

Impacts of Diversity-Focused Team Formation on Learning in Online and Face-to-Face Environments



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Abstract

This study assesses the impact of diversity-focused team formation and class format on student learning outcomes in a team-based learning agricultural statistics class. From 2019 to 2021, students (n = 124) were sorted into teams based on CliftonStrengths core strength categories and demographic attributes. So-called “diverse” teams have all strengths represented, at least one historically under-represented minority (URM), and at least two genders; “not-diverse” teams were missing representation from each strength, URM, and/or gender. The class was taught using team-based learning (TBL) with face-to-face and online team learning sections. In these teaching paradigms, the lectures were viewed asynchronously, whereas team learning was facilitated in a face-to-face setting or in an online Zoom meeting. A difference-in-difference approach elicited differences in peer evaluation, team satisfaction, and grades based on the team formation treatment, the class format treatment, and the simultaneous team formation and class format treatments. The results of the study suggest that diversity-focused team formation has little impact on most metrics; however, diverse teams do have lower team-learning scores and perceived team performance. The class format has a large impact on almost all metrics implying that instructors should take more time considering class format rather than group composition in TBL.

Keywords: team-based learning, diversity, peer evaluation, online learning

Team-based learning (TBL), developed in the 1970s, is a pedagogical tool for engaging students in learning in a way that is fun and highly effective. Team learning is increasingly valued for workplace readiness (Crawford & Fink, 2020; Yeager & Nafukho, 2012) and learning improvements in economics (Asarta et al., 2021; Cagliesi & Ghanei, 2021; Espey, 2012). The key to this approach is that students remain in the same team throughout the course of the semester as they move through Tuckman’s stages of team formation (forming, storming, norming, and performing) in the TBL process of readiness assurance, problem-solving, and peer review (Michaelson et al., 2004). Given that students remain in the same team for the entire semester, team formation is an important consideration. Research suggests that perceived diversity in teams can have both positive and negative impacts on team learning (Birmingham & McCord, 2004; Shemla et al., 2016) yet the impacts of team formation is relatively under-studied, particularly in economics (Cagliesi & Ghanei, 2021).

The pandemic has posed additional challenges to implementing TBL with consistent teams. In spring 2020, education was disrupted with universities moving all courses online for much of 2020 to prevent the spread of the novel coronavirus commonly known as COVID-19. Within the TBL community, efforts to create best practices for online TBL began before the pandemic (Clark, 2018). This included the creation of TBL-specific software to facilitate the main stages of TBL. Nevertheless, the transition to online can be challenging with TBL as lectures are typically asynchronous endeavors, and class time is spent actively working in teams on significant problems that require a great deal of collaboration (Jumat et al., 2020). Instructors must find a way for students to meet (either synchronously or asynchronously) to engage in peer-to-peer learning exercises.

Literature Review and Study Objectives

Team formation is an integral part of TBL (Michaelson et al., 2004) and as such, some studies have looked at the impacts of team formation on individual and team outcomes (Edmondson, 1999; Farland et al., 2019; Ohland et al., 2012; Thompson et al., 2009; Zellmer-Bruhn et al., 2008). The study most like this current study, Farland, et al. (2019) formed teams to be heterogeneous as determined by the student's results on the Basadur Creative Problem-Solving Profile inventory which sorts students into one of four problem-solving profiles. In that study, the authors used measures such as readiness assurance tests, peer evaluation, and the team performance scale (TPS) as outcomes to compare under various team formation strategies. The authors found that forming teams using this approach had no impact on team performance, satisfaction, or quality of team interactions although they do note that only using the problem-solving inventory and no other attributes such as gender and age was a limitation of their study (Farland et al., 2019). Other studies have found team formation to have an impact in an organizational setting. One study found that diverse teams can increase cultural sensitivity (Van Der Zee et al., 2004) while another found that perceived diversity led to an increase in conflict in teams (Zellmer-Bruhn et al., 2008).

