Examining the Impact of Social Identities on Engineering College Students' Contributions to Teams

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***Abstract*—Contribution: This research-to-practice full paper uses a quantitative intersectional approach to examine how social identities (e.g., gender, race, and nationality) impact the ratings of contributions of engineering students in their course teams. Patterns in ratings of contribution across various demographic groups provide valuable insights for designing effective and inclusive teaching practices for diverse student populations, thereby enhancing equity in engineering education.**

***Background:* Team-based learning offers students great opportunities to learn. Existing research has underscored that student social identities play a critical role in determining student learning processes and fostering academic achievement.**

***Research questions:* 1) How do social identities, such as gender, race, and nationality, influence ratings of engineering college students' contributions to team? and 2) How can we characterize the intersectional effects of social identities on ratings of engineering college students' contributions to team?**

***Methods:* We collected data from over 1,700 college engineering students at a research-oriented university located in the Midwest region of the United States. Employing multilevel modeling, we investigated the relationship between engineering students' social identities and their ratings of contributions to course teams.**

***Findings:* Our investigation revealed that students' contributions to teams are statistically significantly associated with their intertwined social identities. White, male, and domestic students tended to be rated as contributing most to group conversations during the process of constructing ideas. However, these identities had a lesser influence on the execution of tasks in terms of idea enactments and their contributions to the overall team project. While White students were more likely to offer ideas, they were less inclined to encourage their peers' contributions compared to peers from other racial groups. International students, especially those from Asian backgrounds, were rated as contributing fewer ideas, which might reflect challenges in actively participating due to potential language barriers. Regardless of their race and nationality, female students were perceived as making more effort than their male counterparts.**

***Keywords*—teamwork, engineering college students, intersectionality, gender, race, nationality**

I. Introduction

Team-based learning, as a commonly used instructional strategy, provides students opportunities to engage with their surroundings, collaboratively construct understandings of learning materials, and has been evidenced to effectively improve student academic achievements [1] - [3]. Sociocultural learning theorists (e.g., Vygotsky and Freire) assume that individuals construct knowledge and assimilate information through interactions, discussions, and collaborations with others, emphasizing that students are encouraged to be active learners and critical thinkers [4] - [5]. Freire highlighted the significant role of dialogue in individual learning and stated that it requires critical elements, such as individuals' ideas and intentions, student faith in their collective power to construct knowledge, and a commitment to think critically and take action [4]. Herrenkohl and colleagues further acknowledged the empowering and humanizing impact of Freire's work on students and argued that power dynamics in education and social identities can influence how learners perceive themselves and are positioned by others within specific contexts (e.g., team-based learning), shaping their interactions with others [6].

Past studies on teamwork in engineering education have indicated that students' social identities (i.e., gender, race, and nationality) are related to students' experiences in collaborative learning [3], [7] - [13]. Henderson [9] applied a social network approach to analyze how gender, race, and epistemological beliefs influenced engineering students' contributions to team ideas in a first-year engineering design course. The findings revealed that gender did not influence how students viewed their teammate's idea contributions and enactments in student design teams; however, students from underrepresented minority groups (UMG) and Asian American and Pacific Islander (AAPI) students were reported to have their ideas enacted less frequently than their White peers [9]. Henderson further implied a bias in the way their peers evaluate URM and AAPI students' contributions and a likelihood that their contributions are not fully recognized or credited [9].

It is noticeable that much of the previous research examined the impact of social identities separately, such as investigating main effects of gender or of race without investigating interactions (e.g., [3]). As students' social identities are intertwined, investigating the influence of a single social identity on students' learning experience and their teamwork effectiveness can lead to a fragmented understanding of power dynamics in course teamwork and an inability to effectively provide feedback to instructors on student adoption of team-based learning strategies.

Intersectionality, as a critical theory, has been applied to highlight marginalized and invisible groups to promote equity and social justice in education [14]. The theory guides us in examining multiple social identities, delving into power dynamics and inequalities rooted in interconnected social identities, and recognizing the fluidity of these identities and power dynamics across contexts and time [15].

