

Preliminary analyses (WIP): Patterns in student response to a team communication intervention

This work-in-progress paper reports on the assessment of an intervention on team communication and decision making processes to see whether such an intervention is related to improvement in the rating of equity of idea contributions. A hierarchical linear model was fit to teamwork data from 3,721 students in 40 courses. We find that students' reports of equitable idea sharing are actually *lower* after the intervention than before; we hypothesize that the decreased rating might reflect increased student awareness of inequities rather than a true decrease in equitable idea sharing. This pattern held for most gender and racial groups, with the notable exception of non-binary students, who instead reported greater idea equity post-intervention, though we note the small sample size for this group. Finally, we find that decreases in reported idea sharing were largest when students reported the intervention was "highly relevant" to their team yet "not very helpful".

Keywords: teamwork, team communication, equity, voice safety, voice enactment

Introduction and Conceptual Framework

Beginning in students' first year, engineering courses often make use of group projects, sometimes in the context of cornerstone design courses [1]. Such contexts provide opportunities for students to develop professional skills as well as to develop rich understandings of technical content [2]. In such spaces, teams of novice engineers work to negotiate design decisions in the face of uncertainty. Ideally, student teams would evidence a fairly even distribution of talk and ideas [3], but the literature is rife with reports of inequitable contributions in student groups, often with inequitable patterns related to gender and race/ethnicity [4-16].

Because students lack significant engineering judgment and technical expertise, other factors that affect their evaluation of ideas, including the confidence with which ideas are presented, the prototypicality of the presenter (do they "seem like" an engineer?), and the rationale used to defend ideas, are all given outsized weight [9]. Our students are embedded in social systems that assign worth and prototypicality to gender, gender conformity, race, ethnicity, and other identity characteristics. Therefore, the decision-making happening in team environments has the potential to work in opposition to the equity and inclusion we would like to see in our engineering classes. As Pawley [17] notes, our students are embedded in inequitable systems and we need to realize those defaults exist before we can address them. This project reports preliminary analyses from our attempts to understand and mitigate patterns of marginalization on teams using an online team formation, support, and assessment tool called Tandem.

In Tandem, students rate themselves and teammates using a fairly typical peer assessment (usually twice per term) as well as complete a short "team health" check regularly (weekly in many courses)[18]. Students also receive tailored lessons on teamwork topics through Tandem. One such lesson, the focus of this analysis, addresses group communication and voice safety, including messages about turn-taking, active listening, ensuring all perspectives are heard, and respecting the value of others' roles and contributions. The interactive lesson also includes commentary regarding how our multiple identities can affect our participation in group

conversations and our willingness to share ideas. An update introduced in the Fall 2021 semester acknowledges the disruption to teamwork practices caused by the COVID-19 pandemic and encourages reflection on how working remotely affects group communication.

Drawing from situated learning and reflective pedagogy, all lessons ask students to connect ideas to their own experiences and to question their initial assumptions about events [19-22] with the goal of leading students to proposed action and further reflection [23]. The Fall 2021 update to the group communication lesson incorporates additional interactivity via in-lesson questions and tailoring. As part of both the pre-pandemic and current lesson, students are encouraged to reflect in short paragraphs on how their own tendencies in group conversation might be affecting the equal participation of others. Goals of the lesson include helping students identify their patterns of thought and behavior on teams, name and build on their strengths, identify diverse strengths of the team overall and of their teammates, and interpret teammates' behaviors in productive ways. The lesson also aims to help students have difficult conversations and give useful feedback to peers.

Voice safety and voice enactment.

Farh & Chen [24] describe the concept of voice as a form of speaking up within an organization or group, with suggestions for improvement, concerns, or opinions. Voice safety is strongly related to psychological safety [25] but focuses specifically on the sense that one can speak up without undue risk to self. Voice enactment, in contrast, is implementation of voiced suggestions.

Voice safety and voice enactment are non-neutral processes embedded in social systems, and student experiences with voice in student teams therefore reproduce racism, sexism, and other implicit and explicit biases. These systems impact how voice takes place and is interpreted, as well as what voice is considered persuasive or authoritative, and what voice is acted upon [26-28]. A number of studies have found significant imbalances in group communication in small teams of STEM learners, with patterns of who challenges and who is challenged, though most of these studies focus on the amount of voice rather than on perceived voice safety or voice enactment [29-32]. More balanced group interactions are a desirable outcome, both for reasons of justice and because voice equity and equitable voice enactment are related to effective teamwork [33].