Research on TBL and other team-learning paradigms in agricultural sciences and in economics is quite sparse and largely descriptive. In a 2020 pre-pandemic survey, authors at the University of Delaware found that only around 30 percent (median = 22 percent) of respondents reported using cooperative learning/small-group assignments in their economics courses which represented an increase from previous surveys (Asarta et al., 2021). Cagliesi and Ghanei (2021) study TBL in an economics classroom and find that it enriches "learning, contextualizing, and applying economics to different issues and policies". In addition to noting the lack of studies on TBL in economics, they also highlight the lack of studies on TBL in an online setting as an important area of future inquiry (Cagliesi & Ghanei, 2021).

From a teaching paradigm perspective, there has been a flurry of research on adaptations made during the pandemic to accommodate a largely online pedagogy. Much of the articles within the broader literature relate to best practices for converting classes quickly to online learning from a face-to-face learning environment (Morgan et al., 2020), building pandemic-inclusive courses (Hanson & Wachenheim, 2020; Pruitt et al., 2020), and incorporating lessons from the pandemic into teaching (Zacharias et al., 2020). In 2023, a study investigated the impacts of the pandemic on grades in animal sciences; in general, they found that students were unhappy with learner satisfaction throughout the COVID-19 transitions but were able to have similar levels of learning (Vautier, Enns, and Cadaret 2023).

This study fills a gap in the literature by looking at teaching outcomes under a TBL pedagogical approach in an agricultural statistics context. The pandemic provided an additional opportunity to assess the impact of diversity-minded team formation and satisfaction outcomes under various teaching and learning paradigms. This study uses a

difference-in-difference methodology to address three overarching objectives:

1. Assess the impacts of diversity-minded team formation, using the CliftonStrengths and demographic attribute approach, on various student outcomes.
2. Assess the impacts of class format, online and face-to-face team learning, on various student outcomes.
3. Assess the interaction of diversity-minded team formation and teaching paradigm of various student outcomes.

Data and Methods

Study Context and Experimental Design

Figure 1 illustrates the typical process of TBL. In TBL, students are expected to read and/or watch asynchronous lectures before coming to class. After engaging with pre-lecture material, students come to class where they are quizzed over the "pre-learning" content through individual readiness assurance tests (iRAT). After the iRAT, and without knowing how they performed in the iRAT, students get into their teams and do the same iRAT together (now called the team readiness assurance test or tRAT). While implementation may vary across classes and instructors, the class in this study implements the tRAT using an "Immediate Feedback Assessment Test" or IFAT which gives immediate feedback about whether their chosen answer choice is correct or not (as indicated by a * on the scratch card). If the first choice is not correct, the team continues to choose alternative answer choices until they come to the correct answer with successively fewer points awarded for each attempt. The questions on the iRAT/tRAT are typically surface-level questions (remember, understand, and apply) such as "which of the following is an example of a descriptive statistic". The iRATs and tRATs are equally weighted, giving an incentive for students to be well-prepared for this activity. After the RAT, the instructor answers any questions students have and may choose to provide a mini-lecture over the most important concepts.

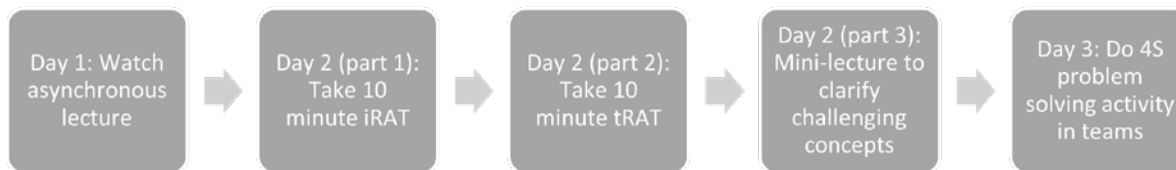
The final step of TBL is the problem-solving phase which takes place in the regular classroom in student teams. More challenging questions (analyze, evaluate, and create) and scenarios are asked of students in a problem-solving activity which may require an additional deliverable. Examples of problem-solving activities include performing a complete regression analysis that each team presents to the class or assessing the appropriate descriptive statistic to use to convey a certain phenomenon.

