Exploring diverse students' negotiation of lab roles through positioning

Mark Akubo, Meagan Sundstrom, and Natasha G. Holmes
Laboratory of Atomic and Solid State Physics, Cornell University, Ithaca, New York 14853, USA

Prior work has found inequities in what experimental roles students take on during instructional labs. Research also suggests that this role division might arise implicitly and that prompting explicit role negotiation might improve equity in lab group work. To understand these various ways students negotiate roles in their lab groups, we use the lens of positioning to analyze two different video episodes of a gender-and-race-diverse group of three students. In one episode, students implicitly take on roles through subtle negotiations and in the second episode, one student explicitly assigns roles. We find that the positioning dynamics in both episodes lead to inequitable learning experiences within the group. This inequity, moreover, occurs along gender and racial lines, prompting future work relating students' intersectional identities to their positioning dynamics in small groups.

2022 PERC Proceedings edited by Frank, Jones, and Ryan; Peer-reviewed, doi.org/10.1119/perc.2022.pr.Akubo

I. INTRODUCTION

Currently, some undergraduate physics laboratory courses emphasize substantially leveraging students' epistemic agency [1–3]. These labs also aim to improve students' expert-like science and engineering practices [4, 5]. Students typically work in small groups during inquiry-based labs [6], where they take on various roles to contribute to the group's work [7]. As they negotiate these roles, students engage in important social dynamics that can offer insight into how they make sense of their place in the group during knowledge-construction: *positioning* [8]. A positioning lens offers opportunities for gaining insight into the social dynamics during knowledge-construction, particularly how students take on, assign, and recognize different roles to participate in knowledge-building [9].

As students take on and negotiate these roles, however, these social dynamics often exhibit equity issues along gender lines [10–13]. Furthermore, issues surrounding physics identity motivate studying group work equity along racial/ethnic lines [14, 15]. Prior work in science education has recommended adding structure or assigning group roles to improve equity in instruction [16–18]. In lab, specifically, researchers have found equitable group work (in terms of access to equipment) in highly structured labs and inequitable work in less structured labs [11]. In the less structured labs, students more often assigned roles implicitly, rather than explicitly, among the group members [12, 13, 19].

In this research, we probe this role negotiation more deeply using the lens of positioning. We describe the roles that the participants engaged in and the dynamics surrounding the taking on of these roles. We seek to understand how these roles affect studentsâ positioning and how positioning influences what roles students take on. We analyze discourses from two purposefully selected video episodes in order to identify and describe the positioning dynamics in one lab group. Such insight is helpful for a richer conversation on issues around (in)equity in small groups within non-traditional undergraduate physics labs. As a gender and racially diverse group of researchers, we desire to contribute to conversations that aim to improve equity in physics classrooms and the field at large.

II. THEORETICAL FRAMEWORK

We use positioning theory to explore how participants took on roles during their lab work as they interact in their group (see Fig. 1). Positioning conveys the sense of how participants make sense of their place in knowledge-building or how they would answer the questions, 'Where am I located in this conversation?' and 'Where do others place me in this conversation?' [8]. Participantsâ answers to these questions are embedded in their discourses when participating in interactions in their groups to construct knowledge. Discourses are the verbal and nonverbal forms of participating in a particular sphere of activity [20] such as physics labs. Through these discourses, students also enact their disciplinary identities [21, 22] and/or social/cultural identities [23, 24].

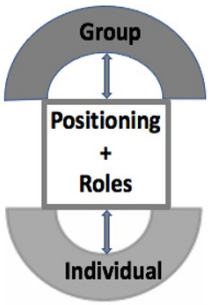

FIG. 1. Schemata illustrating our theoretical framework for the bidirectional relationships between positioning dynamics, experimentation roles, each individual, and the rest of the group..

In this study, we focus on how participants position themselves through roles they take on in the group [12]. Roles describe the major ways students participate or contribute to their group work. In a lab setting, these roles may include handling the equipment and collecting data, analyzing the data, or managing the group, among others [11, 19, 25, 26]. We argue that the social nature of learning [27] leverages positioning dynamics. Positioning dynamics describe the dynamic ways individuals interact with each other to take on roles and support or inhibit others' roles.