In this study, we apply a quantitative intersectional approach [15] - [16] to investigate the influence of engineering students' gender, race, and nationality on students' ratings of contributions to teams in engineering courses. Here, we consider students' contributions to team from two perspectives: constructing ideas and taking actions. Constructing ideas pertains to actively sharing and critically integrating ideas through dialogues, while taking actions refers to enacting ideas and making efforts to accomplish team tasks. Specifically, we seek answers to the following research questions:

RQ1. How do social identities, such as gender, race, and nationality, influence ratings of engineering college students' contributions to the team?

a. How do social identities, such as gender, race, and nationality, influence ratings of engineering college students' contributions to team ideas?
b. How do social identities, such as gender, race, and nationality, influence ratings of the efforts engineering college students make to accomplish team tasks?

RQ2. How can we characterize the intersectional effects of social identities on ratings of engineering college students' contributions to team?

a. How can we characterize the intersectional effects of social identities on ratings of engineering college students' contribution to team ideas?
b. How can we characterize the intersectional effects of social identities on ratings of engineering college students' efforts to accomplish team tasks?

II. Methods

A. Participants

Our research was conducted at a large research-oriented university situated in the Midwestern United States. We analyzed information derived from 1,701 engineering students (i.e., targets being rated by their teammates), who were appraised by their peers within 507 distinct teams. Although the initial participant count exceeded 1,701, we excluded individuals lacking complete demographic data on gender, race, nationality, or discipline (i.e., only students enrolled in engineering were included). The demographic details of the participants are presented in Table I, sourced from the university's learning analytics dataset.

B. Data Collection

Peer assessments of teamwork were collected through Tandem, a web-based pedagogical tool designed to identify inequitable behavior within course teams, particularly towards disadvantaged students from marginalized groups [17]. The peer rating process consisted of eight items rated on a 9-point Likert scale, as shown in Table II. Each student was assessed by their teammates at midterm and final. Our research focuses on students' contributions to team ideas and their efforts to accomplish team tasks, which includes four items: Peer Ideas, Peer Listener, Peer Enacted, and Peer Efforts.

TABLE I. Demographic Information of Participants

		Nationality			
		***Domestic* (percent[1])**	***International* (percent[1])**	**Subtotal (percent[2])**	**Total**
Gender	*Female*	485 (94.54)	28 (5.46)	513 (30.16)	1,701
	Male	1,102 (92.76)	86 (7.24)	1,188 (69.84)	
Race	*White*	851 (99.18)	7 (0.82)	858 (50.44)	1,701
	Asian	450 (82.42)	96 (17.58)	546 (32.10)	
	Minoritized	286 (93.30)	11 (6.70)	297 (17.46)	
		Gender			
		***Female* (percent[1])**	***Male* (percent[1])**	**Subtotal (percent[2])**	**Total**
Race	*White*	240 (27.97)	618 (72.03)	858 (50.44)	1,701
	Asian	166 (30.40)	380 (69.60)	546 (32.10)	
	Minoritized	107 (36.03)	190 (63.97)	297 (17.46)	

Note: [1]The percent is obtained by dividing the subtotal; [2]The percent is obtained by dividing the total.

C. Data Analysis

For our analysis, we applied a four-level linear model where individual responses are nested in students, which is further nested in teams within courses, using Stata/SE 18.0 [12] (See Appendix I[1] for data structure). For each peer rating item, we first separately ran base models (i.e., without main factors) and models where a peer rating item (i.e., Peer Ideas, Peer Listener, Peer Enacted, or Peer Effort) serves as the dependent variable and a students' social identity (i.e., gender, race, or nationality) as the independent variable. Then, we conducted intersectional analyses. We separately ran three more models, each with a peer rating item serving as the dependent variable and two students' demographic factors and their interactions (i.e., gender×race, gender×nationality, or nationality×race) as the independent variables. Follow-up interactions were decomposed using Wald chi-square tests. Given that students were rated on 8 items (Table II; [12]) together by peers, we included other items as a fixed effect in each model mentioned above to account for the covariance of the dependent variable with other items. In total, we operated 28 models for this study.

III. Results

Full details on the estimates for all the multilevel models can be found in the supplementary files[2]. This section includes three subsections, and we will elaborate on the findings for the dependent variables, the main effects of gender, race, and nationality on peer rating items in response to RQ1, and the intersectional analyses pertaining to RQ2.