The author of this study first implemented TBL in 2018 and found that team formation was one of the most challenging and contentious parts of implementing TBL. To determine whether a particular team formation strategy led to better outcomes for students, this study began in the fall of 2019 and ended in the fall of 2021 tracking individual and team performance over 6 semesters (Figure 2). In spring 2020, the class started out as face-to-face and then went online mid-semester due to COVID-19; this semester was

TEAM FORMATION AND LEARNING

Figure 1

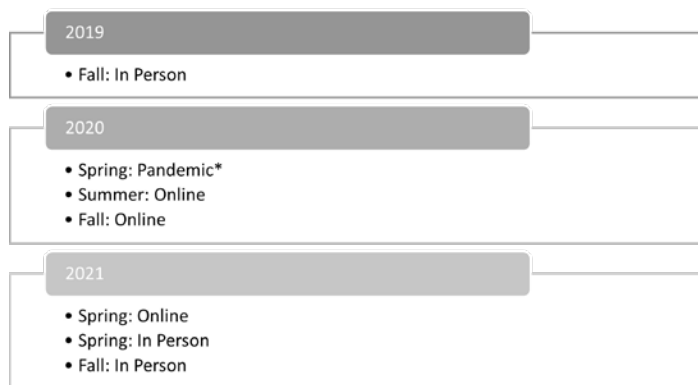
TBL Flow for Each Module



such a departure from “normal” that it was excluded for this analysis (Appendix 1 contains the results from this semester for interested readers). Given the change in modality forced by the pandemic, this provided an opportunity to explore the dual impacts of team formation and course modality. This course was taught online and in person three times each over the study period.

Figure 2

The Timeline and Modality of the Study



Note (*): The pandemic semester was excluded from the study because it was half in-person and half online due to the pandemic occurring in March. The results for the pandemic semester are presented in Appendix 1.

When taught in person, students completed the iRAT, tRAT, and problem-solving activities in the regular classroom under the instructor’s supervision. In the online sections, students were given the iRAT asynchronously in a timed quiz (10 minutes, the same amount of time in the face-to-face class) using a program called Intedashboard. Students had to complete the iRAT before the regular synchronous Zoom session. At the beginning of the online synchronous class, students work through the tRAT in their break-out rooms facilitated by teaching assistants and Intedashboard. After the tRAT, the instructor again provides the mini-lecture and answers clarifying questions before beginning the problem-solving exercise. Intedashboard allows the instructor to see individual and team progress through the readiness assurance process and the problem-solving exercise. It makes it easy to know where teams are struggling even in an online environment.

Data Measures

Given that the team formation aspect of the study began pre-pandemic, team formation across the entire study frame used the same process. The four to six-person teams were intentionally formed to be “diverse” as defined by having the following attributes: at least one student from each dominant strength (executing (E), strategic (S), relationship building (R), and influencing (I), see appendix 2 for full list of strengths in each category), at least two gender identities, and at least two races or ethnicities represented. CliftonStrengths is an online hour-long assessment with 177 paired statements that participants select to ultimately identify the top strengths of the participant (Clifton 2007). The students were asked to take a discounted student version of this assessment and in a learning management system (LMS) quiz, report their top five strengths along with their gender identity, ethnicity/race, and information about their background that might be relevant to the class such as level of comfort with statistics. Based on the top five strengths, students were identified as the strength domain with the highest representation in their top five strengths. For example, the researcher has the top five strengths: Achiever (E), Winning Others Over-WOO (I), Futuristic (S), Arranger (E), and Communication (I). Since their top five strengths include two from E and two from I, this person would be identified as the E domain because the E strengths rank higher than the I strengths. The rationale for using CliftonStrengths as a metric of diversity in teams is that the students already are required to take this assessment in their first semester in the major, so it is an affordable and convenient metric of personality diversity. CliftonStrengths has the added benefit of drawing attention to individual strengths rather than demographic differences.

