“But You Gotta Put In Work”: The Difference of Groupwork

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We report on an extension of previous findings from a project aimed at improving equitable groupwork in the context of undergraduate proof-based courses through designing and implementing group-worthy tasks. This quantitative study reports on three group-worthy tasks implemented in two topology courses. We investigated how student interactions in small groups reflect participatory equity when relating to perceived academic status along with differences in participation patterns between the two classes. Results are indicative of the tasks having the effect of balancing talk turns regardless of status, disrupting status hierarchy, or neither; similar to what has been reported previously. These findings suggest that implementation of group-worthy tasks is not sufficient to ensure equitable participation in small groups and that normalized groupwork has no impact on the effectiveness of the utilized tasks.

Keywords: Status, Equity, Group-Worthy Tasks, Proof, Groupwork

There is a growing consensus that students in undergraduate math courses can benefit from active learning approaches (Freeman et al., 2014). Evidence shows that active learning techniques can lead to more equitable outcomes (see Laursen et al., 2014; Theobald et al., 2020), but these outcomes are not guaranteed. Research shows that inequities can persist in settings including proof-based courses where groupwork is central to the classroom culture (Brown, 2018; Ernest et al., 2019; Johnson et al., 2020). One possible source for these inequities may be how students are perceiving each other’s status, that is, student assumptions about who is “smarter” or “better” at math influences participation during groupwork (Esmonde, 2009b).

Research has shown that the nature of groupwork tasks themselves can magnify or depress inequitable participation (Shah & Lewis, 2019). The structure and content of the task can create or hinder access to students contributing and engaging mathematically. A well-designed group-worthy task can help manage status-related dynamics that would otherwise worsen participation for some students (Cohen et al., 1999; Esmonde, 2009a). We are far from understanding the complex interactions between status dynamics, group-worthy tasks, and equity in undergraduate courses that incorporate active learning strategies (Adiredja & Andrews-Larson, 2017); this lack of understanding is exacerbated in upper-level math courses. This particular setting shifts students’ center of attention to formal proof, which may consequently trigger status issues (Weber & Melhuish, 2022).

In this report we share an analysis of a subset of data from the STructuring Equitable Participation in Undergraduate Proof (STEP UP) project whose aim is to assist instructors in the design and implementation of group-worthy tasks in proof-based courses. Previously, we shared results from a single class leading to the development of conjectures about how different types of tasks structures may disrupt or amplify status issues (Ellis et al., 2025). In this preliminary report, we provide a comparison between the original results and an analysis of a different topology course implementing the same structures. We sought to answer the following research question: How does groupwork, participation, and status interact in group-worthy tasks in two topology courses? Do we find differences in these participation patterns in a course that regularly engaged students in groupwork and one that was typically lecture?

Background and Framing

We conceptualize equity as when an individual in a group has the requisite resources to support their learning (Shah & Lewis, 2019). On the other hand, inequity is when power dynamics are structured in such a way that halts students' access to these requisite resources. These resources can come in many different mediums such as physical access to a shared workspace like a whiteboard or worksheet, the opportunity to contribute to groupwork whether written or verbal, or accessing another group member's ideas. While equity is multifaceted, for this study we are particularly interested in participatory equity. Participatory equity refers to the fair distribution of opportunities to participate, and the realized participation shared amongst all individuals in a learning situation (Shah & Lewis, 2019).

These inequities in group settings may emerge because of imbalanced power dynamics that are rooted in the difference in status among group members. Status characteristics are defined as a "social ranking that everyone agrees is preferable to have a higher rank rather than a lower one" (Cohen et al., 1999, p. 84). Academic status characteristics, like perceived mathematical ability, have been found to be particularly influential inside the classroom (Cohen & Lotan, 2014). These academic status characteristics can be influenced by much broader status characteristics such as gender, race, and ethnicity (Cohen et al., 1999; Ridgeway, 2018). Evidence points towards students with higher status having more opportunities to contribute and participate (Cohen & Lotan, 2014). Increased opportunities to participate leads to greater learning opportunities (Cohen & Lotan, 2014; Esmonde, 2009a).

