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Dynamics of Mixed-Gender Teams in Engineering Education*

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Women are minoritized in U.S engineering programs and most engineering classrooms, and a variety of evidence indicates that they face inequities in team interactions. To reduce the impact of these inequities, some research indicates that instructors should avoid isolating women in engineering teams. While there are studies of mixed-gender teams in engineering education, most have focused on team performance and the team's final product, peer evaluation ratings, leadership self-efficacy, and the mode of collaboration. No comprehensive study of the dynamics of mixed-gender teams could be identified in the context of engineering education. This study investigates multiple measures of team dynamics holistically in mixed-gender teams: peer ratings, task interdependence, conflict, psychological safety, and satisfaction. Further, this research explores the extent to which women's satisfaction improves if their male teammates have similar characteristics (e.g., race/ethnicity and citizenship status) and how the women's satisfaction is related to the GPAs of their male teammates. The participants of this study were enrolled in a first-year engineering course, who provided information about various team dynamics four times during their teaming process. Mann-Whitney U tests were used to explore differences in team dynamics between mixed-gender teams and all-male teams. A multiple regression model was used to predict the women's team satisfaction based on their male team members' characteristics. Mixed-gender teams reported higher levels of task interdependence, but reported similar levels of conflict, psychological safety, and satisfaction. Women tended to be more satisfied when they worked with men who have similar citizenship status (based on class demographics, domestic women are more satisfied if their male teammates are also domestic). The results of this study include recommendations for instructors to improve team formation and facilitation.

Keywords: teamwork; mixed-gender teams; team formation; team dynamics; satisfaction; psychological safety; conflict; interdependence

1. Introduction

Students in effective teams can create a shared identity, increase their positive attitude, develop better social skills, and increase their critical thinking skills if instructors use proper approaches for team formation and team facilitation [1–6].

Interpersonal relationships among team members can influence team members' experiences and students' learning [7–9], and those relationships are influenced by their perceptions. Members of student engineering teams tend to marginalize students perceived to have lower knowledge and skills, excluding them from team activities [10] and limiting their opportunities within the team [9]. The problem is of greater concern if those perceptions are influenced by bias and stereotypes rather than the student's real expertise [11]. Considering the male-dominated setting of engineering classrooms and the importance of interpersonal interactions, it is important to study the experience of women in engineering teams.

Research suggests that one way to possibly decrease bias against female students is to form teams with equal number of female and male students [12]. It is valuable to study the dynamics of these gender-balanced teams in greater detail, especially in light of a recent qualitative study that found that women are less satisfied in teams with two women than teams with one woman [13]. This study aims to investigate dynamics in these gender-balanced mixed-gender teams to inform team formation approaches that could improve women's satisfaction in engineering teams.

2. Literature Review

The most relevant literature is drawn from engineering education and focus on gender dynamics and their relation to team composition. That literature is supplemented by research from STEM more broadly and from other fields, and the discussion is divided into three sections; women in engineering teams, team formation, and team dynamics.

2.1 Women in Engineering Teams

Although women have been described as good team players [14] and tend to respond well to teamwork as a pedagogy, their experience in engineering teams can also have negative impacts [15–19].

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Among the negative impacts women have experienced are being ignored, undervalued, and assigned to non-technical tasks [20], having their speech patterns interpreted as a sign of weakness and lack of ability [21], higher conflict due to poor communication [22], and being assumed to be less interested in leadership [11, 23] or less fit for it [24].

Other research provides some possible explanations for these gender differences, such as gendered differences in the definition of leadership [25] and preferred mode of collaboration [26, 27], and degree of career interest [28]. The more concerning explanation is outright sexism and stereotyping. Some students and faculty believe that female students cannot be proficient in some areas simply because they are female [29]. Although we might like to think that such ideas are outdated, these stereotypes persist even among some leaders in higher education [30]. Natishan, Schmidt, and Mead [31] found that women may need to prove themselves in teams to be seen as equals. Tonso [32] argued that we should change the culture of engineering education before thinking about including more women because engineering culture increases women's difficulties in teams and classrooms. She suggested that additional studies be conducted on how engineering culture influences women, provide more opportunities for women to express their opinions without fear, and modifying engineering practices and policies to expand the definition of engineering and the identity of an engineer. This research seeks to improve our understanding of women's experience in teams.