There were 124 students in this study with 45 percent of the students identifying as white males (Table 1). Only 44 percent of the students were female and 31 percent identified as a minority. There was an equal representation of each strength across the 142 participants (with about 1/5 of the strengths unknown or ambiguous) but that may not have been the case within each semester. Given the constraints of the demographics and strengths of the students, not all teams could be “diverse” by default. Ultimately, 19 of the 28 teams formed over this study period were considered “diverse” based on equal strengths representation, at least two genders, and at least one URM. A not-diverse team may not have had representation from every strength, gender, or ethnic minority. Given the team compositions available to the researcher, there is an opportunity to compare outcomes for students across two treatments: diverse team formation and teaching paradigm (Table 2).

TEAM FORMATION AND LEARNING

Table 1

Demographic composition of study participants by self-reported gender and race/ethnicity

	Female	Male	Total
Asian	2	4	6
Black	4	2	6
Hispanic	6	20	26
White	26	60	86
Total	38	86	124

Table 2

Individuals and teams (in parentheses) in diverse and not diverse teams across teaching paradigm for the study sample

	Diverse	Not Diverse	Totals
Face-to-Face	24 (5)	34 (7)	58 (12)
Fully Online	16 (4)	50 (12)	66 (16)
Totals	40 (9)	84 (19)	124 (28)

Like Farland, et al (2019), this study relies on grades, peer review scores, and team satisfaction as measures of outcomes. Each of the 12 modules in the course had readiness assurance tests (both iRAT and tRAT) and problem-solving activities. The RAT grades were averaged and reported on a 100-point scale for each student. Grades for problem-solving activities are based on completion of the activity and are the same for all members of the team; they were not used as measures in the study as there was little variability in scores across the class. Each semester also featured mid-semester (formative) and final (summative) peer review surveys distributed via Qualtrics with additional team satisfaction instruments included in each of these peer reviews (Appendix 3). Given that these questions are likert scale variables with 1 representing never and 4 representing all the time, average estimates close to 4 imply more frequent observations of these team learning behaviors. The TBL portions of this course (including peer reviews) accounted for 35-40 percent of the course grade.

Within the mid-semester peer evaluation, there were also three questions related to team satisfaction on a strongly disagree to strongly agree scale and seven questions related to psychological safety on a very inaccurate to very accurate scale (Edmondson 1999). These questions were used to determine if teams need to be changed at mid-point because some team members do not feel safe. Over the study period, no teams had to be changed at any point for any reason, including team dysfunction, and these measures are not included in this analysis. In the final peer evaluation, rather than having qualitative feedback on team performance, a team-performance scale (TPS) instrument (Thompson et al., 2009) was used to evaluate the quality of team interactions. The TPS instrument contains 18 questions about team dynamics (all members participated, listened, resolved differences, etc.) on a scale of 0 to 6 with 0 indicating none of the time and 6 indicating all the time (Appendix 3).

Data Analysis Methodology

To analyze the impacts of our two treatments (team formation and class format) on learning and team performance outcomes, we use a difference-in-differences methodology. Figure 3 is a theoretical adaptation from Bradley and Green (2020) illustrating the difference-in-difference approach. The first difference approach considers the difference in the mean of the outcome variable for class format (face-to-face and online) for each group (diverse and non-diverse). The first difference corresponds to the difference between the differences calculated for the two groups (diverse and not diverse) in the first stage. The second difference is how the change in the outcome variables differs between the two groups, which is interpreted as a causal effect. The difference-in-differences approach allows us to determine what would happen to the output variable if the intervention had not occurred (the presumed counterfactual achievement). If there is no impact of a causal factor (such as team formation) on an outcome variable (such as grades) for example, then the differences should remain consistent (i.e. the lines in Figure 3 would be parallel). However, if we observe that there are differences that change over the second aspect of the experiment (the class format) then we will observe that one line goes up while the other remains consistent as shown in Figure 3 and thus know that the two groups were impacted differently under the class format experiment. This approach is useful for capturing the joint impact of a natural experiment (class format in this case) and an imposed treatment (diverse team assignment) simultaneously. Results determine whether differences based on the treatment persisted across the natural experiment or whether differences (such as an inability to communicate) were exacerbated by class format (such as online). The identification assumption of the difference-in-differences method is that the trends of both the treated and control groups are identical in the absence of the intervention.