Gender, voice in teams, and teamwork outcomes.

Research in engineering groups has explored gender differences in voice, finding differences in patterns of speaking up between men and women in first year engineering team design negotiations [30] as well as groups of students negotiating STEM projects in other contexts [7, 31, 34-39]. As has been highlighted elsewhere [26, 40], aspects of engineering discourse are coded White, masculine, and colonial. It is important that we recognize that patterns of participation related to race and gender may be related to mismatches between students' natural styles and the dominant discourse; attempts to make teamwork more equitable and inclusive must make the arbitrary dominance of one discourse visible as part of making engineering teamwork more inclusive [26, 41].

Critically, voice experiences, including the role one plays in group ideation and decision making, have important implications for learning-related outcomes, such as course performance [42], as well as for affective outcomes, such as sense of belonging [43] and social capital [44].

Data Analysis

This work-in-progress paper reports our preliminary analyses surrounding students' experience with the communication lesson and changes in reported equity of idea sharing, using quantitative data collected within Tandem. The tool is currently employed at a large public research-intensive university, primarily in courses within the College of Engineering and the College of Business; in Fall 2021 (the latest complete-term data included in this data set), for example, Tandem was in eight courses serving 1,559 students in total. Including all higher education teamwork data in the set rather than restricting the data set to engineering classes did not change the model, so all data were included.

For this analysis, we initially investigated an item from the frequent team health forms, which we have called *idea equity*. Students respond on a 9-pt scale, where a 9 indicates "all team members contribute creative solutions to our project, about equally" and a 1 indicates "most creative solutions come from one or two team members." We analyzed student responses to the team checks conducted before and after students saw the lesson on communication and idea equity. Not all students saw the lesson at the same time of the semester. It is important to note that low scores in response to this item on a team check can "trigger" the assignment of this lesson in some implementations of Tandem, a function dependent upon instructor preference. However, this imbalance in measurement schedule is controlled for via student-level random time slopes.

We also investigated student-provided feedback on the lesson itself. At the end of each lesson, students are asked to help improve Tandem by selecting (on a 5-pt scale) the relevance and helpfulness of the lesson.

Findings

A series of hierarchical linear models were estimated to predict student and course variation in 5,947 team equity ratings across 3,721 students nested within 40 courses (where a course was defined as the unique pairing of a course and term). We started with an empty model and tested for random effects of students and courses via *chi-square deviance tests*, which compare the fit of models before and after adding random effects. Both random effects were significant ($p < .001$), indicating significant variation in team equity ratings between students and between courses. Next, we added time-, student-, and course-level predictors to explain this variation, which were tested with *Wald tests*. Effect sizes were computed as *pseudo-R²*, which describe the proportion of random effect variance reduced after adding predictors. Following, we highlight a few especially interesting findings.

For most students, ratings of team equity decrease following the lesson.

The first predictor added to the model was the pretest/posttest effect of the communication lesson (i.e., equity ratings before and after the lesson). The effect of the lesson on rating of idea equity was small but significant, $t(2225) = 4.19$, $p < .001$, *pseudo-R²* = 0.06%, such that equity ratings *decreased* from pretest ($M = 6.73$, $SE = .031$) to posttest ($M = 6.63$, $SE = .035$). This decrease is

seen across demographic groups and across courses, with a few notable exceptions (described in the next section).

One interpretation of this finding could be that the lesson on voice has the opposite effect from what is intended, exacerbating differences in who speaks up and whose ideas are listened to in groups. A second, and perhaps more plausible, interpretation is that we instead have helped students to identify inequitable patterns in their teams that they might not have noticed without the lesson. This interpretation is consistent with patterns seen in other attempts to improve organizational culture, such as trainings in sexual harassment, which sometimes have the effect of increasing reported harassment due to increasing awareness of problematic patterns [45].

Non-binary students rate idea equity higher following the lesson.

