Qualitative analysis of the relationships between the teamwork experiences of diverse students and their engineering identities at a Hispanic-serving institution

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Introduction and Background

In 2004, the National Academy of Engineering's oft-cited report, "The Engineer of 2020," emphasized the need to teach engineering students to work effectively in teams, writing that "because of the increasing complexity and scale of systems-based engineering problems, there is a growing need to pursue collaborations with multidisciplinary teams of experts across multiple fields" [1, pp. 34–35]. ABET has similarly dedicated one of its seven student outcomes to teamwork, wording it as: "An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives" [2]. Research studies have also repeatedly underlined the importance of developing engineering students' abilities to work in teams to meet industry needs [3], [4].

As a result, there has been an increased focus within engineering education on how to effectively teach and assess teamwork. Prior work in this area has shown that women and underrepresented minorities (URMs) sometimes have different teamwork experiences from their peers, including reports of feeling less competent in team negotiations, assuming stereotypical tasks in teams [5], and frequent dismissal of their ideas. Other researchers have explored the effects of team disagreements [6], with some finding that team disagreements can sometimes be constructive [7], [8].

Engineering identity has also been identified as an important quality to study in engineering students because of its relation to increased student success and retention [9]–[11]. Prior work has explored the processes involved in developing an engineering identity [5], [12] and proposed models for describing engineering identity [13]–[15].

Yet, few people have investigated how teamwork – and especially disagreements in teams – connects to or influences students' engineering identity and vice versa. The research project described here aims to do just that by addressing three research questions:

1) How often do students disagree, who is more likely to disagree, and what do they disagree about when performing teamwork?
2) What kinds of team dynamics emerge when there is a disagreement?
3) How does teamwork experience (proxied by behaviors and disagreement) inform engineering identity?

This paper describes the initial phase of qualitative data collection and analysis for a mixed-methods project focused on the connections between engineering students' experiences working in teams, their team disagreements, and their engineering identities. First, we describe the larger research project that this effort is a part of. Then, we share the process we used to develop an interview protocol to gather qualitative data for this project and the subsequent analysis. Finally, we present preliminary findings from our qualitative analysis.

Methods

This work is a part of a two-year. mixed-methods project which has gathered quantitative data via a survey instrument and qualitative data via student interviews. The survey instrument included measures of teamwork behaviors, disagreement, and engineering identity to explore connections between these three concepts [5], [6], [13], [16]. (Descriptions of the broader project and the quantitative analysis can be found in [17] and [18].) The survey was distributed to undergraduate and graduate engineering students working in teams as part of their coursework at a teaching-intensive, public, Hispanic-serving institution in the Western U.S. We followed the surveys with interviews of participants recruited from the initial survey respondents. The qualitative data collected through the interviews is the focus of this paper. The development of the interview protocol, implementation of the interviews, and subsequent analysis are described in more detail in this section.

Interview data collection

Informed by [19] and [20], we developed a semi-structured interview protocol with four sections: introduction and warm-up, engineering identity, teamwork, and conclusion. When time permitted, we asked the interviewees to reflect on the stories of the practicing engineers. These stories were developed from publicly-available accounts of the day-to-day experiences of practicing engineers. The interview protocol and other applicable parts of our study design were approved by our institution's human subjects review process.

Two mock interviews were performed to evaluate the clarity (or ambiguity) of the questions and the total time required to perform the interview. It also served as an opportunity for our team to familiarize ourselves with the interview process. Two students volunteered for the mock interviews and received compensation but were not included as official participants in the study.

We conducted ten interviews in Spring 2022 and 18 interviews in Fall 2022. The interviews were conducted on Zoom and were approximately one hour in length each. The audio recordings were transcribed by a professional transcription service. To date, ten interviews from Spring 2022 have been transcribed, cleaned, and used for the analysis described in this paper. Upon completion of the interviews, each participant received an electronic gift card of $50.

Interview data analysis

For this qualitative interview data analysis, we combined Hatch's interpretive analysis framework [21] with Saldana's code-to-theory model [22]. Hatch describes interpretation as, "...giving meaning to data. [...] It's about making inferences, developing insights, attaching significance, refining understandings, drawing conclusions, and extrapolating lessons" [21, p. 180]. Interpretive analysis best met the analytical needs of this stage of the project given its exploratory nature investigating the connections between disagreement in teams and engineering identity that have not been previously explored in great depth. Further, Saldana's code-to-theory model provided a tool to interpret the data.

We used two cycles of coding in our analysis [23]. In the first cycle, we combined two of Saldana's coding methods, initial coding (also known as open coding) and provisional coding (also commonly called *a priori* coding) [22] to code five interview transcripts and generate a shared codebook. To create this codebook, we started by having the four researchers in our team perform a preliminary pass of open coding of a single interview transcript and prepare separate analytic research memos [21], [22] about noteworthy codes that emerged. We compared our individual codes in pairs and looked for areas of overlap and similarity. We repeated this, with each pair looking at an additional two transcripts and continuing to write analytic research memos for each transcript. Then, the pairs each created a shared codebook before our research team came together to create a single, master codebook from the two created by the research pairs. In our second coding cycle, we plan to apply this codebook to the remaining five transcripts from Spring 2022 and refine it as necessary.

The current draft of the master codebook is organized by categories, subcategories, and sub-subcategories (when necessary) in alignment with Saldana's code-to-theory model [22, p. 13]. There are currently nine categories: background, current goals as a student, perceptions of engineering, differences, and similarities with other students, engineering identity, teamwork experiences at the university, teamwork disagreement, how teamwork experiences affected engineering identity, and learning experiences at the university. Appendix A provides the complete list of categories and subcategories.

