Exploring How Status Influences Relational and Participatory Equity in Inquiry-Oriented Small Group Interactions

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While inquiry approaches have the potential to open up more equitable spaces in the classroom, research has shown this is not guaranteed. In this study we focus on the role that status can play in creating (in)equities during small group work. In particular, we compare one low-status student's interaction with two high-status students in two small group episodes. We found that the two episodes differed in terms of participatory and relational equity and our results describe how status and certain patterns of interaction may account for this difference.

Keywords: Status, equity, small group interactions, inquiry-oriented instruction

There is some consensus that research on inquiry approaches in undergraduate mathematics classrooms needs to consider equity issues (Adiredja & Andrews-Larson, 2017; Laursen & Rasmussen, 2019; Melhuish et al., 2022). Scholars have suggested that group work – a common feature of inquiry instruction – may be a potential factor contributing to inequities in learning mathematics at the undergraduate level, particularly along gender lines (Brown, 2018; Ernest et al., 2019; Hicks et al., 2020; Johnson et al., 2020). Johnson et al. (2020) established that men achieved higher scores than women on a conceptual assessment after taking inquiry-oriented abstract algebra. The authors speculated that group work may open up opportunities for microaggressions and implicit bias to occur, which could negatively impact women's confidence in their own mathematical ability, resulting in lower performance. Ernest et al. (2019) characterized several student interactions during group work in an inquiry setting as overtly sexist and implicitly exclusionary towards women. This small body of research points to a need to better understand social processes during group work in inquiry classrooms that may be able to explain such inequitable findings.

Scholars at the K-12 level have argued that status and positioning during group work may amplify inequities in inquiry learning environments (Battey & McMichael, 2021; Shah & Lewis, 2019). Yet, how status influences (in)equitable interactions during group work has been underexplored in research at the undergraduate level. Therefore, this study set out to explore the role of status during group work in an inquiry setting from participatory equity and relational equity perspectives.

Theoretical Framework

In this study, equity is defined as situations in which all students can access resources they need for learning, and *in*equity as situations that *limit* access to resources needed for learning (Shah & Lewis, 2019). Resources needed for learning mathematics in small groups can include physical materials (e.g., notes, definitions, technology), skills to complete the task (e.g., problem-solving strategies, intuition behind a proof), and a safe learning environment (e.g., learn from mistakes, space to make sense). Two interrelated concepts further indicate how situations are more or less inequitable in small groups. First, participatory equity describes situations in which "opportunities to participate—and participation itself—are fairly distributed among all students involved in a learning interaction" (Shah & Lewis, 2019, p. 428). Second, relational equity (Boaler, 2008) describes situations in which the *quality* of interactions provides each student "access to opportunities to develop identities as capable learners" (p. 428). As human

interactions naturally fluctuate, a situation will never be completely equitable or inequitable. For instance, in one situation a student may have more opportunities to participate and influence decision making at one moment, then limited access to such opportunities at another moment.

Unbalanced power dynamics due to differences in status characteristics may amplify inequities in small group work (Esmonde, 2009a; Shah & Lewis, 2019). A status characteristic is known as an "agreed-upon social ranking where everyone feels that it is better to have a high rank than a low rank" (Cohen et al., 1999, p. 84). In the classroom, academic status characteristics such as perceived ability are extremely powerful status markers (Cohen & Lotan, 2014), which can be impacted by diffuse status characteristics (Ridgeway, 2018) such as gender, race, ethnicity, socioeconomic class, etc. (Cohen et al., 1999). For example, it is a widely held belief that "Asian men are good at math" (Shah, 2017) which raises their perceived ability in math, thus increasing their status. Students with higher perceived status typically contribute more in class and small groups, gaining more opportunities to access resources needed for learning. Status hierarchies form quickly when people regularly interact with one another (Berger & Webster, 2018; Ridgeway, 2018) – a key characteristic of inquiry classrooms (Laursen & Rasmussen, 2019). While status hierarchies may become stable over time, it is possible to disrupt this process to promote more equal status positions between students (Cohen et al., 1999). We argue that exploring status positions while students work in small groups can help us understand the role status might play in shaping situations that are more or less (in)equitable.