2.2 Team Formation

Various team formation strategies have been used in engineering education, ranging from self-selection to instructor-assigned teams, including combinations of two or more approaches [33, 34]. Some scholars note that asking students to form their own teams gives them a feeling that they have ownership of the project, improving their chances for success [33, 35], whereas other researchers note that self-selection can result in teams that lack diversity and teams with social cohesion rather than task cohesion [36, 37].

Just as there are various approaches to team formation generally, there is also disagreement in practice about how to consider gender when forming teams. Some professors believe that there is no need to consider gender in team formation because gender bias in teamwork is not an important issue, and women would encounter the same problem at the workplace [38]. Mead et al. [29] found that half of faculty believe that gender does not influence team activities. Beddoes and Panther [38] found that professors rarely consider gender during team formation, but when they do, practice ranges from forming teams to avoid isolating women to forming same-gender teams.

Research shows that the gender composition of teams does affect students' team experiences, but those findings have not always been consistent. Cinar and Bilgin [40] found that having more women in teams decreased gendered differences in peer evaluation within teams, and more students gave a full rating to their teammates. Lloyd and Szymakowski [41] discovered that teams with a higher percentage of women had more conversations about tasks, more collaboration for solving a problem, and a higher level of verbal discussion in the class. Researchers at the Colorado School of Mines found that teams with equal numbers of men and women had lower performance in all team functions, raising questions about mixed-gender team formation [42].

2.3 Team Dynamics

Students' personalities, previous teaming experience, and students' academic performance are among the factors that influence team dynamics [36, 43]. More collaboration has been found to result in better team performance [44]. The importance of team dynamics is well-proven in organizational behavior and psychology. Interdependence, conflict, psychological safety, satisfaction, trust, and cohesion are the most commonly used measures of team dynamics in organizational behavior and psychology, and there are benefits in measuring them in the engineering education context [45, 46]. Measures of team dynamics included in this study are described in more detail below. Satisfaction, cohesion, conflict, and psychological safety have been studied in the context of engineering education [47–49]. Those studies have explored the experience of teams in flipped classrooms or virtual teams or how these team dynamics influence innovation in teams, but have had less focus on the effect of gender composition on team dynamics. It is important to study the relationship of gender and team dynamics given the possibility that women report less satisfaction in mixed-gender teams [13] and particularly because team dynamics can provide an indicator of whether the teams are being managed well [50], making it possible for mixed-gender teams to achieve the benefit of diverse perspectives [51].

2.4 Team Interdependence

Effective teams include members who depend on each other for completing the projects and achieving the team outcomes [52]. Distribution of roles, skills, and resources, giving feedback, and having a reward system all influence team interdependence

[53]. Team interdependence can be in the form of task interdependence or goal interdependence. Task interdependence is when team members need to use each other knowledge and expertise to do their job, and goal interdependence is when the team has developed shared goals [54].

2.5 Conflict

Three types of conflict are described in teams: relationship conflict, task conflict, and process conflict. Relationship conflict might happen because of different personalities in teams and create tension and friction in teams [55]. Task conflict starts when team members have different views about what the teamwork content is and when they have diverse ideas about how to accomplish the team's goal [56]. Process conflict occurs when there is disagreement among team members about how to use resources and assign responsibilities [57]. Conflict has a complex effect on team performance; relationship conflict usually affects team performance negatively, but task conflict might benefit a team because it can be a sign of an existing variety of ideas. Process conflict can have adverse results for teams, but can improve team performance if it occurs in the early stages of the team's work and is resolved [58–63].

2.6 Psychological Safety

Psychological safety is about feeling safe from negative consequences from decision making or suggesting a new idea [64, 65]. Improving psychological safety in teams increases team learning and results in better interaction, more knowledge exchange, and more significant contributions [66–69]. With high psychological safety, students show more commitment, better attitude, and better learning behaviors in teams, as well as less task conflict [70–74].

2.7 Satisfaction

Satisfaction in teams is an indication that team members' expectations are being met. If students' expectations are met about team members' ability and collaboration in teams, they will have higher satisfaction in teams and tend to want to work with that team again [75]. Team characteristics, well-defined team objectives, assessment and rewards, effective leadership, and conflict management strategies have all been found to be associated with team members' satisfaction [76].

