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# Disagreement in Engineering Student Teams: Analyzing the Impact of Gender and Conversational Medium

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# Disagreement in Engineering Student Teams: Analyzing the Impact of Gender and Conversational Medium


## Abstract

Productive disagreement is a healthy part of both the design process and collaborative learning more broadly. However, beneficial effects of disagreement depend upon students' willingness to express disagreement with peers. It is possible that gender and power dynamics at play in team conversations affect that willingness.

Previous studies have investigated gender in team learning, finding that women participate less or differently in group conversation and on project teams overall. Speaker gender and group gender balance may complicate whether and how teams express disagreement. Additional work has shown that students are more willing to express disagreement in an online environment compared to face-to-face, but the role of gender in these interactions has not been studied.

In this project, we investigate disagreement on project-based learning teams engaged in a planning activity, face-to-face or via synchronous chat. Specifically, we compare disagreeing behaviors on 54 teams of 4 or 5 students with varying gender breakdowns, from all male to all female. Almost one third of participants were female (65 of 231 participants); students were assigned to teams following normal course policies that avoided stranding female students. Student teams were assigned to face-to-face or synchronous chat conditions and instructed to compare individual design ideas and determine a design for further consideration; these conversations were recorded, transcribed, and coded for the rhetorical function of each utterance.

In this paper, the authors analyze disagreeing behaviors of the teams to determine how the medium of the conversation and gender breakdown on the team affect the expression of disagreement in team conversations. The results suggest that medium affects disagreeing behaviors, with students interacting in an online chat space more likely to express disagreement than students interacting face-to-face. However, we do not find differences by gender nor an interaction between gender and conversational medium. Additionally, we suspected we might find students who were gender-isolated on teams might be less willing to express disagreement in team meetings than students who were not; however, we actually found such students expressed increased disagreement compared to others of the same gender who were not isolated, though this effect was not significant.

## Introduction

Productive disagreement is a healthy and helpful part of both the design process and collaborative learning more broadly. In the design process, students who do not express disagreement with teammates become a concordance-seeking team that does not consider the whole design space. For collaborative learning to be effective, students must express disagreement in order to realize differences between their mental models, and then they update and defend mental models as peers push them to understand an idea in new and deeper ways. Both of these beneficial effects of disagreement only occur if students are willing to express disagreement with peers [1]. It is hypothesized that gender and power dynamics at play in team conversations affect the willingness for individuals to disagree with one another. Previous work has shown that students are more willing to express disagreement in an online environment compared to face-to-face [2], but the role of gender in these disagreeing interactions has not been studied.

Computer-supported collaborative learning (CSCL) environments have been shown to support student teams and improve peer interactions [3], but these interactions are impacted by the group dynamics [4]. Social presence is one important factor in student interactions. Social presence is defined as interpersonal salience [5]. Online computer-based environments generally have a lowered social presence than face-to-face conversations, as the interlocutors' faces, facial expressions, and voices may be masked. Students have been shown to be willing to provide more substantive critiques of peer writing in an environment with low social presence compared to face-to-face settings, both in high school students and at the university level [6], [7].

Much work has been done investigating gender breakdown of groups in team learning, finding that women participate less or differently in group conversation [8], [9] and on project teams overall [10]. Gender isolation has been shown to negatively impact student retention and overall satisfaction [11]. As gender impacts how students interact on teams and how power plays out in face-to-face conversations, it seems possible that speaker gender and group gender balance may complicate whether and how teams express disagreement, and computer-supported interaction may mediate such effects.

## Methods

The data used for this study was collected as part of a dissertation [2]. First year engineering students in an "Introduction to Engineering" course between Fall 2011 and Winter 2013 at a large public research university were required to have a small-group planning conversation at the start of a design-build-test cycle. The teams (N=54) each had four (N=40) to five students (N=13) (one team had six students). Teams ranged from all male teams to all female teams, with most teams being varying mixtures of male and female students. Student gender was determined via the university registrar student database. The student teams were assigned to one of two conditions for their conversation: (1) a synchronous chat-based environment (Google Drawing), which allowed teams to electronically draw in an open whiteboard environment and communicate via a typed synchronous chat system, or (2) a face-to-face meeting space where teams held their discussions in a small conference room. The students in the online synchronous chat environment

were not co-located.