Preliminary Findings

Though analysis is ongoing, a few findings have begun to emerge from our analytic research memos and draft summary documents.

One notable observation is that the interviews allow us to probe why students responded to the engineering identity survey measures the way they did. This observation provides a glimpse at the version of engineering students are choosing to identify (or not identify) with when they respond to the survey and subsequent interview questions. In turn, we can make connections between how the students describe themselves generally, how they describe engineers and engineering, and how they describe their engineering identities (or lack thereof). For example, one student, Alex, did not identify as an engineer because she struggled with "imposter syndrome" and saw becoming an engineer as something very difficult to achieve. In her interview, she reported not lacking the interest, competence, or recognition to be a successful engineering student or engineer that other identity researchers have observed as contributing to an engineering or STEM identity (e.g. [13], [15]).

Our interviews also provided helpful information on the nature of the conflicts or disagreements that occurred in the students' teams. Many of the disagreements described were relatively minor. They focused on issues relating to a teammate's lack of communication or engagement with the work or disagreements about calculations. This observation that the disagreements were not extreme in scope echoed previous research where survey responses about team conflicts were highly concentrated in responses indicating very little or no conflict [24]. Other prior work has shown that intragroup conflict is "rarely uniform, shared or static" [25], and that team conflict can distribute differently among the various teammates. These initial findings led us to add

questions to our survey around psychological safety, as this has been found to influence how team members experience conflict and contribute to the team's performance [26], [27].

Another finding that is emerging from our data relates to how the students connect their team experiences with their engineering identities. A portion of our respondents said that their team experiences did not inform their engineering identities. In other cases, respondents said that aspects of teamwork negatively influenced their identities. This negative influence was often not due to disagreements within their teams, but more frequently related to what the students felt they were failing to contribute. For example, Olivia expressed her concerns about not contributing enough in her teams, leading her to also experience "imposter syndrome:" "With a group, I put a lot on my shoulders because it's [...] not just me. I can't just give up. [...] So that put a lot of, like, stress on me because [...] I want to contribute in some shape or form, but I literally would be useless in all those things. Like, I would – I would be doing more damage than help." Conversely, another student, Charlotte, found that her engineering identity was strengthened by her senior design team project, due to its open-ended and iterative nature and the requirement to collaborate with and learn from others.

Finally, the effects of the COVID-19 pandemic and the remote learning that resulted are also evident in our data. Many of our students cited the unique challenges that arose from working remotely on teams during online learning, especially for those whose projects required hands-on building or prototyping.

Discussion and Conclusion

This paper describes the data collection and initial analysis of qualitative interview data exploring the connections between engineering students' engineering identities and experiences in teamwork. Two notable points have emerged from our preliminary findings that warrant a brief discussion here and that we hope will seed future conversations on the topics of engineering identity and teamwork.

First, our work has demonstrated the need to draw from multiple frameworks of engineering identity when carrying out research in this area. For example, our survey was designed to rely on two definitions of engineering identity: Tonso's uni-dimensional definition of "belonging as an engineer on campus" [5] and the multi-dimensional definition of engineering identity used by Hazari, Godwin, and others consisting of performance/competence, interest, and recognition [13], [15], [28]. Our interviews showed that these two approaches to engineering identity may be helpful as initial measures of a student's engineering identity, but that students' own identities are frequently more complex and require additional exploration [29].

Second, during the interviews, we were left with the impression that students avoided disagreement when they could and viewed disagreement, in general, in a negative light. Although this could explain the low frequency of disagreement in our study sample and other studies, it might well reveal a misconception that students had about conflicts in engineering teamwork. While viewed negatively by our students, disagreement about task and process can contribute to favorable team outcomes and blind agreement leads to stagnation and complacency

in other fields [7], [8]. Future work is needed to parse the extent of blind agreement in engineering students' teamwork and how it trickles into the engineering identities of students.

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Appendix A - Preliminary Set of Categories and Subcategories

The list below contains the categories and subcategories that have emerged from our coding efforts thus far [22]. Under each subcategory are one or more codes which are not included here for length considerations.

- **Background**
  - School-Related Status
  - Demographic and Socio-Economic Background

  Current Goal as a Student
- **Perceptions of Engineering**
  - Before Entering College
  - After Entering College
  - Qualities of Engineers
  - Perceptions of Teamwork for Engineers
- **Differences and Similarities with Other Students**
  - Similarities
  - Differences
- **Engineering Identity (EI)**
  - EI-Interest
    - Journey to Current Major
    - Interest in Current Major
  - EI-Recognition
    - Self-Recognition
    - Recognition from Others
  - EI-Performance
  - What helped boost EI?
  - What lowered EI?
- **Teamwork Experience at SFSU**
  - General Experience
    - Teamwork Behaviors
    - Role in Teamwork
    - Problems/Challenges in Teamwork
  - Teamwork Experience in ENGR 697
    - Project topic
    - Team Formation
    - Role in Teamwork
    - Communication

        - Team Dynamics
        - Problems/Challenges
        - Disagreement
        - Team Satisfaction
        - What has been learned from this experience?
        - How has ENGR 697 experience changed you?
- **Teamwork Disagreement**
    - Perceptions of Disagreement in Engineering Teamwork
    - Teamwork Disagreement Experience at SFSU
        - Type of/Cause of the Disagreement
        - How disagreement was resolved
- **How Teamwork Experience Affected EI**
- **Learning Experience at SFSU**