3. Theoretical Framework

Social role theory focuses on gender similarities and dissimilarities in social behaviors and the consequences of those similarities and differences. Based on the social role theory, women and men might excel each other in some skills and abilities [77]. This provides a mechanism for well-managed mixed gender teams to out-perform single-gender teams; women might attend more to feelings and interpersonal relationship in the team, while men tend to pay attention more to the problem itself [50, 78, 79]. This can also explain gendered differences in the definition of leadership [25]. Mapping, Bridging, Integrating (MBI) theory posits that well-managed teams must understand and map these differences, bridge and integrate them [51].

Together, these two theories predict that mixed-gender teams should benefit from complementary skills, and their measures of team dynamics should be better than those of single-gender teams. Since mixed-gender teams need to be managed well (map, bridge, and integrate the gender differences) to achieve this, if these benefits are not observed, the most likely explanation is that the mixed-gender teams are not managed well. Here, instructors have a role to facilitate teams so that students can understand and benefit from these differences. Fig. 1 depicts the proposed theoretical framework for this study.

4. Scope and Research Questions

Reviewing the literature in engineering education revealed that the various studies of the experience of women in teams failed to focus on comparing the team dynamics of mixed-gender teams with those of all-male teams. While various studies suggest that female students should not be isolated in team formation, this study aims to describe a broader range of team dynamics and outcomes for mixed-gender teams with an equal number of female and male students. The result of this study can guide team formation strategies and improve instruction

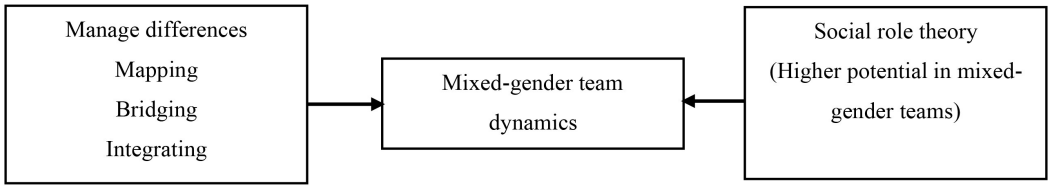

Fig. 1. A theoretical framework describing dynamics in mixed-gender teams.

about effective teaming in engineering classrooms. The research questions (RQs) for this study are:

RQ1: Does task interdependence differ between mixed-gender teams and all-male teams?
RQ2: Does task conflict differ between mixed-gender teams and all-male teams?
RQ3: Does relationship conflict differ between mixed-gender teams and all-male teams?
RQ4: Does process conflict differ between mixed-gender teams and all-male teams?
RQ5: Does psychological safety differ between mixed-gender teams and all-male teams?
RQ6: Does satisfaction differ between mixed-gender teams and all-male teams?
RQ7: Does the ability level of male teammates (measured by GPA and previous programming skill), and the degree of similarity of race/ethnicity and citizenship status to female teammates affect the satisfaction of women in teams?

The level of diversity is difficult to measure in teams because differences in seen and unseen attributes (e.g., race/ethnicity, gender, academic status, personality, culture, age, social-economic status, location, etc.) can create diversity in teams [80]. We cannot account for all these factors, but with a sufficiently large sample, many of them will be randomly distributed, making it feasible to look at differences based on a student being on a mixed-gender or same-gender team. Also, for the last research question, we decided to measure satisfaction instead of performance because high performance in teams can be achieved in the absence of satisfaction. We chose the ability level of male teammates as the independent variable because women might be satisfied if they feel that the men's ability in teams complements their skills, particularly because engineering students are prone to exclude students they perceive to be of inferior ability [10]. In addition, due to the possible cultural differences, similarity of citizenship status to female teammates might influence their satisfaction.

5. Method

5.1 Study Participants

Participants in this study were from two separate cohorts of a first-year engineering class, comprising 35 sections, over four semesters (Fall 2017, Spring 2018, Fall 2018, Spring 2019), taught by 14 instructors at a large Midwestern public university. Students remained on the same team for the entire term and completed various measures of team dynamics at four different timepoints. In total, 3651 students were in the cohorts that participated in this study. For the first to sixth research questions, the study includes only participants in four-member teams with either exclusively male team members (male teams) or exactly two female and two male team members (mixed-gender teams). These are the two most common team compositions in our sample size, accounting for the team experience of 2968 students. For the last research question, only female and male students in four-person mixed-gender teams are included in the study (940 students). After further removing record for students with incomplete data, the demographics of the remaining participants are presented in Table 1 for each research question. For the first to sixth research questions, there were 507 all-male teams and 235 mixed-gender teams. The students' demographic tables are placed below. The number of students included in each research question varies, because data were collected at multiple time points with varying response rates. The sample size and response rates are high, but could not be assumed to be missing completely at random (MCAR), so we had to consider imputation. There are several imputation technics, but multiple imputation was implemented because it has less bias and more statistical power by keeping all data [81, 82].