The students were enrolled in one of two first year "Introduction to Engineering" courses with different projects (one wind-based, one water-based) that followed similar processes. In each course, students initially submitted individual design proposals and then had a conversation to narrow the design down to one team-based design, which is the conversation investigated in this case.

In the conversation, teams were given approximately 45 minutes to discuss the objectives, constraints, and rationale for their designs before determining a final design to build for the following eight weeks of the course. The final design could include parts of individual designs or could be entirely new.

The student conversations were recorded by an instructor that was either present but not participating in the online chat, or through the means of a microphone and recorder in the face-to-face condition.

The participant demographics are shown in Table 1 and Table 2. There were 231 students included in the study, of which 65 were women (28%). The overall female enrollment within the College of Engineering at this institution in 2011 was 23%, slightly higher than the national average [12]. Students were required to select a first year engineering course from about a dozen different choices. Student interest in the courses is relatively high, which was demonstrated by a mean of 3.9 out of 5 to the end of semester evaluation question "I had a strong desire to take this class," where 5 = "strongly agree".

Table 1: Participant Demographics

| Mode | $N_{female}$ | $N_{male}$ | $N_{total}$ |
|---|---|---|---|
| Face-to-Face | 21 | 52 | 73 |
| Online | 44 | 114 | 158 |
| Total | 65 | 166 | 231 |

Table 2: Team Demographics

| Mode | 4 Students | 5 Students | 6 Students | Total |
|---|---|---|---|---|
| Face-to-Face | 12 | 5 | 0 | 17 |
| Online | 28 | 8 | 1 | 37 |
| Total | 40 | 13 | 1 | 54 |

Teams in the online synchronous chat condition utilized Google Drawing (shown in Figure 1). The tool allowed the team to chat in a text based toolbox as well as draw on an open form whiteboard area. The conversation was the first meeting between teammates and student identities were only given away by their unique email address used to log into the system. The instructor was shown as being in the chat, but did not participate.

The Google Drawing tool was newly available at the start of the data collection in 2011 and did change slightly during the multi-year data collection. One major change was the addition of a way for students to insert comments onto the chat, and the comments could be responded to as a

threaded discussion board. The comment feature was enabled but largely unused and therefore not included in the analysis.

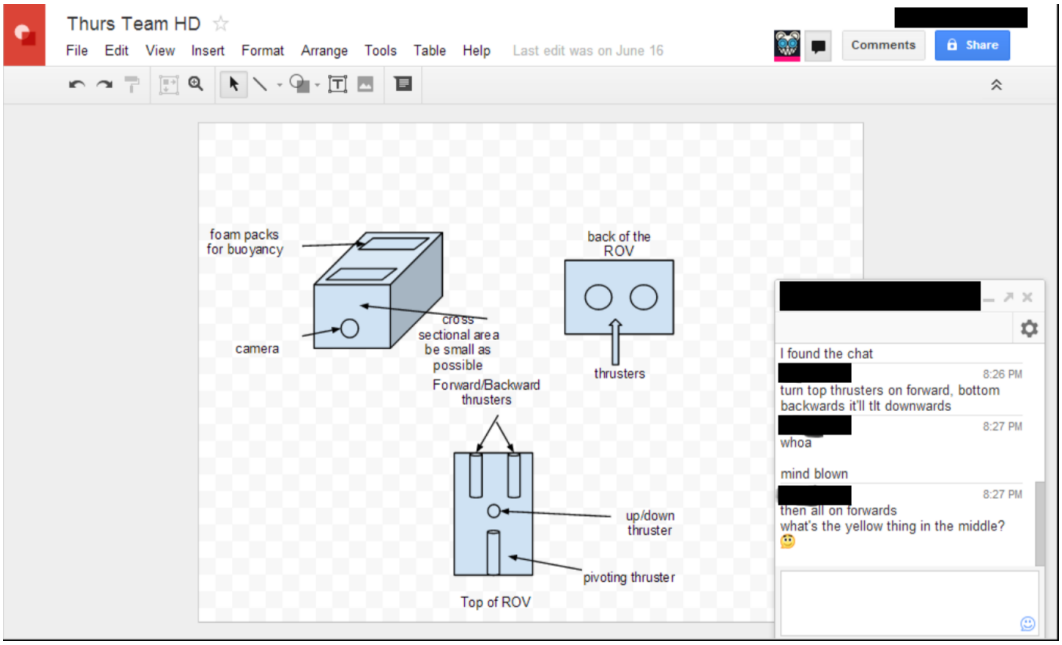


Figure 1: Students utilizing the Google Drawing tool in the Online condition.