In positioning, participants strategically claim and abandon roles in relation to the self and others [28]. Such roles may remain stable during a given moment of interaction, an entire episode of interaction, or through an entire semester. While positioning may lead students to take on various roles, the latter also influences former. For example, students' taking on roles can implicitly position others in the group. In the current study, therefore, we considered both positioning and re-positioning of the individual (self-positioning) and others (other-positioning) [28, 29] during discourses in a small group as participants navigated their roles [30].

We conducted an exploratory case study guided by the following research questions: What positioning dynamics do participants in a gender-and-racially diverse group enact as they take on (or do not take on) roles in a non-traditional college physics lab and how are those dynamics similar or different across participants?

III. METHODS

Guided by the research questions, we analyzed video recordings of a lab group comprised of three students: Zainab (a Black Woman), Matt (a White Man) and Eliz (a White Woman). All student names are pseudonyms and students self-reported their gender and race/ethnicity on a survey. We

examined positioning dynamics around how each of these students negotiated experimentation roles within this small group.

A. Data collection

We collected video and audio data of this group for a full semester of their lab course. We focused our analysis on this particular group because we wanted to explore positioning dynamics in a racially diverse and heterogeneous gender group within the inquiry-based lab. We analyzed one lab session from the middle of the semester because we expected this to be a stable period when students have become familiar with the learning objectives and goals of the lab. In this lab session, students first explored Hooke's law by measuring the relationship between force and displacement of a stretchy object. Then, students identified and performed follow-up investigations, testing various assumptions of the physical model (e.g., whether the model has limitations at very small or very large displacements).

B. Data analysis

The lead author watched the entire video of the lab session and wrote memos on discrete segments of students' interactions (i.e., episodes). These memos described the verbal and non-verbal discourses, the roles students took on, and our interpretations of the interactions amongst students' roles. Subsequently, a larger research team discussed these video episodes during multiple research meetings. In these discussions, we analyzed students' discourses to make sense of the positioning dynamics centering on roles. In order to identify positioning dynamics, we sought to understand how participants' discourses indicated what roles they wanted to take on, how other participants responded to those intentions, and what roles the students ultimately took on. We present data in the form of transcripts of students turns of talk/non-verbal discourses. The turns of talk are not always chronological here but as would make for a coherent interpretation of the discourses.

The lead author selected two video episodes within the lab session for closer analysis. These two video episodes typify the distinct ways the students assigned roles. In the first episode, students conduct an initial exploration of Hooke's law. As they move from planning to executing their experiment, each student's role is decided through implicit, non-verbal negotiation. In the second episode, the group starts to explore the assumptions of the physical model in order to search for unusual outcomes. For this new experiment, after prompting from the teaching assistant (TA), a member of the group explicitly decides what role each student will perform, ultimately splitting into two groups to test two different assumptions. We identified and described the role(s) of each student, as well as the positioning dynamics surrounding these roles, for each video episode.

IV. RESULTS

In this section, we present the two video episodes. For each, we summarize the positioning dynamics of the group that led to students taking up different roles. Interestingly, compared to Matt and Eliz, there were observable differences in the positioning dynamics involving Zainab. In the first episode, Matt positioned her out of data collection role, thus restricting her access to equipment handling. She had to re-position herself to participate in the group as the critical thinker. In the second episode, she took on many more roles. The group's work space configuration is in Fig. 2.

A. Episode 1: Exploring Hooke's Law

In the first video episode, roles were implicitly assigned: participants did not verbally discuss who was to take on what role(s) nor did a participant tell another what role to take on. Rather, each student set out performing a certain role, positioning themselves and others accordingly. These roles, however, were not stable and students engaged in subtle negotiations that resulted in role changes. In the following subsections, we describe the positioning of each student in the first video episode. At the start of the episode, Matt is at location A, Zainab is at location B, and Eliz is at location E (Fig. 2).

At the beginning of the episode, Zainab leaves the lab table to retrieve materials for their experiment. She returns with a clamp, stand, and some masses and starts setting up for the experiment at the end of the table (location D in Fig. 2). These actions indicate that Zainab implicitly positioned herself as the equipment setup person – there was no negotiation for who was to take on this role.