To explore how status shapes group work interactions with respect to participatory and relational equity, we leveraged research using status and positioning theories to analyze small group interactions (e.g., Adams-Wiggins et al., 2020; Alexander et al., 2009; Chizhik, 2001; Esmonde, 2009b; Shah & Lewis, 2019). Table 1 provides the analytic constructs used in our analysis with low- and high-status indicators and examples from our data. The observable group activities in interaction come from status construction theory (Berger & Webster, 2018; Wagner & Berger, 1993), and the low- and high-status indicators were identified from several sources drawing on status theory (e.g., Chizhik, 1999, 2001; Cohen et al., 1999; O'Donnell, 1999).

Table 1. Status Constructs Used to Analyze Small Group Interactions

Observable Activities in Interaction	Low-Status Indicator	High-Status Indicator	Example from Small Group Data
Opportunities to Contribute	Grants opportunities to act (seeks help from others)	Receives opportunities to act (answers questions)	Justin: So now that we have this, how does this relate? (granting opportunities to act)
Communicated Evaluations of Contributions	Negative evaluations ("That is wrong")	Positive evaluations ("That is a good idea")	Alison: So, we have to define Q and W. They're just symmetries. Abigail: Yeah that's smart.
Influence Over Group Decision Making	Ideas rejected or ignored by the group (less ability	Ideas accepted by the group (influences the	Abigail asks if they should start on part two. This idea is not taken up as Justin

	to influence disagreement outcomes)	outcome of disagreements)	suggests they are not done with part one yet.

Methods

Data Collection and Episode Selection

Data comes from a project developing inquiry-oriented introduction to proof curricular materials designed to introduce students to various proof-related activities (e.g., proof construction and comprehension, defining, conjecturing, etc.) using real analysis and group theory concepts. We focused on a curriculum implementation in an Introduction to Proofs course that was taught remotely over Zoom (due to COVID-19) at a large public university. Table 2 contains the 14 participating students' ethnoracial background by gender (some students self-identified as more than one race/ethnicity). Students engaged in group work at least once per day with groups changing every day. The second author attended class each day, entering breakout rooms during group work as a silent observer to capture the students' activity. Screen recordings captured activity over Zoom as well as activity on Google Docs which became a virtual space for students to work together on tasks.

Table 2. Self-Reported Student Ethnoracial Backgrounds and Gender

Gender	Whit	East Asian	Southeast Asian	Hispanic/Latin
Woman (*n*=6)	e	0	0	x
Non-Binary (*n*=1)	5	0	0	2
Man (*n*=7)	1	3	2	0
Total (*n*=14)	5	3	2	1
	11			3

Two group work episodes were selected as the main data source for this study. A group work episode was defined as the time period in which students worked in groups on a specified task. The two episodes were selected based on the second author's extensive work studying the students' collective mathematical activity (see Alzaga Elizondo, 2022). First, in episode 1, Lee (Southeast Asian male) and Alison (white female) were working to prove that group isomorphisms preserve inverses. Lee took a clear lead in proposing and developing the mathematical ideas while Alison followed along, regularly providing evaluations. From the second author's classroom and group observations, Lee had higher perceived status among the classroom community. Contrastingly, in episode 2, Alison, Abigail (white female) and Justin (white male) worked to prove that a group element can appear at most once in a row of the group's Cayley Table. Alison contributed several key ideas to her group's proof such as the overall structure of a contradiction argument and several line-by-line justifications. While Alison was an active participant in both episodes, she appeared to contribute to the co-construction of mathematics in qualitatively different ways. Given the more collaborative activity in episode 2, we conjectured that empirically analyzing status in relation to participatory and relational equity while focusing on Alison would show episode 2 as being more equitable compared to episode 1.