[1] Appendix file: http://bit.ly/4dRo6GJ
[2] Supplementary files: https://bit.ly/3WTxoe6

TABLE II. PEER RATING ITEMS THAT WERE USED IN THIS ANALYSIS

Items	Lower anchor	Upper anchor
Peer Ideas	I didn't hear many ideas from $TeamMember.	$TeamMember offered up many ideas.
Peer Enacted	Our project didn't include many ideas from $TeamMember.	Many of $TeamMember's ideas were used in our project.
Peer Listener	$TeamMember discouraged, dismissed, or didn't listen to other teammates.	$TeamMember encouraged new perspectives by listening to other teammates.
Peer Effort	$TeamMember didn't put in as much effort as they should have.	$TeamMember did more than their fair share of work for our assignments.

Note: $TeamMember represents a team member's name in actual surveys.
See Appendix II for the complete information of all eight peer rating items.

TABLE III. DESCRIPTIVE STATISTICS

Variables	*n*	Mean (M)	Standard Deviation (SD)	Variance	Skewness	Kurtosis
Peer Ideas	10,063	7.34	1.65	2.72	-1.43	5.17
Peer Enacted	10,063	7.22	1.65	2.72	-1.31	4.84
Peer Listener	10,063	7.46	1.61	2.60	-1.40	5.04
Peer Effort	10,063	7.11	1.70	2.91	-1.13	4.32

See Appendix II for the complete information of all eight peer rating items.

TABLE IV. ESTIMATES FOR MAIN EFFECTS

Models			Dependent Variables			
		Independent Variables[1]	*Peer Ideas*	*Peer Listener*	*Peer Enacted*	*Peer Effort*
1	Gender	*Gender*				
		Male	0.026	-0.159***	0.013	-0.104***
2	Race	*Race*				
		Asian	-0.110***	0.121	-0.023	0.009
		Minoritized	-0.112**	0.251***	-0.042	0.010
3	Nationality	*Nationality*				
		International	-0.162***	0.021	0.016	-0.032
4	Gender × Race	*Gender*				
		Male	0.020	-0.146***	0.009	-0.105***
		Race				
		Asian	-0.110***	0.114*	-0.024	0.005
		Minoritized	-0.111**	0.237***	-0.036	<0.001
5	Gender × Nationality	*Gender*				
		Male	0.028	-0.157***	0.013	-0.106***
		Nationality				
		International	-0.162***	0.016	0.016	-0.025
6	Nationality × Race	*Nationality*				
		International	0.042	-0.175	0.091	-0.030
		Race				
		Asian	-0.108***	0.136*	-0.033	0.017
		Minoritized	-0.127***	0.263***	-0.049*	0.008

*Note: [1]reference level for gender, race, and nationality: Female for Gender, White for Race, and Domestic for Nationality. *p<0.05, **p<0.01, ***p<0.001;*
See Appendix III for the complete information of estimates for the four peer rating items.

A. Statistics for dependent variables

Table III presents descriptive statistics for the dependent variables, indicating overall high peer ratings. Among the four items, Peer Listener has the highest average (M = 7.46, SD = 1.61), while Peer Effort has the lowest mean (M = 7.11, SD = 1.70), followed by Peer Ideas (M = 7.34, SD = 1.65) and Peer Enacted (M = 7.22, SD = 1.65). The negative skewness values suggest a tendency that students were more likely assigned higher ratings, while the positive kurtosis values indicate that the distribution is more peaked and contains more outliers.

In terms of correlations between peer rating items, the base models show statistically significant associations between them (see the supplementary files). More specifically, Peer Ideas shows a positive association with Peer Enacted and Peer Efforts but a negative correlation with Peer Listener. The coefficient estimates further suggest that the association between Peer Ideas and Peer Enacted is statistically significantly stronger than the associations of Peer Ideas with the other two items.