In addition to the dynamics between students, the nature of the task can influence the extent that participation can be inequitable in a group setting (Chizhik, 1999, 2001). Borrowing from Complex Instruction, the use of group-worthy tasks has been shown as one possible strategy to balance status and participation (Cohen et al., 1999; Featherstone et al., 2011). A task is considered "group-worthy" if it meets the following criteria: mechanisms are put into place that ensure every individual in the group is learning and engaged, the task affords multiple approaches, and the task endorses a sense of interdependence between group members in a positive fashion (Cohen & Lotan, 2014). These tasks may potentially disrupt imbalanced participation brought on by status differences by affording more opportunities for students to engage in mathematically meaningful ways.

Methods

Participants and Procedures

This study draws data from a larger NSF-supported partnership between mathematics educators and mathematicians aimed at developing and testing group-worthy tasks in proof-based settings. The three task types focused on proof comprehension, proof comparison, and proof construction, respectively. For this paper, we are focused on the set of tasks developed for Topology. The comprehension task (Universal Property of Quotient Spaces Theorem) involved students exploring examples with specific responsibilities and then engaging in discussion of the proof. In the discussion, each group member took turns leading the discussion by asking questions to probe for meaning in the provided proof. The proof construction task involved groups of four students. First, they examined two examples and then constructed a proof of the claim that "The diagonal is closed if and only if X is Hausdorff." Every group member was given a distinct role[1] and the details they needed to finish the assignment. The proof comparison task involved students working in pairs. Each student was given the opportunity to become an expert on a different version of a proof for the focal theorem (homeomorphism preserves connectedness). They then engaged in asking questions, comparing and contrasting, and analyzing the proofs and theorem.

The set of tasks were implemented in an undergraduate introductory topology course in Fall 2023 (Instructor A) and in Fall 2024 (Instructor B). The tasks were spaced throughout the courses. Both were taught at the same large research university in the United States. Instructor A used groupwork throughout their course. Instructor B typically lectured. We note that the proof comparison task was taught by a mathematician on the research team in Fall 2024, as they were substituting for Instructor B. As a result, this task may be influenced by confounding variables related to the change of the instructor.

Data collected included video and audio recordings of the students working in groups on the tasks. The audio was transcribed and cleaned to ensure accuracy and all statements were attributed to the correct student. We also collected data regarding demographics and students' perceived status towards the end of the course. Replicated from Cohen and Lotan (1995), students were provided with a list of students in their class and asked to circle any students perceived as "best at math." An overview of student level data can be found in Table 1.

Table 1. Participant's Student Demographics and Perceived Status

Fall 2023			Fall 2024		
Name (Status)	Gender	Race/Ethnicity	Name (Status)	Gender	Race/Ethnicity
Ariella (low)	Woman*	Hispanic*	Ashley (low)	Woman	White
Lily (low)	Woman	Hispanic	Ben (low)	Man	White
Samantha (low)	Woman*	White*	Carson (low)	Man	White
Zahir (low)	Man*	Hispanic*	Kassandra (low)	Woman	White
Brandon (mid)	Man	White	Olivia (low)	Woman	White
Joe (mid)	Man	Spanish	Aaron (mid)	Man	White
Kieran (mid)	N/A	South Asian	Adrian (mid)	Man*	Hispanic*
Luke (mid)	Man	White	Arturo (mid)	Man	Hispanic
N (mid)	Woman	Mexican	Joseph (mid)	Man	Asian
Pink (mid)	Woman	White, Hispanic	Pepe (mid)	Man*	Hispanic*
Alexis (high)	Woman	White	Alan (high)	Man	White
Julie (high)	Woman	White	Elaine (high)	Nonbinary	White
Kendra (high)	Woman*	Black*	James (high)	Man	White
Xander (high)	Man*	White*	Jane (high)	Nonbinary	White

*Indicates researcher assumption; all other data is student self-identified.

