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Work-in-Progress: Do International Peers Boost Team-Based Learning Effectiveness in Undergraduate Engineering Education?

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Students learning in teams have long been viewed as an effective pedagogical tool in undergraduate engineering education (e.g., Felder & Brent, 2016; Wankat & Oreovicz, 2014). Evidence from the literature indicates that team-based learning approaches usually effectuate more favorable student learning outcomes and learning behaviors, in terms of knowledge acquisition and retention, higher-order thinking, and better positive attitudes towards learning (Amelink & Creamer, 2010). While studies have also shed light on how student team composition affects the learning effectiveness of students (Layton et al., 2010), research on such topics is relatively thin, and much less effort has focused on international engineering students or the dimension of cultural diversity (for examples of exceptions see Staples & Zhao, 2006). This literature gap is concerning, considering the boom of international students in the U.S. engineering education system and the benefits of creating a diverse and inclusive engineering workforce (Chubin et al., 2005). According to the Engineering by the Numbers (American Society for Engineering Education, 2020), the percentage of bachelor's degrees in engineering awarded to international students has grown from around 7% in 2011 to more than 10% in 2019. Motivated by this literature gap, in this work-in-progress, we aim to address the research question of the extent to which international peers boost team-based learning effectiveness in undergraduate engineering education.

Background

Our study adds to the broader literature on cultural diversity. Although there is no consensus in the literature regarding how to measure cultural diversity, metrics have to quantify culture differences include cultural values (e.g., Hofstede, 2001), linguistic-based measures (e.g., West & Graham, 2004), and simply using countries of origin as categorical data (e.g., Morosini et al., 1998). For example, Hofstede's instruments and culture models were developed to quantify national differences in six dimensions: power distance, individualism vs. collectivism, masculinity vs. femininity, uncertainty avoidance, long term vs. short term normative orientation, and indulgence vs. restraint (Hofstede et al., 2018). Another notable example of quantifying culture distance was proposed by West & Graham (2004), who argued that the linguistic-based measures are "more fundamental and more widely applicable" (p. 239). In terms of student team collaboration context, Woods et al. (2021) used Sharma's survey instrument on ten personal cultural orientations, expanded from Hofstede et al.'s (2018) national cultural dimensions, to predict students' reported power distance by their uncertainty avoidance and metrics of country culture. Alternatively, Wei et al. (2019) examined the cultural influence on peer ratings of teammates between international and domestic students by considering team members' cultural orientation on individualism based on their internationality. Following Wei et al. (2019), we define teams consisting of students born in different countries as multicultural teams, as a more straightforward and fundamental way to investigate international students' teaming experiences in U.S. institutions, given the sole focus of our research question on international students.

Data

In this project, we leverage first-year engineering student team data at a large, Midwestern university to evaluate the effects of team cultural compositions on team effectiveness with respect to their country of origin. Our sample consists of students enrolled in a first-semester introductory engineering course (referred to as ENGR101 hereafter) in the Fall 2018 and 2019 semesters. The summary statistics of our sample are presented in Table 1. Among our sample of around 3,900 students, 62% are in teams having at least one international student, and 21% of our sample self-identify as women. Similar to many national datasets (e.g., the Integrated Postsecondary Education Data System), our dataset only has the race/ethnicity category for domestic students, while all international students are aggregated into a single category. The majority of our sample consists of students born in the United States (79%), followed by China (3.6%) and India (3.5%). Countries with low numbers of students are aggregated into regional groupings given their small sample sizes.

Table 1

Summary Statistics

		Proportion (%)
Group Compositions	Multicultural Team	62.1
Gender	Women	21.1
Race/Ethnicity	African-American / Black	1.6
	Asian American	12.6
	Hispanic / Latinx	5.2
	International	16.2
	White	58.0
	Other	6.4
Region of Birth	Africa	0.5
	Canada	0.6
	Central/Eastern Europe/Central Asia	0.7
	Central/South America	0.4
	China	3.6
	Other East Asia	1.1
	India	3.5
	Latin/Hispanic	2.6
	Malaysia	0.8

Other Middle East	1.2
Northern/Southern/Western Europe	1.0
Republic of Korea	1.4
Saudi Arabia	0.8
Other South/Southeast Asia	2.2
Turkey	0.6
United States	79.0
N	3,916

At the beginning of ENGR101, students are nominally assigned into 4-person learning groups using the CATME Team-Maker tool (Layton et al., 2010). The students are assigned into teams based on an algorithm that considers students' gender, race/ethnicity, previous educational background and experiences, schedule availability, and internationality to increase the chances of a successful team with positive dynamics based on small group research literature. See Layton et al. (2010) for a more detailed description of the criteria for team assignment and the rationale for their implementation. Students sit together during class time and work extensively on team-based assignments and projects within each team. To monitor and evaluate team dynamics and collaborations, students provide self- and peer-evaluations at four different points during the semesters studied. Within each of these evaluations, five dimensions regarding team learning effectiveness are assessed, including "Contributing to the Team's Work", "Interacting with Teammates", "Keeping the Team on Track", "Expecting Quality", and "Having Relevant Knowledge, Skills, and Abilities". See Ohland et al. (2012) for more details regarding each index. In this work-in-progress, we used self- and peer-evaluations of teamwork behaviors to proxy for team learning effectiveness due to the high correlation between self/peer-evaluations and student course performance in terms of test scores.