B. Main effects of gender, race, and nationality

Table IV shows the estimates for the main effects of gender, race, and nationality, suggesting different patterns of the influences of students' demographic identities on their contributions to course teamwork. Students' gender was statistically significantly related to their assigned values of Peer Listener and Peer Effort, with male students having lower mean peer ratings (Model 1 in Table IV). On average, male students were assigned 0.159 ($p < 0.001$) lower than female students on the item of Peer Listener, suggesting that male students were

perceived as being less likely to encourage new perspectives by listening to their teammates compared to their female counterparts. Similarly, male students were assigned 0.104 ($p < 0.001$) lower than female students on the Peer Effort item, on average. This indicates that male students were perceived as doing less than their fair share of work for team assignments compared to their female counterparts. On the contrary, students' gender did not show a statistically significant relationship with contribution to team ideas, although male students had slightly greater mean peer ratings of Peer Ideas and Peer Enacted than their female teammates.

In terms of the relationship between students' race and their peer rating values, on average, White students were assigned 0.112 ($p < 0.01$) higher points on Peer Ideas but 0.251 ($p < 0.001$) lower points on Peer Listener compared to their teammates from minoritized groups (Model 2 in Table IV). This pattern extended to the comparison between White students and their Asian teammates, although the difference in Peer Listener mean values between the two racial groups was not statistically significant. Accordingly, White students were perceived as sharing more ideas and of having their ideas heard more frequently than their teammates from other racial groups, while also being perceived as less likely to encourage new perspectives by actively listening to their teammates. Also, Table IV indicates that students' race was not statistically significantly related to the adoption of ideas or the perceived effort contributed to teamwork.

Students' nationality was significantly related to mean values of Peer Ideas, with international students having a 0.162 ($p < 0.001$) lower mean compared to their domestic teammates (Model 3 in Table IV). This suggests that international students were perceived as contributing fewer ideas compared to their domestic counterparts. In addition, international students were perceived as more likely to encourage new perspectives by actively listening to their teammates, and their ideas tended to be utilized more frequently. However, these patterns were not statistically significant.

C. Intersectional analyses

The examination of the interaction item in Model 4 – 6 reveals statistically nonsignificant interactions between each pair of the three social identities. Taking the interactions into account, we found that the observed patterns of their main effects largely remained consistent, except for the influence of students' nationality on Peer Ideas and the racial effects on Peer Listener. International students were perceived as contributing ideas similarly to their domestic counterparts while controlling for the impact of their race (Model 6 in Table IV). Moreover, when controlling for the effects of students' gender or nationality, Asian students' assigned Peer Listener means became statistically significantly greater compared to their White teammates, with increases of 0.114 ($p < 0.05$) in Model 4 and 0.136 ($p < 0.05$) in Model 6, respectively (Table IV). In the following subsections, we will delve into the results of the intersectional analysis for models 4 – 6.

Model 4: Gender × Race

Fig. 1 illustrates the differences in peer rating means across intersectional groups of gender and race. Compared to other racial groups, both female and male White students were assigned higher Peer Ideas means (Fig. 1.a) but lower Peer Listener means (Fig. 1.b). These findings may imply that teammates perceived White students as being more likely to speak up and share many ideas but less likely to behave as an active listener who fostered new perspectives from others. Despite the observed race-based disparities in how actively students shared ideas to their team, the pattern was not reflected in the integration of students' ideas into their teamwork (Fig. 1.c). The main difference in Peer Listener average scores was identified among female students from the Minoritized group, with a lower mean compared to White and Asian female students. By combining their highest Peer Listener average score among the subgroups in Fig. 1.b with one of the lowest Peer Idea means in Fig. 1.a, we may interpret that female students from the Minoritized group were viewed by their teammates as engaged listeners who were more willing to integrate their teammates' ideas but were less likely to express their own ideas.

Our analysis also reveals gender-based differences among racial groups presented in Peer Listener (Fig. 1.b) and Peer Efforts (Fig. 1.d), particularly for White students and students from the minoritized group. This may suggest that White and minoritized female students were more likely to be perceived as encouraging new perspectives by actively listening to their teammates and doing more than their fair share of work for their teams compared to their male counterparts. This trend did not extend to Asian students.

Model 5: Gender × Nationality

As observed in Model 4, gender-based differences were mainly present in Peer Listener and Peer Effort means, particularly for domestic students (Figures 2.b and 2.d). These results may indicate that female domestic students were perceived as outperforming their male teammates in terms of active listening and making efforts to accomplish team tasks. Although female international students behaved were rated more similarly to male counterparts on active listening, they were perceived as working harder in teamwork.