Zainab continues to install the lab setup – a stand from which they will vertically hang a spring and masses – and begins to take measurements. Again, Zainab's discourses suggest that she takes on her role implicitly: she takes charge of the data collection.

Soon after Zainab begins collecting data, however, there is a negotiation between her and Matt for the data collector role (Matt has moved to be in front of the equipment at location D in Fig. 2). The negotiation suggests a subtle contest for the role in which Matt prevailed and Zainab is positioned out of the role:

17. **Eliz**: How long is the spring length? (asking Zainab).
18. **Zainab**: What I'm doing is putting it at um it like (clamping the ruler to the stand at the point from where the spring and the mass will be suspended), so we can find change in the stretch.
19. **Matt**: (Cutting in) Don't measure the um, don't measure this part and this part (touching the place he was referring to).
20. **Zainab:** Um, yeah.

21. **Matt:** You can take it off of there.
22. **Zainab:** Oh, what I'm doing is trying to place it so that we can find change in the stretch.
24. **Matt:** Oh, yea (nodding).
25. **Matt:** (Hangs the holder with masses on the spring as if to test things out)

In line 21, Matt is critical of Zainab's work and gives directives. He does not offer his reason(s) or share his thinking for disagreeing with the work Zainab was doing. At this point, Zainab steps back and Matt takes over the data collection work. From then onward, Matt handles all the data collection, effectively positioning Zainab out of the experiment data collector role. This leads Zainab to re-position herself by taking on a different role: critical thinker. She continues to stand near the apparatus at the end of the table, standing behind Matt and moving around to speak with Eliz (who is still seated at location E in Fig. 2).

In playing the role of a critical thinker, Zainab asks questions that seek clarity, offer double-checking of their work, or push their investigation further:
62. **Zainab:** Also, the spring elasticity is changing? (she leans toward the spring, holding it in her hand as if checking how stretchy the spring is). Should we be checking that?
63. **Matt:** No. This is just preliminary result (hanging the mass holder one more time).
64. **Eliz:** What do you mean the elasticity?
65. **Zainab:** Cos maybe it overstretched a bit (illustrating with her hands).
68. **Zainab:** So then let's deform it then. Let's use all the masses.
70. **Eliz:** Okay. So, then, let's do like really, really large masses. We should put all the masses.
90. **Zainab:** Did we get it deformed?
91. **Matt:** (Cutting in) Yea. I don't know if I would say it's deformed but it went further than it should have (Zainab nodding) based off of the (unclear).

As critical thinker, Zainab advanced the group's investigation by suggesting they explore whether the spring had been deformed. Eliz agrees with this new direction (see line 70), implicitly positioning Zainab in this critical thinker role. Zainab proposes aspects of their ideas that could be open to alternate or competing perspectives. While Eliz supports Zainab's new role, Matt continues to collect data without Zainab.

Eliz's primary role in this episode is data scribe and manager. From the start of their lab work in the group, Eliz sits at her lab stool (location E in Fig. 2) in front of her laptop. She records the group's data and contributes to their lab notes on her personal laptop. Eliz does not manipulate any part of the experimental setup. Eliz's role as manager includes Evaluating data generated and also vetting processes during data collection:
80. **Eliz:** It should have been 6.5.
83. **Matt:** Switch (He was going to switch out the spring for another).
84. **Eliz:** No, no, no, but that's good. We want it to break.

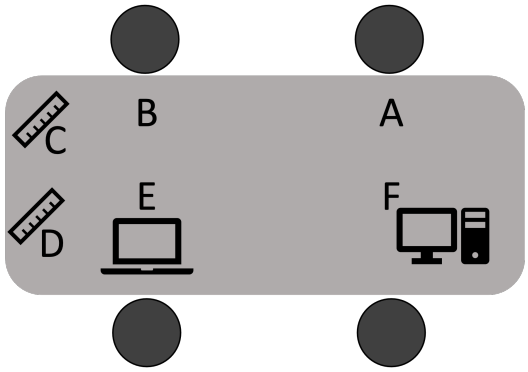

FIG. 2. An illustration of the participants' work station. The circles indicate the four lab stools (A, B, E, and F), the rulers indicate the positions of the two experimental set ups(C and D), Eliz's laptop is at E, and the desktop computer is at F.

