trish to say, "I'm going to give this kid a leash." Coincidentally, Shawn's departures opened space for the girls to lead the work and control the laptop. This is similar to the inadvertent way that James – in the previous episode – yielded the floor to the girls through his passivity. But as soon as Shawn returned, in spite of Cindy's resistance, he would eventually re-appropriate the laptop and resume command.

Both teachers also participated in centering Shawn, likely in unintentional ways. As a woman, Ms. C's very presence as a physics expert counters patriarchal narratives about women in STEM. And on a couple occasions, Ms. C deployed specific moves that effectively attenuated gender marginalization. For instance, upon noticing that Trish was waiting for her group members to solve part of the task using the Pythagorean theorem, Ms. C handed her a calculator and said, "You can do Pythagorean theorem too." However, when Ms. C came by to assist the group, she usually only spoke with Shawn. Partly this happened because Shawn was the only group member that solicited Ms. C's help. Still, Ms. C could have redirected the conversation to the rest of the group, particularly Cindy or Trish. Considering that Ms. C visited with the group multiple times during the session, her presence substantively affected participation patterns.

For his part, the intern teacher, Carl, also centered Shawn. More broadly, though, his way of participating in the space centered masculinity itself. When he came to help the group, Carl only interacted with or kept the laptop near Shawn, thereby affirming Shawn's location as the hub of the group's intellectual activity. On one occasion, Carl eventually took the laptop entirely away from the students; he then attempted to troubleshoot an issue with their code by himself for almost twenty minutes without engaging any of the students. During this time, all of the students ended up on their phones and Shawn played Rick Astley's song *Never Gonna Give You Up* for everyone. In effect, Carl positioned himself as a kind of second "Oracle" figure. This matters because Ms. C had already told her class that Carl was "way more of an expert than me" on coding in GlowScript.

We argue that the net effect of these various dynamics was to center masculinity. Two "Oracles" had a significant, unproblematized presence in the classroom and with this specific group. The way Shawn and Carl appropriated the laptop also rendered the laptop itself as a kind of masculine property. Ironically, of course, the original Oracle of

Delphi was a woman. But even though Cindy exercised agency throughout the session, as evidenced by her content-related talk and repeated bids to use the laptop, she was not granted "Oracle" status. In fact, given that the fourth group member, Mark, hardly ever participated verbally, we might have expected the gender equity differential to be higher than +.05. The fact that it was not higher underscores Shawn's dominance, as well as the subtle interactional ways that the learning environment still maintained patriarchy.

Discussion

This study sought to illuminate patterns of racial and gender equity and inequity at the classroom interactional level. Whereas the field has tended to give needed attention to broad structures that limit access for minoritized groups in computing, we argue that a complementary focus is needed at the classroom level where power is deployed between teachers and students. Our findings are consistent with evidence of White supremacy and patriarchy documented in the literature, albeit with some cause for optimism related to gender equity.

With respect to race, we found that White students dominated participation in small group settings. This is consistent with historical norms in physics and computing (American Institute of Physics, 2020; Margolis et al., 2008). However, our data also point to specific insights related to variations in the kinds of inequities experienced by different racialized groups. Compared with Asian and Middle Eastern-identified students, Black and Latinx students – who Bonilla-Silva refers to as part of the "Collective Black" – experienced far more severe forms of participatory inequity. At least for the Collective Black, distance from Whiteness appeared to amplify marginalization. Since every group session we analyzed included at least one White student, this finding also clarifies the zero-sum nature of equitable verbal participation in classrooms: if teachers allow White students to dominate group work, students of color will be left with fewer participation opportunities.

With respect to gender, we found that girls experienced high degrees of participatory equity – a welcome change from the longstanding marginalization of girls in computing. This was particularly true in groups with greater proportions of girls, which corroborates previous findings in the literature (Dasgupta et al., 2015). At the same time, though, group sessions with high degrees of participatory inequity occurred at rates approaching those of students of color. Further, the data also revealed patterns of patriarchy in small group interactions, even when quantitative metrics indicated gender equity. For example, qualitative analysis of one episode showed how boys – White boys and White men in particular – were positioned as "oracles," thereby reinscribing narratives of masculine superiority in computing contexts (Ensmenger, 2012; Lewis et al., 2016).