International male students' average Peer Ideas score was significantly lower than that of domestic male students, suggesting that international male students were perceived as less likely to actively share ideas (Fig. 2.a). This pattern was also seen in the female subgroups but was not statistically significant. Moreover, the proximity of the two lines in Fig. 2.c indicates that whether students' ideas were used in their teams did not vary by the intersection of gender and nationality.

Model 6: Nationality × Race

Our investigation reveals that variations in mean peer ratings across groups at the intersection of nationality and race were primarily evident in domestic students' Peer Ideas and Peer Listener scores (Figures 3.a and 3.b). On average, domestic White students were assigned higher scores of Peer Ideas yet lower scores of Peer Listener compared to teammates from other racial groups. This finding suggests that domestic White students were perceived as more likely to offer ideas but less inclined to engage in active listening with teammates.

When comparing within same racial groups, although domestic and international students were assigned different peer

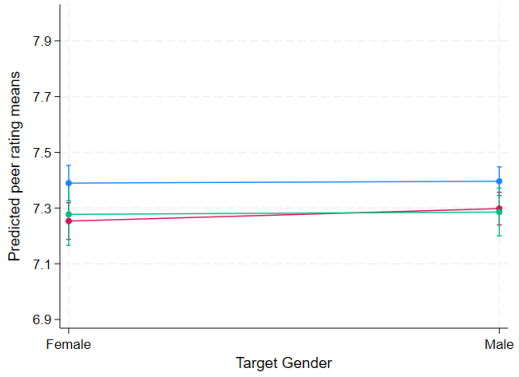

Fig. 1.a. Peer Ideas

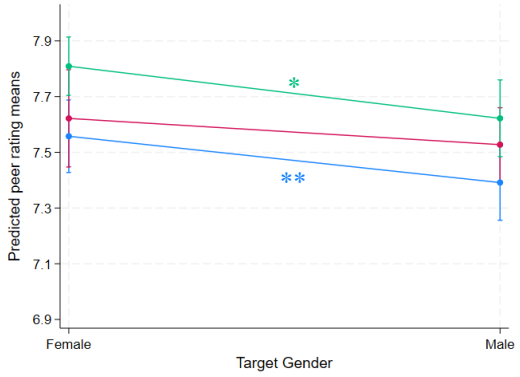

Fig. 1.b. Peer Listener

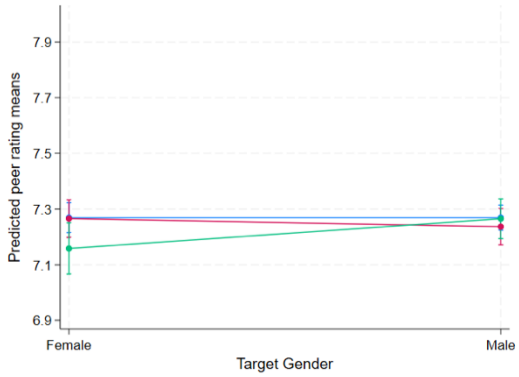

Fig. 1.c. Peer Enacted

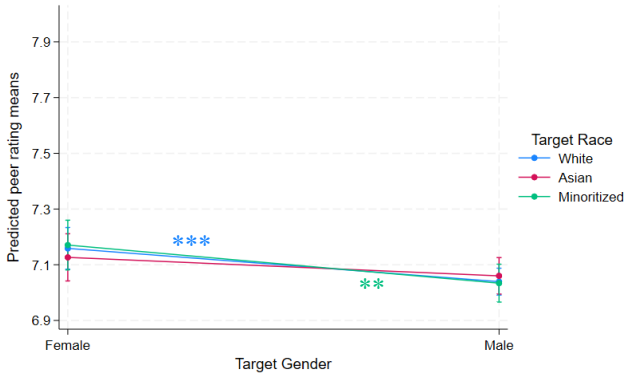

Fig. 1.d. Peer Efforts

Fig. 1. Peer rating means as a function of students' gender and race

