Work in Progress: Toward an Analytical Framework for Inclusive and Marginalizing Talk Moves in Engineering Student Homework Groups

Ms. Tyrine Jamella Pangan, Tufts University

Tyrine Jamella Pangan is a STEM Education PhD student at Tufts University and a Graduate Research Assistant at the Tufts University Center for Engineering Education and Outreach (CEEO). She is interested in integrating social and emotional learning (SEL) in engineering, specifically within the elementary school context.

Dr. Kristen B Wendell, Tufts University

Dr. Kristen Wendell is Associate Professor in the department of Mechanical Engineering at Tufts University, where she also holds a secondary appointment in the department of Education. She leads a research group at the Center for Engineering Education and Outreach (CEEO) and is a member of the Tufts Institute for Research on Learning and Instruction (IRLI). Her research focuses on characterizing and supporting sophisticated disciplinary discourse practices during engineering learning experiences in undergraduate courses, K-8 classrooms, and teacher education contexts. Wendell previously taught at the University of Massachusetts Boston, and she holds a PhD in science education from Tufts and BS and MS degrees in mechanical and aerospace engineering from Princeton and MIT. More information can be found on the Wendell lab website: https://sites.google.com/view/wendell-lab/home.

Work in Progress: Toward an Analytical Framework for Inclusive and Marginalizing Talk Moves in Engineering Student Homework Groups

Introduction

The purpose of this work-in-progress paper is to characterize how different kinds of student discourse moves serve to influence the level of inclusion or marginalization in student teamwork at a moment-to-moment grain size. Teamwork is a crucial component in engineering education due to the collaborative nature of the field (Cross & Cross, 1996). Although students are expected to work together, how they interact with each other can marginalize or center the role of certain team members. Brief instances in which one student in a group subtly – and often unknowingly - encourages or discourages the participation of other students can add up over time to heavily influence a student's sense of belonging in engineering, thereby influencing their opportunities to learn (Secules et al., 2018). The overall goal of our research program is to characterize the relationship between student-to-student interaction patterns and individual students' opportunities to participate in small-group classwork and homework activities. In this study, we focus on discourse moves in a small-group homework activity in a thermal fluids engineering science class.

Background and Literature Review

Undergraduate engineering students are often assigned classwork, homework, and projects that require them to work in teams or small groups with other students. In engineering design courses, team projects are particularly ubiquitous, in part because collaboration is considered central to professional engineering design practice and an essential skill for future design engineers to learn (Lingard & Barkataki, 2011). However, a substantial body of literature on undergraduate student teams in engineering design classes shows that effective collaborative practices are not automatic for students, and there is a wide range in student competencies at establishing effective communication processes, psychological safety, and balanced workloads on their design teams (Tonso, 2006). While the opportunity to collaborate can improve the output of an engineering design team (Sauder & Jin, 2016), it can also detract from the learning experiences of individual students (Henderson, 2020). Students from groups that have historically been non-dominant in engineering, such as students of color and women, are particularly at risk for being relegated to managerial or organizational roles on design teams and therefore having their access to technical learning opportunities curtailed by other team members (Meadows & Sekaquaptewa, 2013).

Many scholars in the engineering education research community are working to tackle this challenge of making team design projects an inclusive, positive learning experience for students from all backgrounds (e.g., Masta et al., 2023). Fewer studies focus on supports for inclusive

student group work in engineering *science* courses, where assignments are typically oriented not towards building a system collaboratively but toward producing a mathematical model of an engineered system. Researchers are just beginning to identify what inclusive group work looks like when students are working together on modeling and analysis problems rather than design projects (Chinandon & Koretsky, 2023). We seek to contribute to this research space.

Conceptual Framework

Our research is grounded in the perspective that learning engineering involves becoming a more central, proficient participant in one or more engineering communities of practice (Lave & Wenger, 1991). Therefore, engineering learning processes can be substantially supported or hindered by instances when a fellow engineering student makes a move to better include or further exclude a student from a classwork or homework group.