For the data described in Table 1, the question students answered was "What is your gender?" with response choices of "Female," "Male," and "Other or prefer not to answer." More detailed information on both gender identity (as well as sexual orientation) is collected by the institution's LGBTQ center, but is not collected here to avoid raising concerns about how the information might be used. Fewer than 0.5% of students choose the "Other or prefer not to answer" option, leaving us unable to make any claims about the experience of non-binary students and how those might interact with our other findings. Since we are considering

Table 1. Gender reported by study participants

	Female		Male in all-male teams		Male in mixed-gender teams		Missing
Gender	Number	Percent (%)	Number	Percent (%)	Number	Percent (%)	Percent (%)
RQ1	436	14.7	1824	61.5	422	14.2	9.6
RQ2-4	423	14.3	1735	58.5	412	13.9	13.4
RQ5	434	14.6	1820	61.3	415	14	10
RQ6	441	14.8	1862	62.8	427	14.4	8
RQ7	441	46.9	–	–	427	45.4	7.7

Table 2. Race/ethnicity reported by RQ7 study participants

Race	Both Female and Male students		Female students	
	Number	Percent (%)	Number	Percent (%)
Asian or Pacific Islander	703	25.8	123	27.9
Black, African American	54	2	9	2
White, Hispanic	290	10.6	48	10.9
Native American / Alaskan	6	0.2	0	0
White, Non-Hispanic	1504	55.1	231	52.4
Other / Mixed-heritage	108	4	16	3.6
Other / Prefer not to answer	65	2.4	14	3.2

Table 3. Citizenship reported by RQ7 study participants

Race	Both Female and male students		Female students	
	Number	Percent (%)	Number	Percent (%)
International	513	18.8	86	19.5
Domestic	2217	81.2	355	80.5

race/ethnicity and citizenship status for the last research question, additional demographics are provided for this research question. Participants responded to the prompt, ''Please indicate the racial/ethnic group with which you most identify'' as follows:

5.2 Data Collection and Analysis

The data were collected using CATME, web-based software to form teams [34] and make peer evaluation surveys [83]. The CATME system was also used to collect team dynamics measures as part of each peer evaluation. The data collection procedure was the same in all classes; students completed four peer evaluations throughout their teaming process. Students rated their perceptions about team interdependence and conflict in the first and second peer evaluations, respectively. In the third peer evaluation, they reported their level of psychological safety in their teams. In the final peer evaluation, at the end of their team project (or close to their project submission), they rated their team satisfaction.

For the first to sixth research questions, Mann-Whitney U tests for two independent samples were used to compare the sample of all-male teams with the sample of mixed-gender teams, reporting effect sizes for all significant results [84]. Effect size was measured using Cohen's d, for which an effect size less than 0.2 is small, between 0.2 and 0.5 is medium, between 0.5 and 0.8 is large, and above 0.8 is very large. The dependent variables for these research questions are task interdependence, task conflict, relationship conflict, process conflict, psychological safety, and satisfaction. These dependent variables were collected using instruments with strong validity evidence and a history of use in engineering education. Cronbach's alpha for these instruments are provided in Table 4 [54, 61, 64, 85, 86]. Vegt et al., [54] designed the interdependence and satisfaction instruments in the context of teams in school and engineering firms. Jehn and Mannix [61] developed the conflict instrument in the context of student teams, and psychological safety instrument is highly respected instrument which have been used by several researchers in a variety of disciplines [64]. These instruments are included in Appendix A. Task interdependence is measured with five items, conflict with nine items (three for each type of conflict), psychological safety with seven items, and satisfaction with three items. CATME uses the original scale of these instruments. Interdependence, conflict, and satisfaction data were collected using a five-point Likert scale (1–5) and psychological safety data collected by a Likert seven-point scale (1–7).