*Note: Error bars represent 95% confidence intervals. Asterisks (*) denotes a statistically significant difference in mean values between female and male racial groups. *p<0.05, **p<0.01, ***p<0.001. Fig. 1.a: White female students (the left-handed blue point) received higher average value of Peer Ideas compared to Asian females (the left-handed red point) and female students from the Minoritized group (the left-handed green point), with statistical significance (p < 0.01 and p <0.05, respectively). This trend was also observed when comparing male students among racial groups. Fig. 1.b: White male students (the right-handed blue point) received lower average value of Peer Listener compared to Asian meles (the right-handed red point) and male students from the Minoritized group (the right-handed green point), with statistical significance (p < 0.05 and p <0.001, respectively). This trend was also observed when comparing White female students to female students from the Minoritized group (p <0.001). Fig. 1.c: Female students from the Minoritized group (the left-handed green point) received lower mean (p < 0.01) of Peer Enacted compared to White females (the left-handed blue point).*

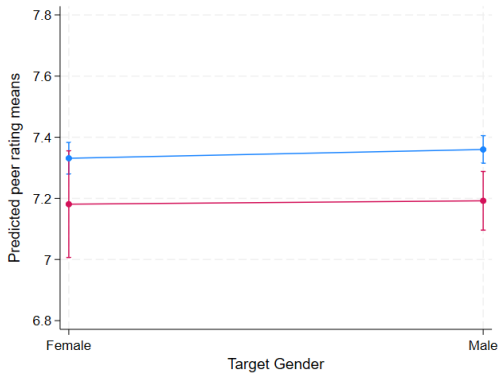

Fig. 2.a. Peer Ideas

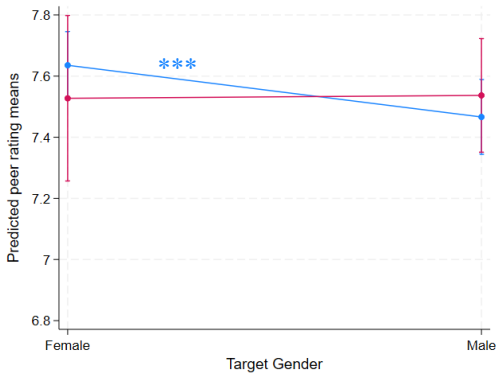

Fig. 2.b. Peer Listener

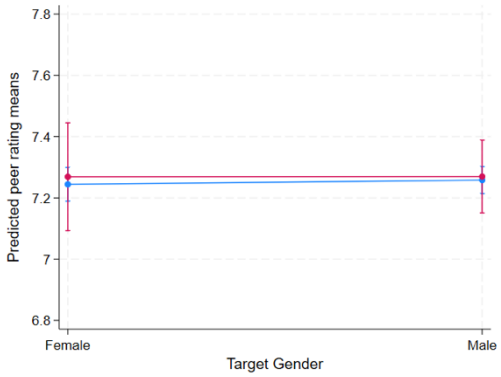

Fig. 2.c. Peer Enacted

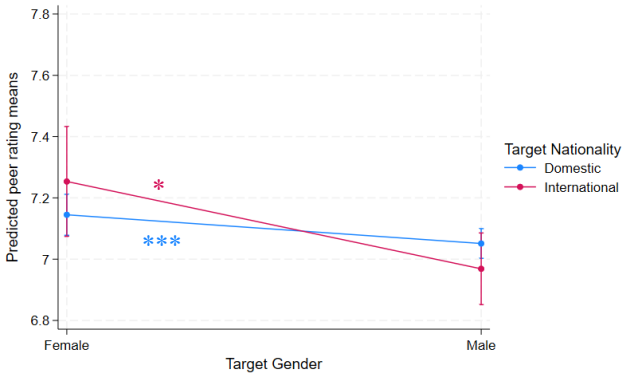

Fig. 2.d. Peer Efforts

Fig. 2. Peer rating means as a function of students' gender and nationality

*Note: Error bars represent 95% confidence intervals. Asterisks (*) denotes a statistically significant difference in mean values between female and male racial groups. *p<0.05, **p<0.01, ***p<0.001. Fig. 2.a: Male international students (the right-handed red point) received lower average value of Peer Ideas compared to domestic meles (the right-handed blue point), with statistical significance (p < 0.01).*