For this study, our conceptions of marginalization and inclusion are based on prior work in education and psychology. To define *marginalization* in students' engineering homework discussions, we drew upon the work of Hall et al. (1994), which defines marginalization as "the process through which persons are peripheralized on the basis of their identities, associations, experiences, and environments" (p. 25). However, we take a broad view of the "associations" and "experiences" that can lead one to be pushed toward the margins of a group; a student's ideas about how to solve an engineering problem could be the "associations" that cue marginalizing behaviors by their peers. At the same time, we acknowledge that marginalization can also occur due to more clearly offensive behaviors, including racial microaggressions (Sue et al., 2007), which have nothing to do with students' engineering ideas. To conceptualize *inclusion* in engineering homework talk, we began with the way Kittleson and Southerland (2004) defined engineering student *collaboration*: "an active give-and-take of ideas between persons rather than one person's passively learning from the other" (p. 268). Inclusive talk has the effect of bringing other students into this collaboration. For examples of classroom discourse that successfully draws students into collaboration with each other, we looked at research in K-12 education on cooperative group work (Cohen & Lotan, 2014), science talk moves (Michaels & O'Connor, 2015), inclusive engineering outreach (Miel et al., 2021), and mathematics micro-identities (Wood, 2013).

Research Question

Building on this previous work looking for evidence of inclusion and marginalization in student discourse, in this research study we are guided by the question: *In what ways does engineering student talk communicate inclusion or exclusion of other students' ideas?*

Participants

The study took place in a sequence of two undergraduate thermal fluid courses at a private, R1 university in the northeastern United States. For five homework assignments across the two courses, students formed two- to five-person teams to solve instructor-developed open-ended problems. The homework assignments were required, but participation in the recording was voluntary and was not rewarded with extra credit. Demographic information was not collected from participants, but the population of the university's engineering school includes around 45% as female-identifying and 54% as male-identifying, and the course demographics roughly matched the school. The project was approved by the university's human subjects review board. Overall, 67 students were enrolled in the course sequence. Students were not asked to complete any additional assignments for the study. Participation in the study consisted of consenting (via signed consent form) to have team homework sessions audio-recorded. The course instructors were not made aware of which students consented and which did not. Consent to participate was granted by 43 students, 64% of course enrollment.

Table 1. Groups and Participants

Group Number*	**Number of Students**
1	4
2	2
3	4
4	4
5	4
6	4
7	5
8	5
9	4
10	4
11	6
12	5
13	4
14	3
15	4
16	3

***** Several students participated in numerous groups. For example, Student 'A' was part of groups 3, 8, and 10.

Study Context

Instructors used results from a survey students took before the start of each course to personalize problems based on students' personal backgrounds and interests. One student was designated in each group as the 'lead student' whose survey results helped instructors develop open-ended problems that were relevant to the students' personal lives. Not all problems were personalized, but all problems were intentionally open-ended so that students could experience the types of ill-structured scenarios they will encounter as professional mechanical engineers. For each of the five homework assignments that included these open-ended probems, two problems were assigned, and students were asked to spend one hour on both problems. Students completed the homework outside of class in a location of their choosing (e.g., a classroom, residence hall study space, lounge, etc.).

Data Collection

The full data set consists of 32 student discussion transcripts from the undergraduate thermal fluids homework sessions, with each session lasting for a duration of roughly 30 minutes, ranging from 200-1000 spoken sentences across two to fiveall students in the group. Data was collected via audio recording devices sent home with students (during the pandemic). Original audio was only used to transcribe dialogue and anonymize participants.

Data Analysis

For this work-in-progress study, we are working with a subset of six discussion transcripts. We used discourse analysis techniques (Brown et al., 1983) to dissect the transcripts for moves that had the potential to include or marginalize other students. Our goal was to produce a codebook defining and exemplifying categories of inclusive and marginalizing student talk in engineering science small-group discussions. The first step in our data analysis process was to review literature, mentioned above, on issues of inclusion in student groups; this literature provided a set of "sensitizing concepts" for our analysis. Then, working at first with two transcripts, both researchers independently tagged turns of talk that we interpreted as "marginalizing" or "inclusive," then used constant comparison (Glaser, 1965; Boeje, 2002) to create a codebook with definitions, examples, and non-examples of five categories – two for marginalizing moves and three for inclusive moves. Next, working with six transcripts, we independently coded, compared results, and refined the codebook in an iterative fashion, working towards adequate interrater reliability between our applications of the categories. After three rounds of codebook iteration, the exact match between the two raters' codes is 73% and the Cohen's Kappa score is 0.46, indicating moderate agreement (Blackman, N. J. & Koval, J. J., 2000). For the results reported in this work-in-progress paper, the raters came to consensus on all the turns of talk where our codes disagreed. For future work, we plan to continue to refine the codebook until we reach a Cohen's Kappa score of 0.8. The final codebook will then be applied to the remaining 26 transcripts.