Analysis

Students in remote environments communicate using different modalities when working together to solve a problem (Hoffman 2019). The first step in our analysis was to create

multimodal transcripts that captured both verbal communication and any activity across different modes (i.e., on Google Doc and Zoom). To map any nonlinear forms of communication, we used descriptive text (i.e., "as she talks, she writes:" or "while everyone else works they edit the text") and/or time stamps. Together, the transcripts provided a complete image of the students' multimodal discourse, which we used with the video data for subsequent analysis.

We leveraged equity analytics (Reinholz & Shah, 2018) to quantify the number of talk turns, the duration of talk, and proportion of talk in each episode. Specifically, we used the multimodal transcripts to count the number of both verbal talk turns and non-verbal participation. Students often used the Google Doc to communicate and illustrate ideas (Alzaga Elizondo, 2022), thus we defined a non-verbal participation turn as any time a student added something to the shared document. Then, we used the constructs in Table 1 to analyze status relations. Specifically, at each talk turn in the multimodal transcripts, the first author attributed who granted/accepted opportunities to contribute, evaluated specific contributions, and whose ideas were taken up, ignored or rejected and how this impacted influence over group decision making. Additional analytic notes were recorded to describe how the students treated and interacted with one another as well as how status differences emerged. The second author went through all analytic notes and transcripts to add anything new or challenge the first author's interpretations. The two authors then met to discuss and compare analytic notes and reconcile any differences.

As we moved into an interpretive phase of analysis, we wrote analytic memos (Creswell & Poth, 2016) that centered on interactions between low-status and high-status pairings: Alison and Lee (Episode 1) and Alison and Justin (Episode 2). The purpose of creating the memos was to systematically find evidence and any counter-evidence for emerging interpretations of the interactions and compare across the two episodes. For example, in episode 2, we began to see an interaction pattern emerge between Alison and Justin that was different from interactions between Alison and Lee and seemed connected to Justin maintaining his high status position (which he implicitly established throughout the episode). The first author wrote memos from re-watching the video data with the transcripts and status analysis, and the second author served to challenge interpretations in the memos. Any disagreements were resolved through discussion.

Results

In the following, we first demonstrate how participation was distributed differently among the students in each episode, with Alison participating less overall in episode 2 compared to episode 1. Then, from a relational equity perspective, we found that the quality of interactions also differed between the episodes. We argue that the students' status relations provides insight into *how* the quality of interactions differed. Specifically, in episode 1, Alison was invited to co-construct a proof with Lee (a high status student) by evaluating lines in the proof, while in episode 2, Alison had to defend her mathematical contributions repeatedly to Justin, a higher status student who established himself as an expert on what formal proofs should look like throughout the episode.

Participatory Equity

Table 3 describes the verbal and non-verbal participation distributions across participants in each episode, which provides insight into how fairly distributed their participation was (Reinholz & Shah, 2018). Meaning, if participation is distributed equally across three people working in a group, each person should have about one-third of the whole amount of talk-time allotted to them. We caution that equitable or fair participation is not synonymous with equal participation (see Reinholz & Shah, 2018). With that in mind, in episode 1, Alison and Lee each participated

about a proportionate 50% of the time, with Alison talking for slightly longer durations and Lee participating more non-verbally. In comparison, Alison participated less than her allotted one-third and for shorter lengths of time in episode 2, and Alison and Justin contributed about the same non-verbally (i.e., adding to the shared google doc). While Alison did not participate a fair share amount in episode 2, we would not claim that this alone implies inequity occurred. Therefore, to further compare the two episodes, we turn to our status analysis and interpretations from a relational equity perspective.

Table 3. Verbal and Nonverbal Participation Distributions.