For RQ7, female students' satisfaction ($FemaleS_i$) is the dependent variable. For independent variables, the number of male students in the team whose race/ethnicity matches a female student's is the first independent variable (Race $Similarity_i$), and a similar process was used for citizenship status to find the second independent variable (CS $Similarity_i$). The average GPA and average previous

Table 4. Variables Cronbach's Alpha

Variable	Number of Items	Cronbach's Alpha
Task Interdependence	5	0.76
Task Conflict	3	0.94
Relationship Conflict	3	0.94
Process Conflict	3	0.93
Psychological Safety	7	0.82
Satisfaction	3	0.84
Females' Satisfaction	3	0.84

MATLAB skills of each woman's male teammates were the third and fourth independent variables. The model for RQ7 is:

$$FemaleS_i = \beta_0 + \beta_1(\text{Race Similarity}_i) + \beta_2 (\text{CS Similarity}_i) + \beta_3 (\text{MenGPA}_i) + \beta_4 (\text{MenMATLAB}_i) + r_{ij} \quad (1)$$

β_0, β_1, β_2, β_3, β_4, are respectively the intercept level of female' satisfaction and the main effects of race/ethnicity similarity, citizenship status similarity, men's average GPA, and men's previous MATLAB skill average. Lastly, r_{ij} is the random error.

Task interdependence, task conflict, relationship conflict, process conflict, psychological safety, and satisfaction variables are collected at the individual level. Students provide their individual perspective on a team-level construct. These values are averaged for a team, which is a common and acceptable way among researchers when analyzing several ordinal items measuring a construct [88–91].

5.3 Course and Team Project Context

Participants engaged in teamwork activities in a first-year engineering course. In this class, students worked in the teams to develop their programming skills and their professional skills. These team-based activities comprised approximately half of the grade in this class. Prior to engaging in an eight-week project, students developed a team charter (called by other names such as a team contract) to describe the teaming process. The project was open-ended project and student teams had to select a solution strategy and provide a justification for their choice.

5.4 Interrater Agreement

In this study, we measure some team constructs by averaging students' answers in their perception about their teams. Aggregating individual data to the team level assumes that there is sufficient agreement among different raters. There are two compositions models that describe these team-level constructs. In the direct consensus model, individual-level measurements are aggregated to create a group level measurement. For example, the satisfaction measures an individual student's satisfaction. In the referent shift-consensus model, students evaluate a team-level construct, such conflict, which measure students' perceptions of whether there is conflict in the team. In both models, the aggregation must present the shared perceptions among team members, and there is an agreement about team dynamics [92–94].

The most common index for measuring within-unit agreement is r_{wg} [95, 96], which is suitable for multiple-item surveys comparing rating variance with the variance that would be expected if there were no agreement. A higher r_{wg} indicates more agreements among units, and researchers rely on cut-off values to interpret the level of agreement. It is generally accepted that an r_{wg} above 0.7 represents an acceptable level of agreement. Researchers have also categorized the strength of agreement: lower than 0.3 as lack of agreement, 0.31–0.50 as weak agreement, 0.51–0.70 as moderate agreement, 0.71–0.90 as strong agreement, and higher than 0.90 as very strong agreement [97–99].

For this study, since we are using team-level dynamics, r_{wg} was calculated for all team-level constructs. The r_{wg} values were 0.85 for interdependence, 0.90 for task conflict, 0.95 for relationship conflict, 0.93 for process conflict, 0.88 for psychological safety, and 0.84 for satisfaction. Based on the recommended cut-off values, all within-unit agreements are strong or very strong, so the data can be aggregated at the team level.

6. Results

The data were checked for Welch's t-test's assumptions, and no dependent variable was normally distributed. All assumptions for Mann-Whitney U tests were met, so that approach was used for RQ1-6 to identify significant differences between all-male teams and mixed-gender teams in term of task interdependence (RQ1), task conflict (RQ2), relationship conflict (RQ3), process conflict (RQ4), psychological safety (RQ5), and satisfaction (RQ6). Since this constituted six analyses on highly related samples, the Bonferroni correction was used to address the issue of multiple comparisons.