Findings

Our analysis allowed us to characterize two kinds of marginalizing moves (*interrupting* and *taking up disproportionate space*) and three kinds of inclusive moves *(encouraging sharing*, *acknowledging peer ideas*, and *valuing peer ideas)*. Below, Table 2 shows the relative frequencies of each kind of move in 6 different group homework sessions. We then define and give an example and non-example of each kind of move.

Table 2. Proportion of engineering student homework discussion coded as an inclusive or marginalizing talk move

Type of Inclusive or Marginalizing Talk	Turns of Talk in Category (% of Total Turns of Talk)
Encouraging sharing	87 (6.15%)
Acknowledging peer ideas	167 (11.81%)
Valuing peer ideas	47 (3.32%)
Interrupting	140 (9.90%)
Taking up disproportionate space	6 (0.42%)
*Not coded as either inclusive or marginalizing	967 (68.39%)

Inclusive Moves

(1) ***Encouraging sharing.*** One way students increased the participation of other students was by *encouraging sharing*, which we define as proactively putting out an open-ended call for others' input. To be coded as an *encouraging sharing* move, a student's utterance had to go beyond simply asking for affirmation or refutation of an idea they themselves had stated. For example, when working on a problem about a firefighting hose, S made an *encouraging sharing* move when they put out a call for a peer's idea:

> **S**: Yeah. What do you think Abe? What should we do?

(2) ***Acknowledging peer ideas.*** A second way students conveyed inclusion of other students' ideas was to acknowledge those ideas in a follow-up question/thought or to reference that idea through repetition, elaboration, or a challenge/counter. For example, when working on a problem determining the specific heats of a gas using a resistance heater, participant M acknowledges participant J's idea by elaborating on how they can measure temperature:

> **J:** We can measure the temperature
> **M**: We could – yeah we could just have a sensor – we can have a box with a constant uh a constant volume. And then we have work in as a resistance heater. Um. Then we measure – we have a thermometer

(3) ***Valuing peer ideas.*** A third way students conveyed inclusion of other students' ideas was to show a positive reaction to an idea that someone else shares. Valuing peer ideas goes beyond a one or two-word statement of agreement. To be coded as *valuing peer ideas*, a student's response had to go beyond one or two-word agreements like "yeah" and "ok". For example, when working on a problem to determine the flowrate of a water hose, B made a *valuing peer ideas* move when they demonstrated a positive reaction to A's question/assumption:

> **A:** Also the fact that it says it should work well, does that mean that it shouldn't be hitting the ground at nine meters?
> **B:** Yeah, that seems like a fair assumption

Marginalizing Moves

(4) ***Interrupting.*** Although an interruption to someone's speech does not always result in that person's exclusion from the conversation, when a student begins voicing a new idea or question while a first student is actively speaking, the potential for the first student to feel marginalized or unrecognized always exists. Therefore, we included *interrupting* as one category within marginalizing moves that occurred in the homework conversations. We counted a turn of talk as *interrupting* if it began before the current speaker finished their sentence or question or before they paused their speech. For example, when working on a problem to design a tripod for a large hose, P interrupts S before S is able to articulate their idea:

> **A:** Tripod. That might be good.
> **S:** Yeah that was like – we could –
> **P:** Yeah. I mean do you want us to do that?