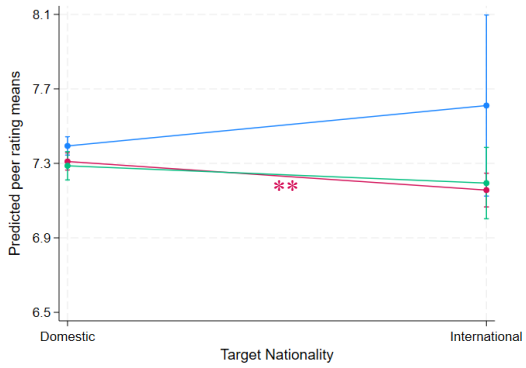

Fig. 3.a. Peer Ideas

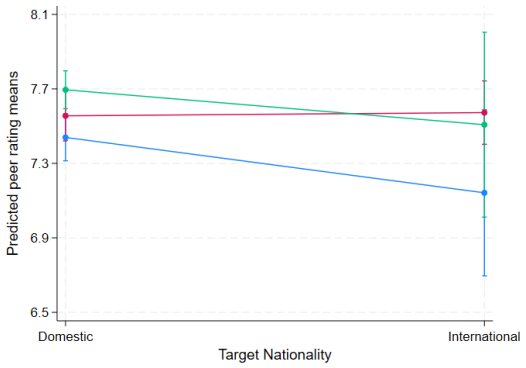

Fig. 3.b. Peer Listener

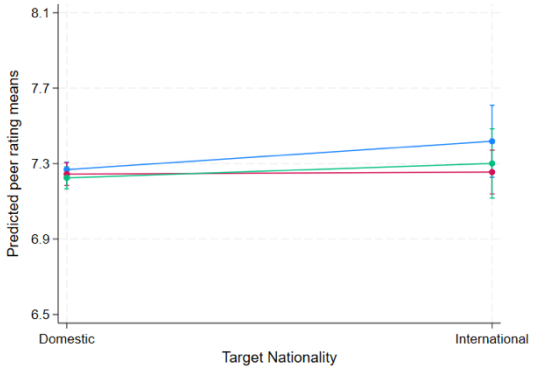

Fig. 3.c. Peer Enacted

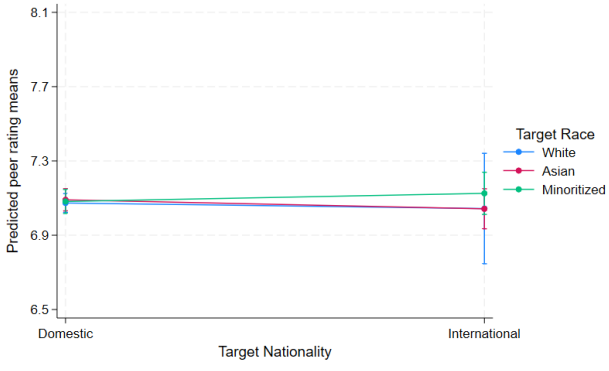

Fig. 3.d. Peer Efforts

Fig. 3. Peer rating means as a function of students' nationality and race

*Note: Error bars represent 95% confidence intervals. Asterisks (*) denotes a statistically significant difference in mean values between domestic and international groups. *p<0.05, **p<0.01, ***p<0.001. Fig. 3.a: Domestic White students (the left-handed blue point) received higher average value of Peer Ideas compared to Domestic Asian students (the left-handed red point) and domestic students from the Minoritized group (the left-handed green point), with statistical significance (p < 0.001 and p < 0.01, respectively). Fig. 3.b: Domestic White students (the left-handed blue point) received lower average value of Peer Listener compared to Domestic Asian students (the left-handed red point) and domestic students from the Minoritized group (the left-handed green point), with statistical significance (p < 0.05 and p < 0.001, respectively).*

rating values, the differences in average scores are statistically non-significant (Fig. 3.a – 3.d), except for Asian students' Peer Ideas (Fig. 3.a). On average, domestic Asian students were viewed as more likely to voice and actively offer ideas compared to their international counterparts. In addition, Fig. 3.a – 3.d show that, although the range between the lowest and highest average peer rating scores was wider for international racial subgroups than for domestic students, the differences were not statistically significant. This may be due to the obviously smaller sample size of international racial subgroups (e.g., only 7 White international students).