Students in the face-to-face condition met for their discussion in a private conference room where their interactions were audio recorded. The recordings were transcribed for analysis. More teams were assigned to the online versus face-to-face condition due to the time intensive and costly transcription process of the audio recordings. The instructor was salient in the face-to-face conversations because of the microphone.

Transcripts of the online and face-to-face interactions were broken into thematic units (t-units) to account for ideas contributed. A thematic unit is an independent clause and all of its dependent clauses [13]. Breaking the transcripts into t-units required a level of judgment by the the person coding the conversation, and contributions that are not independent clauses (such as “OK”) were coded as independent t-units when they stood alone, or were combined into a more complex t-unit when they occurred adjacent to an independent clause. There were 7,590 t-units considered in the original analysis. All coding was done by one investigator. A reliability check was carried out by a second investigator, which showed congruent results for 1,007 of 1,008 units (approximately 15% of the entire sample).

The transcripts were originally coded at two levels following [14], [15]. Each conversation was considered for its topic and rhetorical contribution. For this specific study, the rhetorical contribution was analyzed. The rhetorical function was determined for each t-unit if the contribution was (1) information seeking, (2) information providing (no rationale), (3) information providing (with rationale), (4) topic directing, (5) expressing agreement (no rationale), (6) expressing agreement (with rationale), (7) expressing disagreement (no rationale), (8) expressing disagreement (with rationale), (9) politeness/convention, or (10) other.

To quantify the inter-rater reliability, Cohen's Kappa was used. Cohen's Kappa is a measure of agreement where "0" indicates chance agreement rather than no agreement. The interrater reliability for the rhetorical function coding was found to be Kappa = 0.924 ($p < 0.001$), 95% CI (0.906, 0.942).

For the purposes of this study, the original data categories of (7) Expressing disagreement (no rationale) and (8) expressing disagreement (with rationale) were combined into one category, disagreement.

The disagreement category was then normalized by the total number of t-units for a given participant/team to find the frequency of agreement or disagreement in the conversation. For example, if there were 43 agreement t-units and 151 total t-units in the conversation, the frequency of agreement was 28%. Similarly in the same conversation, if there were 5 disagreement t-units, the disagreement frequency was 3%.

$$\text{Disagreement Frequency} = \frac{\text{t-units coded 7 and 8}}{\text{total t-units}} \tag{1}$$

For all numerical analysis, ANOVAs were performed using SPSS.

## Results

The first research question addressed is if the overall proportion of disagreement is different between face-to-face and online interactions. This was analyzed at both an individual participant level and on a full team conversation level as two separate one way ANOVAs in SPSS.

For individual participants, there is a statistically significant increase in the level of disagreement online versus face-to-face. The descriptive statistics are shown in Table 3. The mean disagreement level of individual participants online was 0.0598 compared to 0.0358 during in person face-to-face conversations. The mode of interaction was found to be significant ($p = 0.001$). A histogram showing the disagreement level compared to the fraction of participants for each online and face-to-face medium is shown in Figure 2.

Importantly, we do not expect that student teams assigned to meet online actually experienced higher levels of disagreement; instead, we believe that this difference reflects students' ability to feel safe expressing disagreement. The lowered social presence of the online chat allowed students to more readily express their possible disagreements with one another. While disagreement was a small portion of the overall conversation, it can have a large impact on the overall discussion.

One student, who was in the face-to-face condition, indicated that it was difficult to express disagreement to peers face-to-face. She noted, "I really think [redacted name] took over this meeting, and the rest of us couldn't disagree with anything he said or we'd have lost all of our credibility."

On the contrary, in the online chat condition, one student expressed, "being online let us address everyone's concerns by looking up all the pieces and having that be part of our conversation. I

think by the end we all thought we are headed in the right direction."