Episode 1

Participation	Talk Turns	Duration	Percentage	Proportion	Nonverbal
Alison	50	8.1 min	49.49%	0.99	9
Lee	49	6.6 min	50.51%	1.01	24
Total	**99**	**24 min**	**100%**		

Episode 2

Participation	Talk Turns	Duration	Percentage	Proportion	Nonverbal
Alison	51	5.6 min	28.65%	0.86	7
Abigail	51	7.0 min	28.65%	0.86	11
Justin	76	9.7 min	42.70%	1.28	7
Total	**178**	**24.5 min**	**100%**		

Status and Relational Equity: Episode 1

The mathematical proof activity between Alison and Lee was characterized as less collaborative compared to the group's activity in episode 2 because Lee contributed most of the mathematical ideas used to complete the task and how Alison responded to those ideas had little impact on the mathematical direction of their work (Alzaga Elizondo, 2022). Our analysis suggests that Lee's higher status (relative to Alison) may have provided him with more opportunities to contribute a substantial amount of the mathematical work. However, throughout the episode, Lee regularly made moves to grant Alison opportunities to contribute to the task by inviting her to evaluate the work. We argue that the ways Lee invited Alison to check and evaluate lines of the proof and incorporated her suggestions provided evidence that Alison was trusted and viewed as a peer with expertise, which may have equalized their status differences to some degree. The following exchange exemplifies Alison and Lee's interactions:

Lee: From here can I just jump to like, therefore e_2- therefore phi(e_1) is the identity by definition or is that skipping some steps? (pause)

Alison: Hold on I'm thinking (pause) yeah I think that's good. (reads) "By definition of identity." So phi(e_1) must be the identity in-

Lee: Oh wait, but we're not saying for all H, we have to prove that that's all H.

Alison: the identity- What do you mean all h? Oh for the identity for all h? But we've already proved that there is only one identity. Isn't that in the definition of identity?

Lee: Yeah, but like this is showing the identity for all these, some elements of H until we show- I guess we can use onto right?

Alison: Yeah. (nods affirmatively) Yeah, we probably have to use onto.

Lee granted Alison an opportunity to contribute an evaluation by asking her if he could "just jump" to the conclusion "therefore phi(e_1) is the identity by definition" or if there were missing steps (which there were). Inviting Alison to check and evaluate their work in this way was a typical interaction pattern between the pair. Alison responded by asking for time to think, then accepted Lee's invitation by saying she thinks the proof is "good" (positive evaluation). She continued reading the proof until Lee realized they did not prove that phi(e_1) is the identity "for all" elements in H. Alison offered the idea that the class had "already proved that there is only one identity" and asked if that's in the definition of identity (granting Lee an opportunity to contribute). Lee accepted by first positively evaluating Alison's contribution that there is only one identity ("yeah"), then suggesting that their proof is showing the identity property for "all these, some elements of H" (meaning all the elements in the image of phi, which may only be a subset of H). Lee granted Alison another opportunity to contribute by asking "I guess we can use onto right?" which she accepted and positively evaluated ("yeah"), further agreeing by reiterating they "probably have to use onto."

While Lee (a high status student) contributed more substantial mathematical ideas than Alison (a lower status student), the way he granted her opportunities to evaluate their work before moving forward may have balanced out the potential status differences between them. From a relational equity standpoint, their interactions showed mutual respect for each other's expertise and potentially provided opportunities to access a positive mathematical identity (Esmonde, 2009b).

Status and Relational Equity: Episode 2

In a prior study, this group's mathematical proof activity was characterized as highly collaborative because all students contributed to the mathematical direction of their work (Alzaga Elizondo, 2022). However, their interactions viewed through a status and relational equity lens paints a slightly different picture. Specifically, one interaction pattern between Alison and Justin that emerged was Alison contributing a (valid) direction to make progress on their proof which Justin would positively evaluate only to then immediately question whether her idea was formal enough. The following exchange exemplifies this interaction pattern. Prior to the exchange, Abigail was defending her claim: by the nature of the (Cayley) tables, each entry in the first row and first column are unique (referring to the row and column headers). Justin and Abigail had a back and forth about whether she thought the identity symmetry was different than three rotation symmetries (for an equilateral triangle). Alison entered the conversation by contributing "it's different actions" and suggesting an idea for their proof.