[1] (1) 'Linguist' assisted group with provided key definitions of Hausdorff, diagonal, and closed; (2) 'Zoologist' assisted group's understanding of provided "strange and exotic" topologies: trivial, discrete, finite-complement, and poset topologies; (3) 'Product Manager' assisted group with provided definition of the product topology; (4) 'Summoner' assisted group by recruiting additional resources for the group.

Data Analysis

The transcript data were analyzed to create two ratios related to participatory equity for each student, adapted from Reinholz and Shah (2018). The first ratio is the "Words Spoken Ratio." This ratio compares the total words spoken by a student compared to how many words they would have spoken if each member of the group spoke exactly equally. The "Talk Turn Ratio" was computed similarly, but this time was based on how many times a student spoke. One talk turn reflects a contribution until a new speaker contributes. A ratio greater than one indicates a student is participating more than expected if everyone contributed equally (e.g., a student is expected to contribute a quarter of the time in a group of four) and less than one indicates a student is contributing less than expected. The status survey data was analyzed by grouping students into quartiles based on how many peers identified them as "best at math." Due to little differences in the first two quartiles, they were combined into a single group. This resulted in three categories in which the lower third is classified as "low" status, the middle third as "mid", and the upper third as "high."

We then created a series of graphs with Words Spoken Ratio on the vertical axis and Talk Turn Ratio on the horizontal axis and data points colored by status (see Figure 1 below). We provide a descriptive analysis of these graphs to consider the degree that participation patterns from the Fall 23 implementation were consistent (or not) in the repeated Fall 24 implementation.