(5) ***Taking up disproportionate space.*** The second kind of marginalizing move that appeared in the homework conversations was *taking up disproportionate space*, which we defined as a student dominating the conversation without contributing to the collective sense-making of the group and without seeking input or refinement of their ideas from peers. This kind of move often transpired when a student took multiple turns of talk, consecutively, to provide great detail on an idea outside the scope of the homework problem. In the following example, P and his peers are figuring out the rate of water flow from a fire house. P makes a detour into projectile motion concepts to help others understand his thinking about the horizontal velocity. However, to do so, he takes five turns of talk, pausing only for one-word input from his peers in between those turns. His intent was not to disenfranchise his peers, but during this minute of their discussion, no one else was able to contribute to the group's collective sense-making.

> **P**: Ok. I feel like we're talking about the same thing but differently. So what I'm saying is like if we had like - I don't maybe like a table and we had a ball with some velocity, right?
> **S**: Mhm.

P: And the ball is basically rolling off the table. Initially, like at this point when it's leaving - when it's about to leave the the table, right when it's about to fall off, if this is the ground.

C: Yeah.

P: At this point, the only velocity the ball will have is x velocity. It cannot have a y velocity because it's been coming from a vertical position, so it will only have v x. But as it starts going down like this if it's following a projectile motion, right, so this is maybe our 9 meters, right here. As it starts going down - and these other points, that way it does have an x and a y velocity.

A: Mhm.

P: An x and a y velocity all throughout, x and y velocity, right. But another fact about projectiles is at any point during the projectile of an object, its x velocity will always be the same as its leaving x velocity.

A: Right.

P: That's the other thing about projectiles. So whatever velocity it starts with here, it will continue with it throughout the projectile motion, all the way til it falls.

Discussion

Although there were instances of marginalizing moves in the six engineering homework conversations that we have analyzed, there is no evidence that these marginalizing moves were intentionally made to marginalize or exclude. Rather, student interruptions or sequences that took up disproportionate space were more often made with the intent of helping the group, to explain something, to make progress, or to offer extended ideas. In the moment, the students being interrupted or excluded from a long sequence of talk turns did not express awareness that another student's behavior had the potential to move them to the edges of the discussion. It is also important to note that we did not identify any marginalizing moves that consisted of clear microaggressions. Compared with cases of identity-based microaggressions described in the literature, the marginalization in these homework discussions was more subtle and centered more on what students were implicitly communicating about the value of each other's ideas. Given this paper is a work-in-progress, the authors wish to further explore two additional research questions: (1) *Are there patterns of inclusive moves that cue a minimally participating student to share an idea? (2) Do conversations with more equal participation across students have different talk move patterns than less equal conversations?*

References

Blackman, N. J., & Koval, J. J. (2000). Interval estimation for Cohen's kappa as a measure of agreement. *Statistics in Medicine*, *19*(5), 723–741. https://onlinelibrary.wiley.com/doi/10.1002/(SICI)1097-0258(20000315)19:5%3C723::AID-SIM379%3E3.0.CO;2-A

Brown, G., & Yule, G. (1983). *Discourse analysis*. Cambridge University Press. https://doi.org/10.1017/CBO9780511805226

Boeije, H. (2002). A purposeful approach to the constant comparative method in the analysis of qualitative interviews. *Quality & Quantity*, *36*. 391 – 409. https://doi.org/10.1023/A:1020909529486

Chindanon, K., & Koretsky, M. (2023). Group practice in engineering: Productive interactions during a realistic, open-ended task. *Studies in Engineering Education*, *4*(2), 144-175. https://doi.org/10.21061/see.112

Cohen, E. G., & Lotan, R. A. (2014). Designing groupwork: Strategies for the heterogeneous classroom (3rd ed.). Teachers College Press.