The overall decrease held for most groups when data was considered separately by gender (women, men, non-binary), $F(2, 1256) = .27, p = .76$, race/ethnicity (White, Asian, Black, Other, Self-described/Undisclosed), $F(4, 1064) = 1.14, p = .33$, and course (Engineering, Business, other), $F(2, 2292) = 1.13, p = .32$. We note the limitation of this analysis, including that multiple groups (race/ethnicity categories as well as non-engineering and non-business disciplines) are lumped together as “Other” for analyses based on low numbers rather than on some theoretical reason that these groups might have similar experiences. We also considered gender and race as two separate analyses. We return to this issue in our discussion. However, breaking down results by group as we are able has the affordance of allowing us to begin to explore patterns of marginalization that might not otherwise be visible to instructors or researchers.

While the pattern of lower ratings post-lesson held for most students, an exception to this trend was apparent in respondents of non-binary gender identity, a group often omitted from quantitative analyses for lack of reliable institutional data and/or small numbers of participants. As shown in Figure 1, non-binary participants showed a substantial increase in ratings of idea equity post-lesson. The effect was not statistically significant, $t(1316) = -.032, p = .75, pseudo-R^2 = 8.06\%$, however, due to the small sample ($n = 20$) and large variability ($b = -.37, SE = 1.16$). Nevertheless, we hope to further investigate this finding to better understand this historically marginalized group’s experiences with teamwork, voice and idea equity, and this lesson in particular.

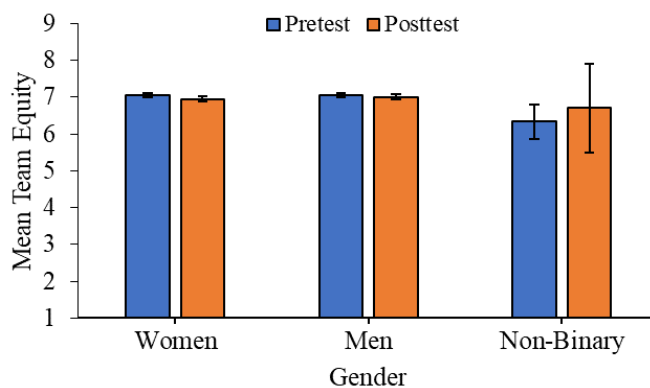


Figure 1. Mean team equity at pre- and post-test by gender. Error bars represent +/- 1 standard error.

One (aspirational) interpretation of the pattern is that students who are more likely to be marginalized on teams already are aware of the patterns of marginalization explained in the lesson, so the “awareness raising” effect of the lesson is minimal, and their ratings only reflect improvements in group processes.

Role of relevance and helpfulness of the lesson.

Finally, we examined the effect of student-level ratings of the relevance and helpfulness of the lesson on change in equity ratings from pre- to post-lesson. There were significant main effects of relevance and helpfulness such that equity ratings tended to decrease with relevance ($b = -.30$, $SE = .09$, $p = .001$) and helpfulness ($b = -.44$, $SE = .09$, $p < .001$). Moreover, relevance and helpfulness interacted significantly ($b = .16$, $SE = .04$, $p < .001$) such that the decrease in equity with relevance was generally lessened the more helpful the lesson was. Collectively, these effects explain 16.1% of the intercept variance between students and 3.7% of the pre-/post-lesson slope variance between students.

Figure 2 shows that team equity ratings generally decreased following the lesson (all values of Y are greater than zero). This decrease was most apparent when students rated the lesson as not helpful (helpfulness=1), but extremely relevant (relevance=5). Conversely, the decrease was least apparent when students rated the lesson as both extremely helpful and relevant.