Results

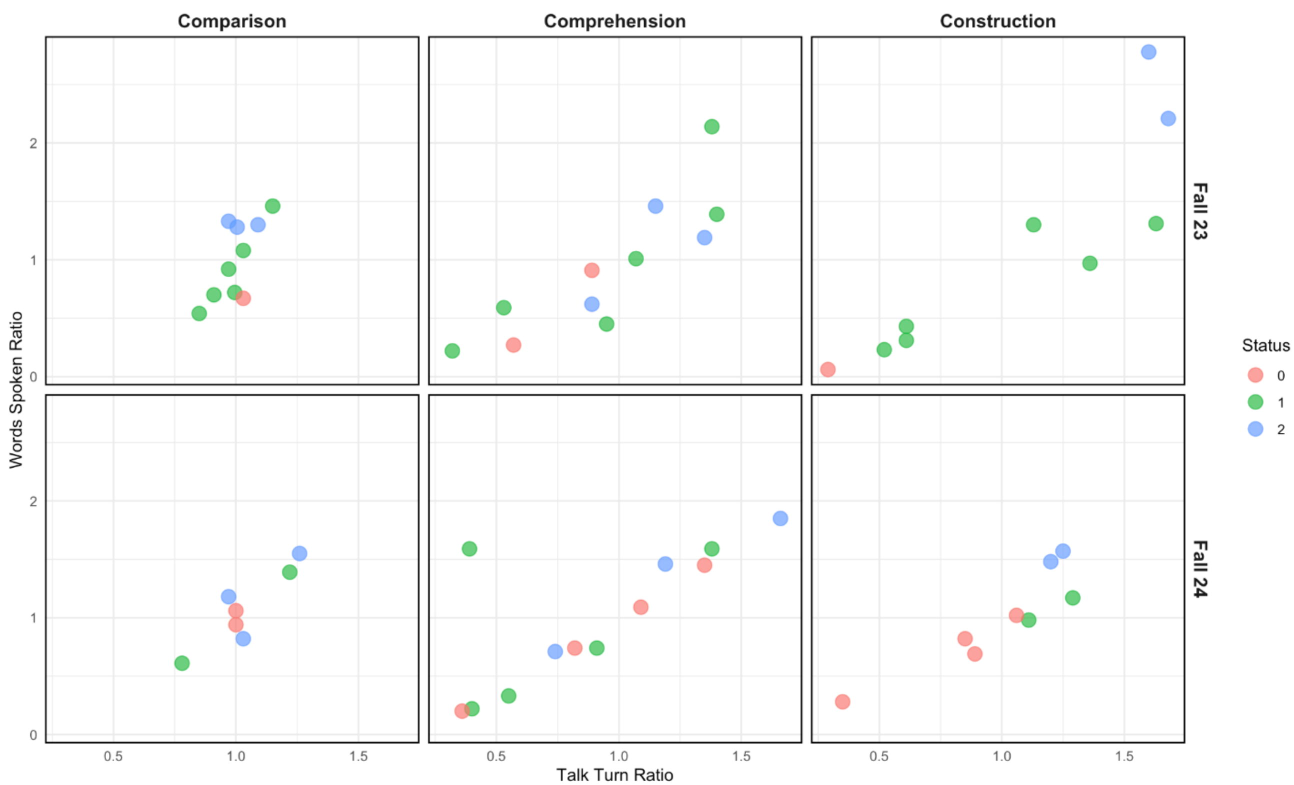

Figure 1. Correlations between Words Spoken Ratios and Talk Turn Ratios parsed by perceived status for each task for both classes.

When looking at these graphs, we want to attend to two features related to participatory equity. First, the closer all the ratios are to 1, the less differences there are in contribution ratios by student. Second, we want to see if there are clear orderings of status vertically and horizontally. There should be no pattern in a task that disrupts status hierarchy's relationship to status. In Figure 1, a task is said to not disrupt status if there is a hierarchical order from low to high status students along the vertical and horizontal coordinates. For example, the construction task in Fall 23 shows no disruption of status since the graph has high status students participating more and trickles down to the low status students.

In Ellis et al. (2025), we discussed the fact that the construction tasks seemed to maintain status hierarchy in participation both in terms of words spoken and number of contributions with the high-status students having the highest ratio of both. For the comprehension task, we noted that the status hierarchy was disrupted across both dimensions. Surprisingly, despite the substantial class differences for Instructor A and B, we see roughly the same outcome in both cases. The comprehension task with discussion prompts seems to be operating as intended. The construction task with group roles does not.

The comparison task was not as clear cut. This was a task with partner exchanges and comparisons across proof approaches. We claimed the implementation in Fall 23 did a good job balancing turns in talk, but not number of words. That is, the higher status students appeared to talk more than lower status students. In the Fall 24 implementation, we see the low status students are clumped right at 1. At this point, we can say that the structure of the task led to even turn taking in both classes, but the relationship with words spoken and status is less clear.

Discussion and Preliminary Nature of This Report

For this preliminary report, we expand upon our findings in the prior report by keeping the tasks and subject area constant with the instructor differing. We wanted to explore the degree to which we would see the same type of pattern across classes despite substantial deviation in the standard pedagogical approach to the class. We were surprised to find the degree to which the patterns in participation seemed to be replicated. This finding leads us to conjecture that the task features themselves may be the dominant variable for status disruption in a task. It seems that exploration and proof discussion prompts might disrupt status more than group roles in this context. This implies that a productive avenue of inquiry could be to test whether these patterns are consistent in other contexts. Additionally, we are interested in which task features contribute to these participation patterns. At this point, we have additional data gathered from abstract algebra, discrete mathematics, and real analysis. If we can demonstrate that it is simple changes to the task features that are disrupting status, then this may lighten the instructor's cognitive load when planning and creating classrooms that are more inclusive for students. Overall, we see promising implications for the teaching and learning of undergraduate proof-based courses.

We welcome feedback on ways we might account for the mathematical nature of student's contributions within our measures for participatory equity. Additionally, the current report was focused solely on participatory equity, but our team would benefit from feedback on how we can measure and quantify relational equity.

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References

Adiredja, A. P., & Andrews-Larson, C. (2017). Taking the sociopolitical turn in postsecondary mathematics education research. *International Journal of Research in Undergraduate Mathematics Education*, *3*(3), 444–465.