Results

This results section is presented in three parts: 1) differences in educational outcomes, peer assessment, and team performance for diverse and non-diverse groups, 2) differences in educational outcomes, peer assessment, and team performance for face-to-face versus online, 3) key findings of the double difference effect. Some key takeaways are that most educational outcomes do not differ based on the diversity treatment but do differ by class format. On the other hand, measures of team-cohesion are lower for diverse teams than non-diverse teams although this effect lessens when there is a switch in format (online largely removes the difference in team cohesion). The difference-in-differences effect is only prevalent for the team-performance scale measure.

Results of Diversity-Focused Team Formation Treatment

Interestingly, peer evaluations and most educational outcomes were not statistically different for diverse and non-diverse teams. The only statistically significant differences in the two groups were in the tRAT score and final team-performance scale (TPS) measures (Table 3). The tRAT score is the average score on the group assessment over the semester. Diverse student groups scored 2.93 percentage points lower than not-diverse teams (87.78% compared to 90.71%). With a value of 7 indicating a high degree of perceived team cohesion, diverse groups rated their team performance at 6.41 while not-diverse teams rated their team performance at 6.66. Individual measures, such as iRAT and peer review scores, are not statistically significant in this treatment.

Results of Class Format Treatment

The iRAT scores increased 10% ($p < 0.01$) in the online class format compared to the face-to-face format, and the final course grades increased by 3.59% (Table 4). There was a marked increase in final team satisfaction, peer evaluation scores, and the perception of team-performance (TPS) in the online setting as well. It is not at all surprising to find that students performed better in an online environment, but it is surprising to find that they were more appreciative of their peers (as illustrated by the higher peer evaluations and final team satisfaction scores) and they perceived their team performance to be higher (as shown by the statistically higher TPS score). The only measure that did not see a significant difference in this treatment was the mid-semester team satisfaction score which was highly rated under both teaching formats (4.74 for online and 4.66 for face-to-face).

Results of Difference-in-Differences

The difference-in-difference approach tracks the impact of learning and team satisfaction outcomes under the co-occurrence of diversity and class format treatments. Given that the only statistical difference in the diversity treatment was for the tRAT and the TPS measure, while in the class format treatment, almost all measures were statistically different, it is nice to see which metrics remained statistically significant across both treatments. Based on the results of this estimation, only one outcome had a significant effect in the difference-in-difference estimation: team-performance scale (TPS) (Table 5). The perceived team-performance increased for diverse teams in an online environment compared to an in-person class format (Figure 4).

This study finds that diverse teams tend to have lower team performance and lower team satisfaction relative to non-diverse teams in an agricultural data analysis class. Class format (online) had a positive impact on grades, team satisfaction, and peer evaluation. The combined impact is limited to the perception of team-performance where diverse teams achieved larger gains than not-diverse teams in the online setting. It is not surprising that individual grades were not statistically different across the diversity treatment for two reasons. First of all, individual grades such as the iRAT and final grade tend to be more “noisy” than peer evaluation as individual performance (particularly in a statistics class) can have a large range. At the same time, team performance (the tRAT score) is typically high with not much differences between teams on average. Since team performance on problem-solving is “public” information due to simultaneous report, diverse teams might have perceived their own team to be less cohesive than others if their team consistently answered incorrectly or incoherently during simultaneous report. Moreover, group process studies have found that diverse teams do not have a positive effect except under longer time frames because notable heterogeneity causes conflict early on but tends to resolve and have team benefits later on in the team-forming process (Birmingham & McCord, 2004, p. 75). Unfortunately, the length of a semester (16 weeks) may not be quite long enough to capture the benefits of diverse teams. Overall, the implications of this team-formation treatment might be that diversity-focused team formation might not impact most metrics of student learning and satisfaction.