Interestingly, neither Zainab nor Matt negotiates Eliz's role as the data scribe and manager. Neither of them try to be the data scribe or manager themselves and neither of them question Eliz's role. In other words, Eliz positions herself as the data scribe and manager (see lines 80, 83-84)and the other group members position her in this role too.

Matt takes on the role of data collector: he takes measurements to generate data. Though there are two occasions when Matt collects items and brings them to the group's work station, he does not carry out any direct work of installing the setup (but done by Zainab). Instead, Matt negotiates (as described earlier) and maintains the role of data collector. As described previously, Matt contested the data collection role with Zainab, starting out by being critical of how she was conducting the experiment to generate data (line 19, above). Eliz also supports him in this role by asking him to report the data to her for recording.

B. Episode 2: Exploring Further Assumptions

Unlike the first video episode where participants implicitly took on roles, in the second episode, Eliz explicitly assigns everyone roles. This assignment is initiated by the TA's explicit suggestion for the group to divide the labor:
94. **TA**: There is three of you. There is no rule that you all have to be looking at the same thing, the same time... So, get like, you know, several springs and all of you do something different and see if you come up with the coolest thing.

Eliz then provides explicit directions about what roles Matt and Zainab will perform:
97. **Eliz:** Okay, so, one person will check if the diameter of the spring changes the point at which it breaks down. And another person checks if the magnitude of the K changes where it breaks down. Okay, and I can do excel and if you guys check and I can just record the data. Okay.

Eliz's command leads to the group's functioning as two smaller groups: Matt does one experiment and Zainab does the other. Eliz also positions herself again as the data scribe

and manager in the group, suggesting she will record the data, while also taking charge of how the group will operate. Eliz, however, ends up helping Matt:

146. **Matt:** (Working to fit the second clamp) I don't know how this works (as he held it and said). I can either hang this right now or I don't know what to do.

149. **Eliz:** Go back to the original thing and I'll hold the spring (reaching for the clamp, and drawing it closer with the stand) and you can just change the mass. How's that?

While Eliz had suggested she would be the data scribe for both experiments, she spends the rest of the episode helping Matt collect the data for his experiment. This leaves Zainab to carry out multiple roles for the second experiment: setting up a new apparatus, collecting and recording data, and analyzing data. She also travels multiple times back and forth between the group's work station and other parts of the classroom to gather another set of equipment, as well as between multiple positions at the work station (her new apparatus is at location C while the desktop computer she uses is at location F in Fig. 2). In this way, the explicit role assignment ultimately results in inequity: Eliz and Matt work together on one experiment, while Zainab is left to carry out an experiment on her own.

V. DISCUSSION AND CONCLUSION

In this study, we analyzed two video episodes from a mid-semester lab session. We focused on the discourses of a select small group characterized by race and gender diversity. We used the lens of positioning to understand how students negotiated their roles.

Prior work suggests the presence of inequities in lab roles, particularly for equipment handling [11–13, 31]. Research also suggests that such inequities are not explained by student preferences, rather something more implicit or subtle happens in the lab as students negotiate their roles [10, 19]. Positioning offers a useful lens for understanding both the implicit and explicit dynamics because we can characterize both subtle and overt negotiations of roles, exemplified in the two video episodes we described.

Implicit role negotiation (the first video episode we described) seems to occur through non-verbal actions: we observed a subtle contest for the data collector role between Matt and Zainab. Based on prior research, men tend to get recognized as more competent with machines and tools in physics and usually take on the equipment handling role [12, 13, 25]. The subtle negotiation between Matt (a man) and Zainab (a woman) for positioning as experiment data collector contributes to the understanding of entanglement between engagement in physics and gender performance [12].

In the second episode, Eliz explicitly assigned roles to her peers and herself and broke the group into two smaller groups, with Matt and Eliz executing one experiment and Zainab executing another. Her intent for this positioning is unclear and open to speculation, but, as a result, the new positioning dynamics and distribution of roles asymmetrically taxed [32] Zainab's time and energy compared to Matt and Eliz, indicating inequitable group work. Also, Eliz's self-restriction to the data scribe and manager role in both episodes self-constrains her access to equipment handling [33]. While these roles are indicative of gender inequities seen previously [e.g., 11, 33], it is curious that the two women did not contest each other's roles. Could each of the women be positioning each other as a same gender ally? Such alliances have been previously observed between participants in a racially homogeneous group, where authority shifted from one peer to another from moment to moment [10]. Alternatively, were the two women just not interested in each other's roles, given the wide range of students' preferences for lab roles [19]? Unfortunately, the data here do not speak to the intentions behind these negotiations.