Cross, N., & Cross, A. C. (1996). Winning by design: The methods of Gordon Murray, racing car designer. *Design Studies*, *17*(1), 91–107. https://doi.org/10.1016/0142-694X(95)00027-O

Glaser, B. G. (1965). The constant comparative method of qualitative analysis. *Social Problems, 12(*4), 436 – 445. https://doi.org/10.2307/798843

Hall, J. M. (1999). Marginalization revisited: Critical, postmodern, and liberation perspectives. *Advances in Nursing Science*, *22*(2), 88 – 102. https://doi.org/10.1097/00012272-199912000-00009

Henderson, T. S. (2021). *Eurocentrism in engineering: Consequences for teamwork in engineering design* [Doctoral dissertation, University of Michigan]. University of Michigan Library. https://dx.doi.org/10.7302/2865

Kittleson, J. M., & Southerland, S. A. (2004). The role of discourse in group knowledge construction: A case study of engineering students. *Journal of Research in Science Teaching, 41*(3), 267–293. https://doi.org/10.1002/tea.20003

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press. https://doi.org/10.1017/CBO9780511815355

Lingard, R., & Barkataki, S. (2011, October). Teaching teamwork in engineering and computer science. 2011 Institute of Electrical and Electronics Engineers (IEEE) Frontiers in Education Conference, Rapid City, South Dakota. https://doi.org/10.1109/FIE.2011.6143000

Masta, S., Grant, J., Margherio, C., Dickerson, D., Ohland, M. W., & Pawley, A. L. (2023). On faculty responsibility for increasing students' sense of support in the classroom: Lessons from I-MATTER about Black and Brown students. ASEE Annual Conference & Exposition, Baltimore, Maryland. https://peer.asee.org/43758

Meadows, L. A., & Sekaquaptewa, D. (2013, June). The influence of gender stereotypes on role adoption in student teams. ASEE Annual Conference & Exposition, Atlanta, Georgia. https://peer.asee.org/22602

Melsky, K., Stuopis, I., Wendell, K., & Kemmerling, E. C. (2023). Personalized problems and student discourse in thermal fluid transport courses. *International Journal of Mechanical Engineering Education*, *0*(0). https://doi.org/10.1177/03064190231195609

Michaels, S., & O'Connor, C. (2015). Conceptualizing talk moves as tools: Professional development approaches for academically productive discussion. *Socializing intelligence through talk and dialogue*, 347 – 362. https://doi.org/10.3102/978-0-935302-43-1_27

Miel, K., Swanson, R. D., Portsmore, M., Paul, K. M., Moison, E. A., Kim, J., & Maltese, A. V. (2023). Characterizing engineering outreach educators' talk moves: An exploratory framework. *Journal of Engineering Education*, *112*(2), 337 – 364. https://doi.org/10.1002/jee.20514

Secules, S., Gupta, A., Elby, A., & Turpen, C. (2018). Zooming out from the struggling individual student: An account of the cultural construction of engineering ability in an undergraduate programming class. *Journal of Engineering Education*, *107*(1), 56 – 86. https://doi.org/10.1002/jee.20191

Singh, Y. V. (2021, August 18). Classification using pre-trained Bert Model (transfer learning). *Medium*. https://medium.com/@yashvardhanvs/classification-using-pre-trained-bert-model-transfer-learning-2d50f404ed4c

Sue, D. W., Capodilup, M., Torino, G. C., Bucceri, J. M., Holder, A. M. B., Nadal, K. L., & Esquilin, M. (2007). Racial microaggressions in everyday life: Implications for clinical practice. American Psychologist, 62(4), 271–286. https://doi.org/10.1037/0003-066X.62.4.271

Sauder J, & Jin Y. (2016). A qualitative study of collaborative stimulation in group design thinking. *Design Science*, *2(*4), 1 – 25. https://doi.org/10.1017/dsj.2016.1

Swenson, J., & Wendell, K. (2016, October 12–15). A case study of students' engagement in a control systems homework problem. 2016 Institute of Electrical and Electronics Engineers (IEEE) Frontiers in Education Conference, Erie, Pennsylvania. https://doi.org/10.1109/FIE.2016.7757655REFR

Tonso, K. L. (2006). Teams that work: Campus culture, engineer identity, and social interactions. *Journal of Engineering Education*, *95*(1). https://doi.org/10.1002/j.2168-9830.2006.tb00875.x

Wood, M. B. (2013). Mathematical micro-identities: Moment-to-moment positioning and learning in a fourth-grade classroom. *Journal for Research in Mathematics Education*, *44*(5), 775 – 808. https://doi.org/10.5951/jresematheduc.44.5.0775