Looking closer at the team performance scale (TPS) measure and using Figure 3 as a basis for comparison, it is interesting to note the big change in the perception of team learning for diverse groups in an online environment (Figure 4). Given that the team-learning for online learning environments took place largely in break-out rooms and it was not required for students to have on their cameras, it is interesting that diverse teams had a much larger boost in perceived performance relative to their not-diverse peers. Sample questions for the TPS (see appendix 1, page 12) were time-based likert scale questions such as “all team members made an effort to participate in discussions” and “members who had different opinions explained their point of view to the team.” Studies have shown that online learning environments can help the academic performance of under-represented minorities (URMs) by leveling the playing field in terms of educational access (Yeboah and Smith 2016).

While the difference-in-differences is not statistically significant for the tRAT score, it is interesting that the not-diverse teams maintained a lead over the diverse teams (see Figure 5). It is not surprising that both groups had an increase in the tRAT scores given the iRAT scores were 10% higher for online students. However, given the large gains in the TPS (Figure 4), one might have expected the tRAT score gap to be smaller for the diversity treatment in the online class format. In a statistical sense, the tRAT scores were not different between the diverse and not-diverse students in an online format.

TEAM FORMATION AND LEARNING

Figure 3

The difference-in-differences approach with two treatment variables

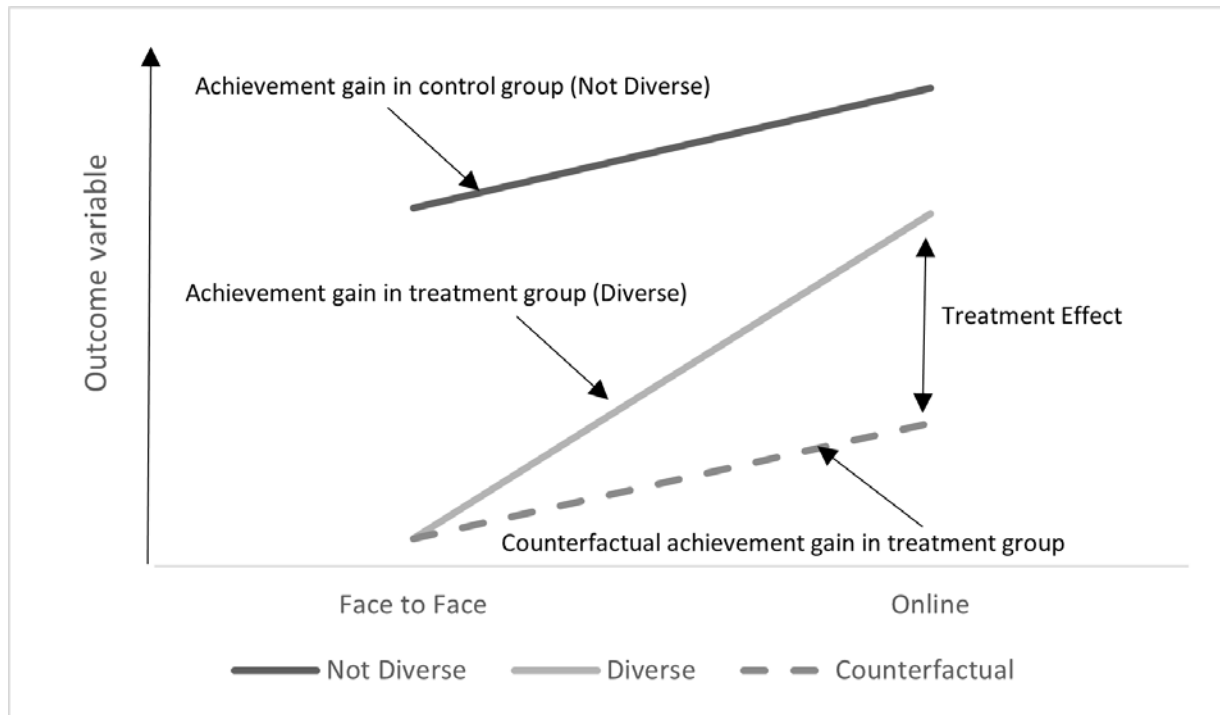


Table 3