Previous research suggests that more structure improves equity in lab group work [e.g., 16–18, 30, 34], such as through explicit role assignment [18, 33, 34]. Given our analysis of two episodes with implicit and explicit role assignments, and the inequitable outcomes in both cases, we do not know if explicit role assignment may actually be a silver bullet for alleviating inequity.

In both episodes, positioning dynamics were interestingly different across the participants in ways that suggests greater inequity for the Black Woman. Based on our results, there is a need for more research centering around more than how men's and women's roles are assigned, namely to include the overlap of students' gender and race – intersectionality [35]. It is important for us to gain insight into how and why students position themselves in different knowledge-building interactions based on their identity-related moves or bids for recognition. These dynamics can be intersectionally driven.

ACKNOWLEDGEMENTS

This material is based upon work supported by the NSF GRFP Grant No. DGE-2139899 and NSF Grant No. DUE-1836617. We thank Ian Descamps, Sophia Jeon, Matthew Dew, Emily Stump, David Hammer, and Rachel Scherr for meaningful discussions about this work and Anna Phillips and Scott Allen for their data collection efforts.

[1] E. Miller, E. Manz, R. Russ, D. Stroupe, and L. Berland, Addressing the epistemic elephant in the room: Epistemic agency and the next generation science standards, Journal of Research in Science Teaching **55**, 1053 (2018).

[2] C. Z. Elgin, Epistemic agency, Theory and research in education **11**, 135 (2013).

[3] N. G. Holmes and C. E. Wieman, Introductory physics labs: we can do better, Physics Today **71**, 1 (2018).

[4] E. Etkina, A. Van Heuvelen, S. White-Brahmia, D. T. Brookes, M. Gentile, S. Murthy, D. Rosengrant, and A. Warren, Scientific abilities and their assessment, Physical Review special topics-physics education research **2**, 020103 (2006).

[5] L. K. Berland, C. V. Schwarz, C. Krist, L. Kenyon, A. S. Lo, and B. J. Reiser, Epistemologies in practice: Making scientific practices meaningful for students, Journal of Research in Science Teaching **53**, 1082 (2016).

[6] N. G. Holmes and H. J. Lewandowski, Investigating the landscape of physics laboratory instruction across North America, Physical Review Physics Education Research **16**, 020162 (2020), publisher: American Physical Society.

[7] C. Howe, Optimizing small group discourse in classrooms: Effective practices and theoretical constraints, International Journal of Educational Research **63**, 107 (2014).

[8] R. Harré and L. Van Langenhove, Varieties of positioning, Journal for the theory of social behaviour 10.1111/j.1468-5914.1991.tb00203.x (1991).

[9] K. T. Anderson, Applying positioning theory to the analysis of classroom interactions: Mediating micro-identities, macro-kinds, and ideologies of knowing, Linguistics and Education **20**, 291 (2009).

[10] M. O. Akubo, *Gender Dynamics in Small Group within a Student-Centered Physics Course: An Exploratory Single Case Study*, Ph.D. thesis, The Florida State University (2021).

[11] K. N. Quinn, M. M. Kelley, K. L. McGill, E. M. Smith, Z. Whipps, and N. G. Holmes, Group roles in unstructured labs show inequitable gender divide, Phys. Rev. Phys. Educ. Res. **16**, 010129 (2020).

[12] A. Gonsalves, Persistent discourses in physics education: gender neutrality and the gendering of competence, Cultural Studies of Science Education **9**, 461 (2014).

[13] A. T. Danielsson, Exploring woman university physics students' doing gender and doing physics, Gender and Education **24**, 25 (2012), https://doi.org/10.1080/09540253.2011.565040.

[14] S. Hyater-Adams, C. Fracchiolla, N. D. Finkelstein, and K. Hinko, Understanding connections between physics and racial identities through recognition and relational resources, in *2016 Physics Education Research Conference Proceedings* (2016) pp. 164–167.