Alison: Yeah it's different actions but I think for the sake of our proof we need to somehow say we're limited to you know (pause) just four, well in this case we don't have- however many symmetries there are. (pause) I might be articulating that wrong. (pause)

Justin: I think the original route we're going down is right, where we have this, I think this is definitely the right way. I'm just trying to make sure that we have the proper way saying that proper, like-

Alison: Yeah, I agree, we have to find the way to set it up before we can just say. (pause)

Justin: Well, (cross talk with Abigail) I just want to make sure there's no holes, I guess-

Abigail: (cross talking) Q is identical to W then

Alison: (responding to Justin) I understand that.

Alison stated they need to argue there are a limited number of symmetries to choose from "for the sake of our proof." She then made a self-doubting comment ("I might be articulating that wrong"), which we interpreted as a low-status indicator (see Adams-Wiggins et al., 2020). Justin

positively evaluated Alison's contribution and her original idea to prove by contradiction ("I think the route we're going down is right") and countered by stating that he wanted to make sure it was formal enough (the "proper way"). Alison agreed with him that they "have to find the way to set it up." After a brief pause, Justin reiterated that he had to "make sure there's no holes" implicitly suggesting that Alison's logic may be faulty. Alison reasserted that she understood his concern ("I understand that").

We interpreted this repeated interaction pattern as potentially increasing rather than balancing status differences between Alison and Justin. Alison (a lower status student) contributed more substantial mathematical ideas than Justin (a high status student), which could have equalized their status. While her contributions were regularly met with initial positive evaluations, they were often immediately followed by repeated questioning from Justin who viewed himself as the expert on the "proper way" of proving (meaning, what is acceptable as a formal proof by the mathematical community). From a relational equity perspective, while their interactions were mostly friendly, Alison was treated as a peer with less expertise in formal proof compared to Justin, which could have potentially limited the opportunity to access a positive mathematical identity.

Discussion

Our results show how small group interactions that were deemed highly collaborative in terms of mathematical proving activity (episode 2) were potentially more *in*equitable compared to small group interactions that were characterized as less collaborative (episode 1). First, participation was distributed differently among the students in each episode, with the focal student, Alison, participating less overall in episode 2 compared to episode 1. Then, from a status and relational equity viewpoint, the quality of interactions also differed between the episodes. In episode 1, while Alison (a lower status student) contributed less substantial mathematical ideas than Lee (higher status), an interaction pattern between them may have balanced their status differences, promoting mutual respect for each other's expertise (attenuating inequity; Shah & Lewis, 2019). Contrastingly, in episode 2, Alison contributed more substantial mathematical ideas than Justin (higher status), yet an interaction pattern between them potentially increased their status differences by maintaining Justin's high status as an expert in formal proofs while implicitly lowering Alison's status (amplifying inequity).

We see two primary implications from this study. First, our work shows that studying small group collaboration in inquiry classrooms solely from a mathematical perspective does not paint a complete picture in terms of how (in)equities might occur. Second, if differences in status are not intentionally disrupted (particularly regarding gender and perceived mathematical ability), women's opportunities to access positive mathematical identities may be limited, which could lead to negative outcomes (e.g., Ernest et al., 2019; Johnson et al., 2020). Therefore, inquiry instructors may need specific training on how to enact group work in ways that mitigate such status differences (Melhuish et al., 2022). A direction for future work could be to adapt research at the K-12 level that has developed and implemented group work principles to reduce status hierarchies (i.e., Complex Instruction, Cohen et al., 1999) for undergraduate inquiry settings.

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