Method

To address our research question of whether international peers boost team-based learning effectiveness in undergraduate engineering education, we used a multivariate regression model structured to isolate variation based on the unique assignment of students to groups for identification. Eventually, we examine the effects of multicultural team compositions on self- and average peer-ratings to address our research question. While the regression coefficients on self- and average peer-ratings are our parameters of interest, we also controlled for demographic characteristics to account for the systematic differences in ratings among different demographic groups, and we also controlled for high school GPA to proxy for the prior ability before they enter college. The functional form of our regression model is:

$$y_{itc} = multicultural_i + \boldsymbol{D}_i + g_i + \boldsymbol{R_{itc}} + \boldsymbol{T_{ic}} + \boldsymbol{C_{it}} + \varepsilon_{itc}\ , \quad (1)$$

In equation (1), the bold components stand for vectors. We used y_{itc} to denote the self-rating and average peer-rating of student i in evaluation period t for CATME dimension c, $multicultural_i$ to denote whether student i is in a multicultural group, $\boldsymbol{D}_i$ to denote the demographic variables including gender, race/ethnicity, and region of birth of student i, while g_i denotes the high school GPA (in terms of percentiles) of student i, $\boldsymbol{T}_{ic}$ denotes the time and evaluation period fixed-effect, $\boldsymbol{C}_{it}$ denotes the CATME dimension fixed effect, and ε_{itc} denotes the error term, clustered at the student team level.

Since students in our sample are assigned into teams with a systematic framework that is not purely random, one may have the concern that students in multicultural teams and domestic student teams are systematically different in terms of unobserved and observed variables, e.g., prior academic abilities. In order to mitigate this concern, we also regressed the high school GPA variable against the complete set of control variables (except the high school GPA variable itself) in equation (1). In results omitted for brevity, we found multicultural group assignment is not statistically significantly correlated with high school GPA, suggesting students in multicultural teams and domestic student teams have similar pre-college performances, supporting the validity of our research design.

Preliminary Results and Implications

Table 2 present our preliminary results. Given the purpose of our research question, we only focus on the coefficient of multicultural team. Essentially, our results indicate that students in multicultural teams have, on average, a 0.042 unit higher peer-rating and a 0.039 unit higher self-rating, statistically significant at the 0.1 level on the scale of 1 to 5. Converting our effect sizes to standard deviation levels, a 0.042 unit increment in peer-rating is equivalent to 0.07 standard deviation higher level of peer-rating, while a 0.039 unit increment in self-rating is equivalent to 0.05 standard deviation higher level of self-rating. While these effects are small to modest in size, they are nontrivial, and they highlight the potential benefits of enrolling students from different countries of origin into the same learning group, in terms of boosting self- and peer-ratings. Results from our study have the potential to shed light on an effective strategy using student learning teams to facilitate team collaboration.

One limitation of this work in progress is that we used self- and peer-ratings to proxy for team learning effectiveness. For future directions, we aim to leverage structural equation modeling to mitigate this limitation, by treating team dynamics as an unobserved variable that affects student academic performances in the underlying class, and also examine the interactions between multicultural team structure and team dynamics across the different evaluation periods along the semester.

Table 2

Regression Results of CATME Ratings for Fall 2018 and Fall 2019 Semesters

		Peer-Rating	Self-Rating
Group Compositions	Multicultural Team	0.042*	0.039*
		(0.020)	(0.020)
Gender	Men	-0.119***	0.027
		(0.025)	(0.024)
Race/Ethnicity	African-American / Black	-0.147**	-0.029
		(0.070)	(0.055)
	Asian-American	-0.047*	0.020
		(0.026)	(0.026)
	Hispanic / Latinx	-0.110***	-0.069*
		(0.036)	(0.037)
	International	-0.172***	-0.047
		(0.046)	(0.044)
	Other	-0.044	-0.050
		(0.033)	(0.033)
High School GPA	GPA	0.268***	0.051
		(0.038)	(0.038)
Region of Birth	Africa	0.020	-0.066
		(0.084)	(0.100)
	Canada	-0.068	-0.263***
		(0.078)	(0.093)
	Central/Eastern Europe/Central Asia	-0.060	0.045
		(0.119)	(0.109)
	Central/South America	0.119	-0.154
		(0.114)	(0.110)
	China	0.064	0.120**
		(0.055)	(0.056)
	Other East Asia	0.097	0.005
		(0.071)	(0.081)
	India	-0.052	0.007
		(0.061)	(0.053)
	Latin/Hispanic	-0.006	0.084
		(0.057)	(0.058)
	Malaysia	0.053	-0.113
		(0.090)	(0.097)
	Other Middle East	-0.049	-0.036
		(0.093)	(0.077)
	Northern/Southern/Western Europe	0.005	-0.034
		(0.083)	(0.084)

	Republic of Korea	-0.080	-0.081
		(0.092)	(0.090)
	Saudi Arabia	0.078	-0.044
		(0.094)	(0.082)
	Other South/Southeast Asia	0.035	-0.147**
		(0.071)	(0.066)
	Turkey	-0.153	0.153
		(0.132)	(0.120)
Evaluation Time	2	0.049***	0.068***
		(0.007)	(0.008)
	3	0.097***	0.103***
		(0.007)	(0.009)
	4	0.163***	0.171***
		(0.008)	(0.009)
Semester	Fall 2019	-0.020	-0.047***
		(0.016)	(0.016)
CATME Dimensions	E	0.026***	0.055***
		(0.005)	(0.007)
	H	0.184***	0.143***
		(0.005)	(0.007)
	I	0.048***	0.103***
		(0.006)	(0.007)
	K	-0.063***	0.013*
		(0.005)	(0.007)
N		78,100	

Note. ***/**/* denote 0.01/0.05/0.1 significance levels, respectively. Standard errors clustered at the individual level are reported in parenthesis. Models are specified as linear regressions. The baseline groups for race/ethnicity, evaluation time, CATME dimensions and region of birth are White, 1, C and United States, respectively.

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