Author. (Year 2)

Brown, S. (2018). E-IBL: An exploration of theoretical relationships between equity-oriented instruction and inquiry-based learning. In A. Weinberg & C. Rasmussen, J. Rabin, M, Wawro, & S. Brown (Eds.), *Proceedings of the 21st Annual Conference on Research in Undergraduate Mathematics Education* (pp. 1–15)

Chizhik, A. W. (1999). Can students work together equitably? An analysis of task effects in collaborative group work. *Social Psychology of Education*, *3*, 63–79.

Chizhik, A. W. (2001). Equity and status in group collaboration: Learning through explanations depends on task characteristics. *Social Psychology of Education*, *5*(2), 179–200.

Cohen, E. G., Lotan, R. A., Scarloss, B. A., & Arellano, A. R. (1999). Complex instruction: Equity in cooperative learning classrooms. *Theory into Practice*, *38*(2), 80–86.

Cohen, E. G., & Lotan, R. A. (2014). *Designing groupwork: Strategies for the heterogeneous classroom.* Teachers College Press.

Ellis, B. M., Austin, C. K., Hamilton, C. D., Dvarishkis, B. C., Melhuish, K. M. (2025). Examining inequitable talk and perceived status during group-worthy tasks in an undergraduate topology course. In S. Cook, B. Katz, & K. Melhuish (Eds.), *Proceedings of the 27th Annual Conference on Research in Undergraduate Mathematics Education* (pp. 439–447).

Ernest, J. B., Reinholz, D. L., & Shah, N. (2019). Hidden competence: Women's mathematical participation in public and private classroom spaces. *Educational Studies in Mathematics*, *102*(2), 153–172.

Esmonde, I. (2009a). Ideas and identities: Supporting equity in cooperative mathematics learning. *Review of Educational Research*, *79*(2), 1008–1043.

Esmonde, I. (2009b). Mathematics learning in groups: Analyzing equity in two cooperative activity structures. *The Journal of the Learning Sciences*, *18*(2), 247–284.

Featherstone, H., Crespo, S., Jilk, L. M., Oslund, J. A., Parks, A. N., & Wood, M. B. (2011). *Smarter together! Collaboration and equity in the elementary math classroom*. National Council of Teachers of Mathematics.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, *111*(23), 8410–8415.

Johnson, E., Andrews-Larson, C., Keene, K., Melhuish, K., Keller, R., & Fortune, N. (2020). Inquiry and gender inequity in the undergraduate mathematics classroom. *Journal for Research in Mathematics Education*, *51*(4), 504–516.

Laursen, S. L., Hassi, M. L., Kogan, M., & Weston, T. J. (2014). Benefits for women and men of inquiry-based learning in college mathematics: A multi-institution study. *Journal for Research in Mathematics Education*, *45*(4), 406–418.

Reinholz, D. L., & Shah, N. (2018). Equity analytics: A methodological approach for quantifying participation patterns in mathematics classroom discourse. *Journal for Research in Mathematics Education*, *49*(2), 140-177.

Ridgeway, C. L. (2018). Status construction theory. In P. J. Burke (Ed.), *Contemporary social psychological theories* (p. 301–323). Stanford University Press.

Shah, N., & Lewis, C. M. (2019). Amplifying and attenuating inequity in collaborative learning: Toward an analytical framework. *Cognition and Instruction*, *37*(4), 423–452.

Theobald, E. J., Hill, M. J., Tran, E., Agrawal, S., Arroyo, E. N., Behling, S., ... & Freeman, S. (2020). Active learning narrows achievement gaps for underrepresented students in undergraduate science, technology, engineering, and math. *Proceedings of the National Academy of Sciences*, *117*(12), 6476–6483.

Weber, K., & Melhuish, K. (2022). Can we engage students in authentic mathematical activity while embracing critical pedagogy? A commentary on the tensions between disciplinary activity and critical education. *Canadian Journal of Science, Mathematics and Technology Education*, *22*(2), 305-314.