Mann-Whitney tests indicated that task interdependence was greater for mixed-gender teams (Mdn = 3.28) than all-male teams (Mdn = 3.2), U= 49647.5, $p < 0.0183$, with a small-to-medium effect size (d = 0.27). Task conflict was the same for mixed-gender teams (Mdn = 1.17) and all-male teams (Mdn = 1.17), U= 56488, p = 0.48. Relationship conflict was similar for mixed-gender teams (Mdn = 1.75) and all-male teams (Mdn = 1.75), U = 54871.5, p = 0.08. There was no significant difference in process conflict for mixed-gender teams (Mdn = 1.33) and all-male teams (Mdn = 1.33), U = 55694.5, p = 0.32. Psychological safety between mixed-gender teams (Mdn = 6) and all-male teams (Mdn = 6.1) was not significant, U = 56149.5, p = 0.21. Finally, satisfaction was equal for mixed-gender teams (Mdn = 4.33) and all-male teams (Mdn = 4.33), U = 55657.5, p = 0.15.

To predict female students' satisfaction in mixed-gender teams (RQ7), multiple linear regression was used. The data for this research question met the

Table 5. Predicting female students' satisfaction based on their male team members' characteristics

Variable	*B*	*SE B*
Intercept	3.29**	0.35
Men's average GPA	0.19	0.10
Race similarity	0.03	0.06
Citizenship status similarity	0.18**	0.07
Men's MATLAB skills	–0.01	0.05
R^2	0.02	
F for change in R^2	3.36	

Note: B is the unstandardized beta, and SE B is the standard error for the unstandardized beta.
*$p < 0.05$, **$p < 0.005$.

assumptions in multicollinearity, multivariate normality, and homoscedasticity, and the dependent and independent variables were continuous. The data were winsorized to omit extreme outliers. Female students' citizenship status similarity with their men team members had significant effect on female students' satisfaction in mixed-gender teams. But men's average GPA, men's MATLAB skills, and female students' racial/ethnic similarity with their male team members did not show any significant result.

However, R square for this multiple regression analysis was very low, suggesting that there are other variables influencing the women's satisfaction in teams. Table 5 summarizes the result for this analysis.

7. Discussion

This study aimed to compare the dynamics of mixed-gender teams with all male teams. Based on proposed theoretical framework, mixed-gender teams have more potential for having better team dynamics than all-male teams. Based on the results, in the first stage of teaming, task interdependence was significantly higher for mixed-gender teams than all-male teams. It shows that in the initial stages of teaming, members of mixed-gender teams rely more on each other's unique expertise, which has been shown to result in better team dynamics [50]. Nevertheless, the subsequent stages of teaming showed no differences between team dynamics of mixed-gender teams and all-male teams in terms of task conflict, relationship conflict, process conflict, psychological safety, or satisfaction. For conflict, it is still a somewhat positive result because the theoretical framework would predict that mixed-gender teams would have higher conflict due to their higher level of diversity. While no negative effects for mixed-gender teams relative to psychological safety and satisfaction were observed, mixed-gender teams did not demonstrate the improved team dynamics that some have observed. These results suggest that there is more that instructors can do so facilitate mixed-gender teams to reach their potential [42, 100].

The last research question aimed to identify approaches in team formation related to the satisfaction of female students. The only notable result is that female students were more satisfied if their male teammates had the same citizenship status. Since few teams had more than one international student, this result is best interpreted as domestic female students having a preference for working with domestic male students over international male students. It may be that adding cultural (and possibly language) differences complicates the gender differences being managed, resulting in a less satisfying team experience. Racial/ethnic similarity, men's average GPA in teams, and men's MATLAB skills did not have any significant effect on female students' satisfaction, suggesting that there are other unmeasured factors influencing female students' satisfaction.

8. Limitations and Implication

We acknowledge that the data were collected from a single university and might not reflect the demographics of students at other universities. This study reported the student perceptions of team dynamics, but lacked the corroboration that would be provided by expert observation. We did not consider the intersection of race/ethnicity and gender, and the result is thus more representative of the experience of White women. As mentioned, gender is treated as a binary variable because we had not enough "Other" responses. Also, we need to acknowledge that changes to team formation have other consequences, and only apply in the academic context, where the focus is on learning – but would not necessarily be practical in the workforce.