[15] S. Hyater-Adams, C. Fracchiolla, T. Williams, N. Finkelstein, and K. Hinko, Deconstructing black physics identity: Linking individual and social constructs using the critical physics identity framework, Physical Review Physics Education Research **15**, 020115 (2019).

[16] D. C. Haak, J. HilleRisLambers, E. Pitre, and S. Freeman, Increased structure and active learning reduce the achievement gap in introductory biology, Science **332**, 1213 (2011).

[17] S. Freeman, D. Haak, and M. P. Wenderoth, Increased course structure improves performance in introductory biology, CBE–Life Sciences Education **10**, 175 (2011).

[18] P. Heller and M. Hollabaugh, Teaching problem solving through cooperative grouping. part 2: Designing problems and structuring groups, American Journal of Physics **60**, 637 (1992), https://doi.org/10.1119/1.17118.

[19] N. G. Holmes, G. Heath, K. Hubenig, S. Jeon, Z. Y. Kalender, E. Stump, and E. C. Sayre, Evaluating the role of student preference in physics lab group equity, Physical Review Physics Education Research **18**, 010106 (2022).

[20] J. P. Gee, *An introduction to discourse analysis: Theory and method* (routledge, 2010).

[21] R. M. Lock and Z. Hazari, Discussing underrepresentation as a means to facilitating female students' physics identity development, Physical Review Physics Education Research **12**, 020101 (2016).

[22] Z. Hazari, C. Cass, and C. Beattie, Obscuring power structures in the physics classroom: Linking teacher positioning, student engagement, and physics identity development, Journal of Research in Science Teaching **52**, 735 (2015).

[23] H. B. Carlone, The cultural production of science in reform-based physics: Girls' access, participation, and resistance, Journal of research in science teaching **41**, 392 (2004).

[24] H. B. Carlone, A. Johnson, and C. M. Scott, Agency amidst formidable structures: How girls perform gender in science class, Journal of Research in Science Teaching **52**, 474 (2015).

[25] A. T. Danielsson and C. Linder, Learning in physics by doing laboratory work: towards a new conceptual framework, Gender and Education **21**, 129 (2009), https://doi.org/10.1080/09540250802213081.

[26] J. Day, J. B. Stang, N. G. Holmes, D. Khumar, and D. A. Bonn, Gender gaps and gendered action in a first-year physics laboratory, Physical Review Physics Education Research **12**, 020104 (2016), publisher: American Physical Society.

[27] L. Vygotski, Interaction between learning and development, Readings on the development of children , 34 (1978).

[28] R. Harré, F. M. Moghaddam, and F. Moghaddam, *The self and others: Positioning individuals and groups in personal, political, and cultural contexts* (Greenwood Publishing Group, 2003).

[29] R. Harré, Positioning theory: Moral dimensions of social-cultural psychology. in j. valsiner (ed.), the oxford handbook of culture and psychology (pp. 191–206). oxford university press, (2012).

[30] D. T. Brookes, Y. Yang, and B. Nainabasti, Social positioning in small group interactions in an investigative science learning environment physics class, Physical Review Physics Education Research **17**, 010103 (2021).

[31] D. Doucette and C. Singh, Share it, don't split it: Can equitable group work improve student outcomes?, The Physics Teacher **60**, 166 (2022).

[32] M. Boveda and A. E. Weinberg, Facilitating intersectionally conscious collaborations in physics education, The Physics Teacher **58**, 480 (2020).

[33] D. Doucette, R. Clark, and C. Singh, Hermione and the secretary: how gendered task division in introductory physics labs can disrupt equitable learning, European Journal of Physics **41**, 035702 (2020).

[34] K. D. Tanner, Structure matters: Twenty-one teaching strategies to promote student engagement and cultivate classroom equity, CBE–Life Sciences Education **12**, 322 (2013), pMID:

24006379, https://doi.org/10.1187/cbe.13-06-0115.

[35] K. Crenshaw, Demarginalizing the intersection of race and sex: A black feminist critique of antidiscrimination doctrine, feminist theory and antiracist politics, u. Chi. Legal f. , 139 (1989).