IV. Limitations

Although our analysis provides some interesting insights, a number of limitations should be taken into account. First, it is important to clarify that while the university uses the term "gender" for our variable of interest, the data we received was categorized under "sex" and included two groups - *male* and *female*. For our race variable, we pooled the institutional categories representing Black, Hispanic, Native American, and Hawaiian students into one collective Minoritized group due to their low occurrence rates, which aligns with established quantitative methodologies. We recognize that our data and methodological choices are not ideal, necessitated by limitations in the available institutional data and shaped by historical trends of inclusion and exclusion impacting the representation within our dataset.

Second, although multilevel modeling takes into account variability across levels, this study only examined targets' gender, race, and nationality as main factors at the student level, without considering their roles as moderators on team dynamics and other factors at student (e.g., motivation, self-efficacy, personality traits, and academic performance), team (e.g., team size, team task difficulty) and course (e.g., instructor teaching practice and class format) levels. Previous research has indicated the importance of these factors in shaping students' teamwork effectiveness (e.g., [3], [7], [11], [13], [18]). Furthermore, our analysis did not examine the biases in peer assessment that may arise due to the demographic characteristics of the raters (i.e., those who evaluated their teammates), as demonstrated in our previous study [12].

Third, our study considered students' contributions to course teams by using survey items to broadly assess their ideas and efforts. We did not delve into ideas or efforts specifically pertaining to professional technical or logistical aspects.

Fourth, our analysis focused on the central tendency (i.e., average peer ratings) of demographic subgroups throughout the course, though differences across groups might manifest as differences in the shape of the distribution rather than differences in the mean. We also acknowledge that the impact of demographic factors on student team contributions may change over time. Therefore, future studies should conduct longitudinal cross-sectional analyses to gain insight into this question.

V. Conclusion

In this study, we applied a quantitative intersectional approach to examine the intersectional impacts of gender, race, and nationality on the perceived team contributions of engineering students in team-based learning contexts. The findings indicate that students' social identities were related to the team communication process (e.g., actively sharing and listening to ideas) but were less related to team behaviors like enacting ideas and making efforts to complete team tasks.

Our findings suggest that White, male, and domestic students may exert greater influence on conversations during the brainstorming process. White students were perceived to offer more ideas and were less likely to encourage or listen to what their teammates shared compared to other racial groups. White and minoritized female students were more likely to be attentive listeners than their male counterparts. This may be related to racial and gender stereotypes in engineering: White men may be seen as natural engineers while students from other intersectional social groups (e.g., female students from the Minoritized group) may be more likely to be perceived as incompetent, afraid to offer ideas, and inclined to avoiding conflicts if their ideas differ from those of White males [19].

In terms of the effect of nationality, international students were less likely to offer opinions than domestic students, especially international male students and Asian international students; however, our results did not show statistically significant differences in active listening between domestic and international gender or racial subgroups. In addition to potentially having less voice, international students may also have language barriers that put them at a disadvantage in group discussions and make it difficult for them to effectively express their opinions.

It is notable that, although Asian students have not typically been viewed as an underrepresented racial group in engineering based on demographic representation, our results indicate that they exhibited similar patterns to the Minoritized group in terms of sharing ideas and engaging active listening with teammates. This aligns with trends identified in prior research [9].

Our analysis also illustrated limited differences in the adoption of ideas offered by intersectional subgroups when idea contribution was controlled for, except for Minoritized female students, whose ideas were perceived to be less frequently utilized compared to those of White female teammates. The results are different from those of Henderson [9], which may be attributed to the greater diversity of our sample in terms of educational levels, courses, and group activities. For example, juniors or seniors might share more similar personal epistemologies about engineering knowledge and then be more likely to acknowledge others' contributions [9].

The main gender-based disparity was shown in students' perceptions of their teammates' efforts towards team tasks. Female students, regardless of their race and nationality, were more regularly perceived as contributing fairly to the team's efforts than their male counterparts.

Overall, our study illustrates important patterns in students' contributions to teams across intersectional social identity subgroups and provides essential insights for instructors and course designers. The findings can support faculty and faculty developers in creating and implementing effective and inclusive learning materials, promoting equity in engineering education.

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