Implications for practice

We argue that teachers must actively develop ways of structuring group work to attenuate inequity, as well as stand ready to intervene on inequitable dynamics that arise in the moment. However, one reason this can be hard for teachers is the very structure of group work. Compared with whole-class discussions, where teachers have much more direct control over the distribution of participation opportunities, group work becomes a quasiprivate space where students interact often independently of the teacher. For that reason, some teachers may feel that what happens in group work is beyond their control. However, if "collaborative computing" is a crucial practice worth achieving (K–12 Computer Science Framework, 2016), educators must take responsibility for building learning environments that intentionally support minoritized students' participation. Students of color and girls are not to blame for racial and gender inequity. Teachers need to lead in this work by deploying explicit pedagogical moves to elevate minoritized students and their ideas in ways that counter White supremacist and patriarchal practices.

A necessary first step in this work is for teachers to become aware of inequities emerging in their own classrooms, which too often remain invisible. Using tools like EQUIP to monitor participation patterns can support these efforts. But how can teachers be supported in turning awareness into pedagogical action to counter inequity? While we see this as an ongoing, significant challenge for the field, we agree with Ryoo et al. (2015) that a "village" of mutually supportive educators is crucial. As we have found in our work with physics teachers, such communities can be spaces for engaging key questions about equitable groupwork, such as: what does a "participation opportunity" mean in the context of group work? Who decides about talk and resource use, and why?

One concrete pedagogical consideration suggested by our findings concerns how teachers compose groups. Although "diverse" groupings may serve certain goals, we argue that teachers need to prioritize minoritized students' feelings of safety and comfort. Collaborating in groups with minoritized peers of the same social marker group can be a way to counter social isolation and foster feelings of belonging, which has been documented as a major obstacle for minoritized students in computing (Miliszewska et al., 2006; Rosa & Mensah, 2016). Additionally, teachers should be intentional in setting norms for equitable group work, specifically in terms of group roles and guidelines around control and access to resources, particularly shared computing devices. Pedagogical approaches like Complex Instruction have been successfully used in STEM areas like mathematics education to navigate these kinds of issues (see Featherstone et al., 2011).

Limitations & opportunities for future research

We acknowledge several limitations of our study. First, we only examined the quantity of talk rather its quality. In addition, we only quantified verbal forms of participation. We note that students do make valuable non verbal contributions to group work, and that students who rarely speak can still provide important ideas that shape the direction of problem solving. Second, although some of our data did involve teachers, the significant roles they play in designing and supporting certain forms of participation (and marginalizing others) was not a focus here – we plan to pursue this in future research. Finally, we recognize that equity and inequity are subjective experiences that can only partially be captured through observational means. In future work we hope to incorporate interviews with students, which center their voices alongside the kinds of quantitative and qualitative analyses of classroom interaction presented here.

Conclusion

The integration of computing across STEM education poses exciting possibilities for student learning. By itself, though, this integration does not constitute equity. Instead, what matters is how students from minoritized groups experience these new learning opportunities. If we accept that we live and teach in a White supremacist patriarchal culture, then we should expect these oppressive forces to play out in classrooms and account for them in our teaching. Beyond this, though, merely providing minoritized students equitable access to dominant forms of participation (i.e. participation that was created by and embodies values of Whiteness and masculinity) seems insufficient to the broader task of justice for minoritized groups in society writ large. This raises questions about the fundamental goals of equity work in computing education, and whether predominant conceptualizations of "equity" are even adequate for realizing fair and humanizing futures for women and people of color.

Notes

1. For elaboration of this point in the context of computing, see Lewis, Shah, & Falkner (2019) chapter in *The Cambridge Handbook of Computing Education Research.*
2. The term *contribution* refers here to a sequence of talk from a single student, regardless of the number of sentences within or content of the sequence.

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