Mean difference in learning and team satisfaction outcomes by diversity treatment

Outcome Variable	Diverse		Not-diverse		Mean Difference
	N (1)	Mean (2)	N (3)	Mean (4)	Diverse - Not-diverse (5)
Mid Team Satisfaction	36	4.7407 (0.0862)	76	4.6886 (0.0734)	0.0521 (0.1132)
Final Team Satisfaction	40	3.7450 (0.0218)	84	3.7318 (0.0236)	0.0132 (0.0321)
Mid Peer Evaluation	40	3.7381 (0.0387)	84	3.6784 (0.0299)	0.0597 (0.0489)
Final Peer Evaluation	40	3.7465 (0.0311)	84	3.7530 (0.0387)	-0.0065 (0.0496)
iRAT	40	64.3310 (2.5197)	84	66.7091 (1.8093)	-2.3781 (3.1020)
tRAT	40	87.7854 (1.1322)	84	90.7126 (1.4123)	-2.9272* (1.8101)
Final Grade	40	81.5763 (2.2155)	84	83.1480 (1.2004)	-1.5717 (2.5198)
TPS	37	6.4120 (0.0880)	79	6.6633 (0.0485)	-0.2513*** (0.1005)

Note: Bootstrap standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

TEAM FORMATION AND LEARNING

Table 4

Mean difference in learning and team satisfaction outcomes by class format treatment

Outcome Variable	Online		Face-to-face		Mean Difference
	N (1)	Mean (2)	N (3)	Mean (4)	Online – Face-to-face (5)
Mid Team Satisfaction	58	4.7471 (0.0527)	54	4.6605 (0.1037)	0.0866 (0.1163)
Final Team Satisfaction	66	3.7920 (0.0190)	58	3.6724 (0.0283)	0.1196*** (0.0340)
Mid Peer Evaluation	66	3.7329 (0.0318)	58	3.6575 (0.0354)	0.0754* (0.0476)
Final Peer Evaluation	66	3.7961 (0.0336)	58	3.6995 (0.0455)	0.0966** (0.0565)
iRAT	66	70.6970 (1.8619)	58	60.53103 (2.1171)	10.1659*** (2.8194)
tRAT	66	90.7046 (1.1718)	58	88.70307 (1.7499)	2.0015 (2.1060)
Final Grade	66	84.3233 (1.0950)	58	80.7266 (1.9231)	3.5968* (2.2130)
TPS	60	6.7499 (0.0535)	56	6.4045 (0.0645)	0.3455*** (0.0838)

Note: Bootstrap standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 5

Estimates for learning and team satisfaction outcomes in the difference-in-difference model