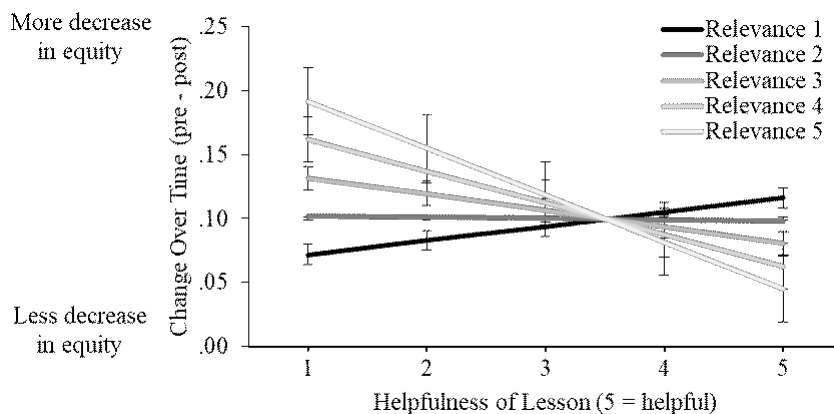


Figure 2. Mean change in equity ratings (pre-lesson equity minus post-lesson equity) as a function of relevance and helpfulness ratings. Equity drops in all cases (all values here are larger than zero on Y-axis) but is related to both student rating of helpfulness of the lesson (X-axis) and student rating of relevance of the lesson (darkness of line).

If the lesson is addressing idea equity topics that are not related to team struggles, or at least that students *perceive* as unrelated to team struggles, the helpfulness of the lesson is relatively unimportant (fairly flat slopes with relevance ratings of 1 or 2). In contrast, when the lesson is rated as highly relevant (relevance rating of 5), we see more impactful differences, with students rating the lesson as highly relevant but unhelpful having a much larger decrease in ratings post-lesson than students seeing the lesson as highly relevant but also highly helpful.

Discussion and Future Work

As noted initially, because low scores on “idea equity” can trigger this lesson for at least a subset of the teams in our dataset, we expected to find an increase in ratings following the lesson, due

purely to regression to the mean. Instead, we find a decrease for most student groups, which we interpret as indicating that students learn about systemic issues in the lesson and are then more sensitive to such issues when they next rate their team. This interpretation, of course, is only a hypothesis, and we need to follow this finding further.

The finding that non-binary students' experience with the lesson looks so different from men's and women's is important, though we note the limitation of small n (20) means the finding is not significant. Still, we hope to conduct this analysis again in a few semesters after the collection of more data. Non-binary students are a subgroup of engineering students not often captured well in quantitative analyses. Additionally, interviews will help us to better understand their experiences.

As this is a work-in-progress report, our "future work" plans are significant and ongoing. We can see that a subset of students find the lesson on voice and voice safety very relevant but not helpful; we intend to conduct interviews to better understand these perspectives. The issues their teams are encountering might be different from those discussed in the lesson, or perhaps they see their issues reflected in the lesson but do not find relatable suggestions to implement.

Further, the numbers reported here look only at two time points, but the data set includes team-level ratings of idea equity throughout the semester. We will investigate whether ratings rebound if we look out to further weeks and whether the rate of decrease changes. Because not all students see this lesson, and students may see this lesson at different points in the semester (again, depending on how the instructor has implemented Tandem), we might be able to construct comparison groups to see whether we can better understand the trajectory of idea equity in a team over the semester separate from any effect of the lesson.

We also aim to investigate race/ethnicity and gender as they are actually experienced, both by considering intersectional identities and by considering team make-up. The current dataset, while large by some standards, still required "boxing" of groups into bins for analysis. Any attempt to quantify lived experiences by group already simplifies experiences of identity, but the distribution of students in our dataset also means that we grouped multiple race/ethnicity groups into "other" for purposes of analysis, clearly a limitation.

Tandem is envisioned as a tool for formatively assessing teams, and our goal is that it makes use of critical quantitative processes [e.g., 44-47]. To have any hope of employing these analyses responsibly, we need to continually examine what we mean by "equity" as well as to call out our own shortcomings in our analytical processes. Our goal is for Tandem to help identify and disrupt systemic marginalization, and we need to be careful that we do not perpetuate it instead. Because of the large and increasing number of student teams using Tandem (including the likely scenario of expansion to additional universities in the near-term), we see the opportunity to examine intersectional experiences through quantitative methods and through the lens of various operationalizations of equity.

Finally, we hope to develop Tandem to better serve students and faculty. We aim to develop a "playbook" of templates for students with phrases for difficult conversations, helping students to identify and surface issues. We also aim to develop instructor-facing content to help instructors recognize patterns of marginalization on teams that sometimes are less obvious.

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