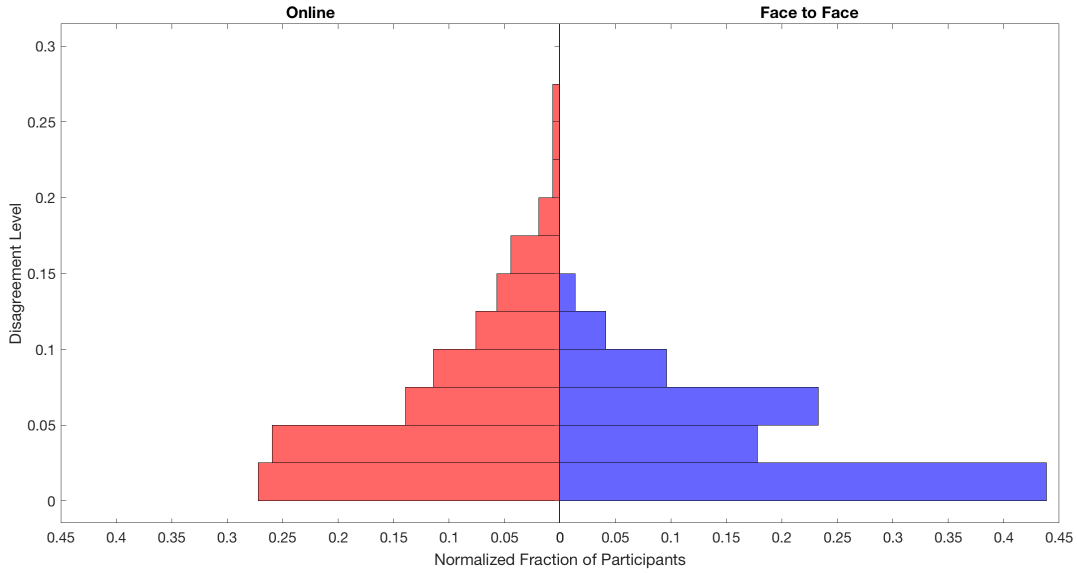


Figure 2: A histogram showing the disagreement level of participants for face-to-face and online interactions.

Table 3: Descriptive Statistics for the proportion of disagreement of individuals by communication mode

| | | | | | 95% C.I. | | | |
|---|---|---|---|---|---|---|---|---|
| Mode | N | Mean | Std. Deviation | Std. Error | Lower Bound | Upper Bound | Min | Max |
| Face-to-Face | 73 | 0.0358 | 0.03523 | 0.00412 | 0.0275 | 0.0440 | 0.00 | 0.15 |
| Online | 158 | 0.0598 | 0.05557 | 0.00442 | 0.0511 | 0.0686 | 0.00 | 0.26 |
| Total | 231 | 0.0522 | 0.05121 | 0.00337 | 0.0456 | 0.0589 | 0.00 | 0.26 |

The next research question addressed is if the overall proportion of disagreement is different between male and female participants. This was examined on the individual participant level using a single one way ANOVA in SPSS.

The descriptive statistics are shown in Table 4. The results showed that gender did not have a significant impact on disagreement ($p = 0.164$). A histogram showing gender compared to disagreement is shown in Figure 3.

An additional two way ANOVA was completed examining both gender and communication medium (online versus face-to-face). As shown in the single variable ANOVA, the mode of communication was significant ($p = 0.003$), but the gender was insignificant ($p = 0.203$) and the interaction was also not significant ($p = 0.949$).

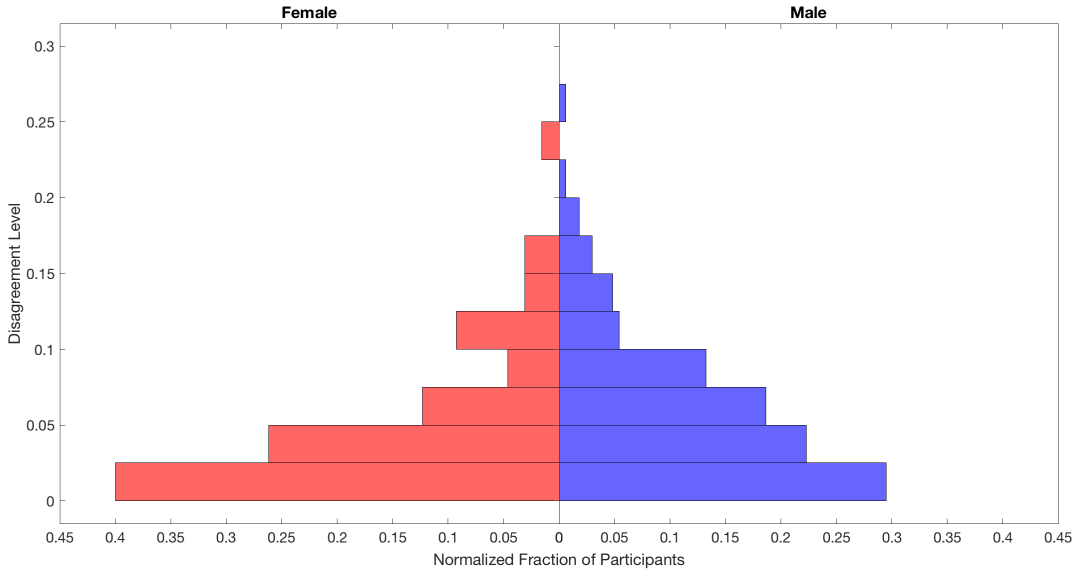


Figure 3: A histogram showing the disagreement level of participants by gender.

