WIP: Using engineering discourse instruction to promote equitable and inclusive group work

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Work in Progress: Using engineering discourse instruction to promote equitable and inclusive group work

Abstract

This work in progress paper describes a two-session instructional module on equitable engineering talk, which explicitly addressed the role of discourse in engineering practice as well as the importance of inclusive and equitable discourse in a first-year engineering course. In the module, students audio recorded themselves as they worked in small groups to plan an initial solution to an engineering design problem. After listening to their recorded discourse, they participated in scaffolded reflection about engineering group work interactions. The module provided students with the opportunity to assess and evaluate their own discussions for equity and inclusion as well as those of experienced engineers. Data were obtained in the form of student written work and post-intervention in-class video of student group interactions.

Introduction

Group work is a fundamental component of undergraduate engineering programs and offers students the chance to practice student-to-student interactions within an engineering team. Not only does the engineering studies literature emphasize that team interactions are central to professional engineering practice [1], [2], but also the engineering and science education literature has emphasized that group discourse can create an environment that allows for knowledge construction [3]–[5]. However, when negotiating these interactions, implicit bias and structural inequities can result in the marginalization of certain voices, including women and underrepresented minorities [6], [7]. Providing instruction to students on specific engineering discourse practices may support productive, equitable and inclusive group work.

Background

All first-year engineering students at a research university in the northeastern United States are required to take an Applications in Engineering course in their first semester. Each engineering department offers one or more sections of the course with each section having a different focus on a particular sub-discipline of engineering. While the section topics vary widely, each section is asked to incorporate group work, ethics, and engineering design into the course curriculum.

The "Simple Robotics" section of the Applications in Engineering course has been offered each year for over five years. This section is heavily project-based and requires group work throughout the semester. Mid-way through the fall 2019 semester, the thirty students in the "Simple Robotics" section participated in a two-day instructional module on equitable engineering talk. This module explicitly addressed the role of discourse in engineering practice as well as the importance of inclusive and equitable discourse.

The equitable engineering talk module took place over two 75-minute class sessions and two homework assignments. Before the first session, students were asked to spend 20 minutes individually generating ideas to solve the "Campus Sprinkler Design" problem, which requested a redesign of the campus sprinkler system for efficiency and even distribution of water. This

problem was adapted from a database of conceptual design problems developed to elicit mathematical modeling practices and critical thinking from engineering students [8]. It did not include physical prototyping. During the first in-class session, students worked in small groups on the sprinkler design problem and audio recorded their discussions. They then began to view and discuss video of the same problem being discussed by more advanced engineers –young engineering professionals who had been recognized for their strong communication skills. The videos of advanced engineers included five excerpts which featured the following effective and inclusive engineering talk moves: *questioning the problem, defining terms and requirements, turn taking, responding directly, making joint decisions about process, drawing while talking, distributing tasks*, and *vocalizing estimations*. The students then viewed excerpts of their discussion that had been labeled for their particularly productive discourse strategies. Between the first and second class sessions, students listened to the recordings of their own group talk and compared them to the more advanced engineers' talk. Finally, during the second class session, students met in pairs, small groups, and as a whole class to generate and refine a characterization of "effective" and "inclusive" engineering talk.

Methods

Our study was guided by the research question: How do first-year engineering students respond to explicit instruction on engineering discourse methods? Data sources generated during the engineering talk module included students' written work artifacts and instructor notes from module implementation. We reviewed these artifacts and notes for evidence of student reasoning about engineering talk and perceptions of the module itself. One week after the completion of the module, we collected video data as students worked in teams on their final robot design projects during two separate 75-minute class sessions. We reviewed these video recordings for evidence of student take-up of the engineering talk moves discussed during the engineering talk module.

Preliminary Results and Future Work

Data analysis is ongoing; however, preliminary results show clear evidence of students' careful reasoning and sustained interest in engineering talk during the module, but limited evidence of intentional engineering talk strategies during their robot design work *after* the module.

How did students reason about engineering talk during the engineering talk module?

Students noticed a range of productive talk strategies in their own and other engineers' recorded group work:
- "The advanced group was more quantitative and used images and numbers to support their ideas."
- "Clarifying what the scenario is and what resources/materials are available, so everyone is on the same page"
- "Good implementation of visuals to increase understanding"

Students also pointed out weaknesses in their own sprinkler design problem talk:
- "Switching topics/focus before everyone in the group was ready to move on."
- "While discussing, we seemed to jump into the quickest solution to a problem rather than taking time to really analyze the issue at hand."

- "At one point: two separate conversations being held at the same time"

How did students perceive the engineering talk module as a learning experience?

Students stated that they found several aspects of the module to be particularly useful or thought-provoking:
- Understanding biases and the role implicit bias plays in group dynamics
- Importance of engineering talk

Students also perceived limitations of the module and made suggestions for improvement:
- Better incorporation with the rest of the course content
- More examples and suggestions of *how* to implement strategies into practice

How did students approach engineering talk during subsequent robotics design sessions?

The students actively engaged in analysis of engineering talk during the module, and their written reflection responses showed a new appreciation for the value of productive engineering talk. However, preliminary analysis of the post-module robot design team video indicates that the talk moves introduced in the module were not taken up broadly in an intentional way. We did see some examples of students using the *drawing while talking* move to explain their ideas, but there was also evidence of some students being overlooked or outright ignored by their fellow group members. It is possible that much more sustained practice and feedback would be needed to disrupt pre-existing interaction norms within student design teams.

Student responses to explicit instruction in engineering talk during the focused tasks were encouraging, but more work is needed to design an intervention that supports sustained change in student behavior outside of the explicit instruction.

References

[1] J. Trevelyan, "Technical Coordination in Engineering Practice," *J. Eng. Educ.*, no. July, pp. 191–204, 2007.
[2] L. L. Bucciarelli, *Designing Engineers*. Cambridge, Massachusetts: MIT Press, 1994.
[3] M. T. H. Chi, S. Kang, and D. L. Yaghmourian, "Why Students Learn More From Dialogue- Than Monologue-Videos: Analyses of Peer Interactions," *J. Learn. Sci.*, vol. 26, no. 1, pp. 10–50, 2016.
[4] M. D. Koretsky, D. Gilbuena, S. B. Nolen, G. Tierney, and S. E. Volet, "Productively Engaging Student Teams in Engineering: The Interplay between Doing and Thinking," in *IEEE Frontiers in Education Conference (FIE) Proceedings*, 2014.
[5] S. Michaels and C. O'Connor, "Talk Science Primer," *Terc*, pp. 1–20, 2012.
[6] M. R. Banaji and A. G. Greenwald, *Blindspot: Hidden Biases of Good People*, 1st ed. Delacorte Press, 2013.
[7] C. M. Steele, *Whistling Vivaldi: And Other Clues to How Stereotypes Affect Us (Issues of Our Time)*. W.W. Norton, 2011.
[8] Purdue University, "Campus Sprinkler Design," 2004. [Online]. Available: https://engineering.purdue.edu/ENE/Research/SGMM/Problems/Problems/CampusSprinklerDesign/SinglePage.