Considering these limitations, this study has some implications for engineering education. Engineering instructors should provide appropriate training for students to assist them in map, bridge, and integrate these gender differences in a way to improve the team dynamics and achieve the anticipated higher level of team-member effectiveness. Women's satisfaction in mixed-gender teams is a complex issue, and mixing national/cultural diversity with gender diversity was associated with lower satisfaction. Instructors need to exercise more supervision of teams with gender and/or national/cultural diversity. This work did not disaggregate by citizenship status to determine how the experience of female international students might differ. Further research in this area, both qualitative and quantitative, would be valuable.

9. Future Directions

This study suggests research questions for further studies. We investigated the experience of mixed-gender teams as a whole. Additional studies to address the experience of individual men and women in these teams would bring more value for engineering education, as would further research on different team composition. Whereas this study addressed four significant team dynamics in organizational behavior, there are others that might be investigated in similar ways, such as cohesion and trust. There are additional student characteristics that might be investigated as well – particularly disaggregating the data simultaneously by race/ethnicity and gender and even citizenship status. Others may wish to explore the effect of students' personality traits, nationality/culture, and language. This study showed that there is more to learn about the factors that affect the satisfaction of women in engineering teams. Further study could identify appropriate frameworks and design a model to understand this issue more deeply.

10. Conclusion

Engineering education scholars have done a variety of studies about gender in undergraduate engineering teams. This study extends the research base on mixed-gender team dynamics. Based on proposed theoretical framework in this study, mixed-gender teams have higher potential than same-gender teams to have better team dynamics, but for utilizing this potential, their team members should be able to understand the differences, communicate and integrate these differences. This study found that mixed gender teams had better team dynamics in the beginning of teaming, but their subsequent team dynamics were similar to those of all-male teams. Looking through the lens of the theoretical framework, it appears that improvements in facilitating mixed-gender teams are needed to realize the expected improvements in team dynamics. This might take the form of a priori instruction or mentoring throughout ongoing team interaction.

Managing gender differences in mixed-gender teams appear to be complicated by the introduction of cultural (and possibly language) differences. This could be addressed through team formation strategies that avoid putting male international students with domestic female students, but this would not address the satisfaction of female international students. As a result, it will be important to address cultural issues as well, either through instruction or team facilitation.

Notably, there are factors affecting female students' satisfaction that were not included in this study that could be addressed by additional studies. We approached this work with the intent of identifying possible mechanisms that would lead women to be less satisfied when they are placed in a team with at least one other woman compared to when they are isolated, but in a large sample, most team dynamics of mixed-gender (two female, two male) teams are surprisingly similar to the dynamics of all-male teams, and few variables were related to women's satisfaction.

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Appendix A. Surveys

A1. Team dynamic survey questions

Question Type	Sub-Question
Psychological Safety* (Edmondson, 1999)	If you make a mistake on this team, it is often held against you. (reversed scale)
	Members of this team are able to bring up problems and tough issues.
	People on this team sometimes reject others for being different. (reversed)
	It is safe to take a risk on this team.
	It is difficult to ask other members of this team for help. (reversed scale)
	No one on this team would deliberately act in a way that undermines my efforts.
	Working with members of this team, my unique skills and talents are valued and utilized.
Task Conflict** [87]	How much conflict of ideas is there in your work group?
	How frequently do you have disagreements within your work group about the task of the project you are working on?
	How often do people in your work group have conflicting opinions about the project you are working on?
Relationship Conflict** [87]	How much relationship tension is there in your work group?
	How often do people get angry while working in your group?
	How much emotional conflict is there in your work group?
Process Conflict** [87]	How often are there disagreements about who should do what in your work group?
	How much conflict is there in your group about task responsibilities?
	How often do you disagree about resource allocation in your work group?

Interdependence** [54] (with minor modification)	My teammates and I have to obtain information and advice from one another in order to complete our work
	I depend on my teammates for the completion of my work
	I have a one-person job; I rarely have to check or work with others (scale reversed)
	I have to work closely with my teammates to do my work properly
	In order to complete our work, my teammates and I have to collaborate extensively
Satisfaction** [54] (with minor modification)	I am satisfied with my present teammates
	I am pleased with the way my teammates and I work together
	I am very satisfied with working in this team

* Using very inaccurate to very accurate scale (Seven-point Likert scale).
** Using strongly disagree to strongly agree scale (Five-point Likert scale).

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