Table 4: Descriptive Statistics for the disagreement of individuals by gender.

| | | | | | 95% C.I. | | | |
|---|---|---|---|---|---|---|---|---|
| Gender | N | Mean | Std. Deviation | Std. Error | Lower Bound | Upper Bound | Min | Max |
| Female | 65 | 0.0447 | 0.0595 | 0.00632 | 0.0321 | 0.0573 | 0.00 | 0.24 |
| Male | 166 | 0.0552 | 0.05116 | 0.00397 | 0.0473 | 0.0630 | 0.00 | 0.26 |
| Total | 231 | 0.0522 | 0.05121 | 0.00337 | 0.0456 | 0.0589 | 0.00 | 0.26 |

In addition to examining participant gender and the medium of conversation, an additional analysis examined at the conversation level if there was an impact on disagreement in teams with one gender stranded (i.e. one female on a team of all male members, or one male on a team of all female members). There were only 14 students in this situation (10 women and 4 men). There was no significant impact of strandedness found ($p = 0.107$). The mean disagreement level on teams with a stranded gender was 0.0636 ($N = 14$) compared to a mean disagreement of 0.0514 on teams without a stranded gender ($N = 40$), nor was there a difference when teams with stranded men ($p = 0.077$, $N=4$) or teams with stranded women ($p = 0.533$, $N=10$) were considered separately.

## Conclusions & Limitations

The disagreeing behaviors of teams and individuals were analyzed. It was found that on an individual level, the medium of conversation has a significant impact ($p = 0.001$) on disagreeing interventions, with online interactions (average disagreement = 5.98%) having a higher frequency of disagreeing t-units than face-to-face interactions (average disagreement = 3.58%). Gender did not have a significant impact on the disagreement of individuals ($p = 0.164$), nor did being isolated on a team by gender have a significant impact ($p = 0.107$).

This data further supports previous research showing that lowered social presence increases the ability to express disagreement, as shown by increased disagreement in the online synchronous chat communications compared to the face-to-face communications. To the extent that students' willingness to express disagreement to peers affects the course outcomes (such as with teams engaged in creative design, and with students engaged in collaborative learning), instructors should consider conversational medium as potentially affecting the efficacy of class activities. When considering forming and supporting student project teams, the medium of communication has a significant impact on the characteristics of that communication. The benefits of having diverse perspectives are well studied and only accrue when students are willing to express their differences of opinion. It is recommended that student teams be exposed to multiple modes of communication in order to allow for students to more readily express their opinions and improve the overall dialogue.

The data did not show a significant impact of gender, suggesting gender does not significantly impact students' ability to express disagreement on teams, or at least that differences weren't detectable statistically.

The authors note that the data set has several limitations. This paper attempts to apply qualitative methods (coding of rhetorical functions) to a relatively large (for a qualitative study) sample. However, 231 students on 54 teams are still not enough to meet all of the assumptions for our analyses, especially because the students are grouped by gender, by conversational medium, and on teams of four and five students. As such, at least some of the assumptions are violated for our ANOVA analyses (namely, independence of cases is violated because students are grouped on instructor-defined teams, and the group sizes are uneven and sometimes very small). Additionally, proportion of disagreement was not normally distributed, as can easily be seen in Figure 2 and Figure 3 of the Results section. Many students had very low levels of disagreement. It is possible that differences by gender or by medium are not appropriately detected using this statistical method.

Finally, the context of data collection limits the generalizability of the results. The data was collected from first year engineering students at one particular institution. As student progress through their educational careers, the effect of gender and gender isolation may change as students begin to feel more comfortable working in diverse teams. Additionally, while women were well represented in the data set for the institutional and national averages in engineering, the overall engineering field is still male dominated, and women in more male-dominated individual courses may be affected differently.

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