Dependent Variable	Midterm Team Satisfaction (1)	Final Team Satisfaction (2)	Midterm Peer Evaluation (3)	Final Peer Evaluation (4)	iRAT (5)	tRAT (6)	Final Grade (7)	TPS - Team (8)
Diff-in-diff	-0.14	-0.04	0.04	0.09	0.58	2.46	-2.28	-0.51***
Face-to-Face treatment:								
Mean not-diverse	4.60	3.67	3.63	3.71	60.81	90.06	80.66	6.58
Mean diverse	4.74	3.68	3.69	3.68	60.13	86.78	80.82	6.16
Diff	0.14	0.01	0.058	-0.029	-0.67	-3.28	0.15	-0.41***
Diverse team formation treatment:								
Mean not-diverse	4.75	3.78	3.71	3.78	70.72	91.16	84.84	6.73
Mean diverse	4.74	3.84	3.81	3.84	70.63	89.30	82.71	6.83
Diff	0.004	-0.063*	-0.099*	0.062	-0.09	-1.86	-2.22	0.098
Obs.	112	124	124	124	124	124	124	116
R-squared	0.01	0.11	0.04	0.03	0.1	0.02	0.03	0.22

Note: Bootstrap standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

TEAM FORMATION AND LEARNING

Figure 4

Team performance scale by class format and diversity treatment on aggregate

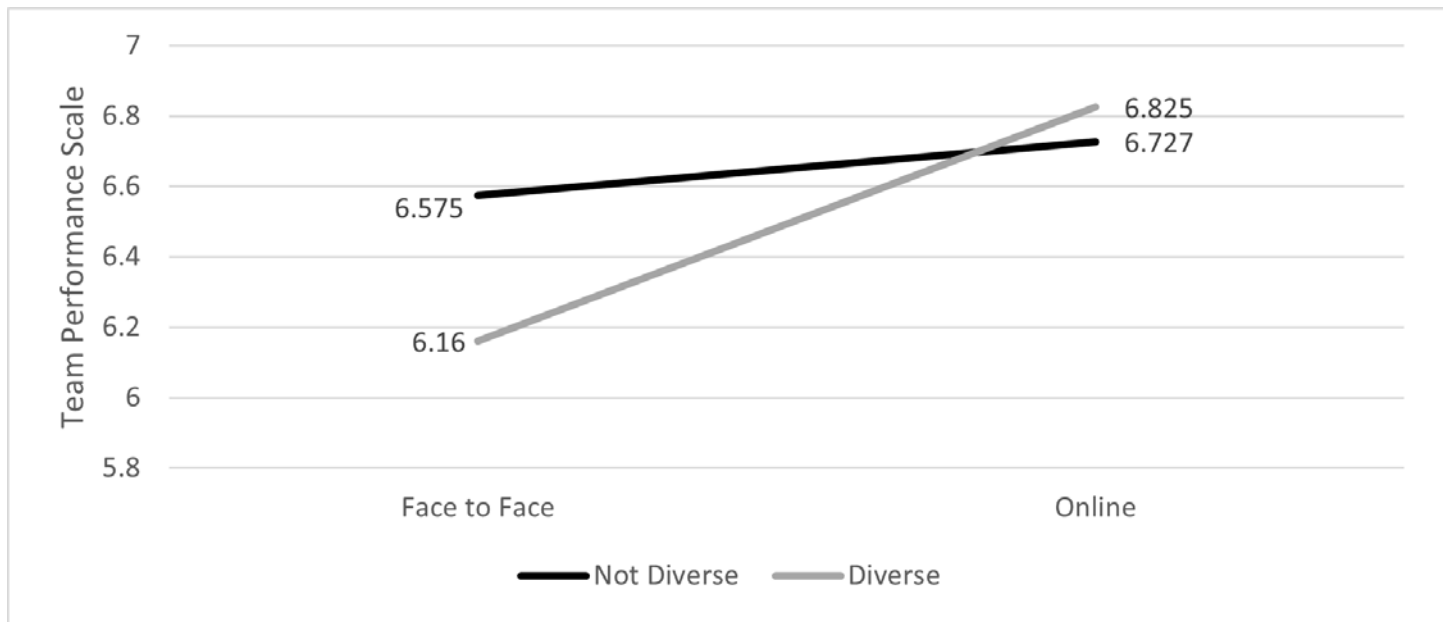
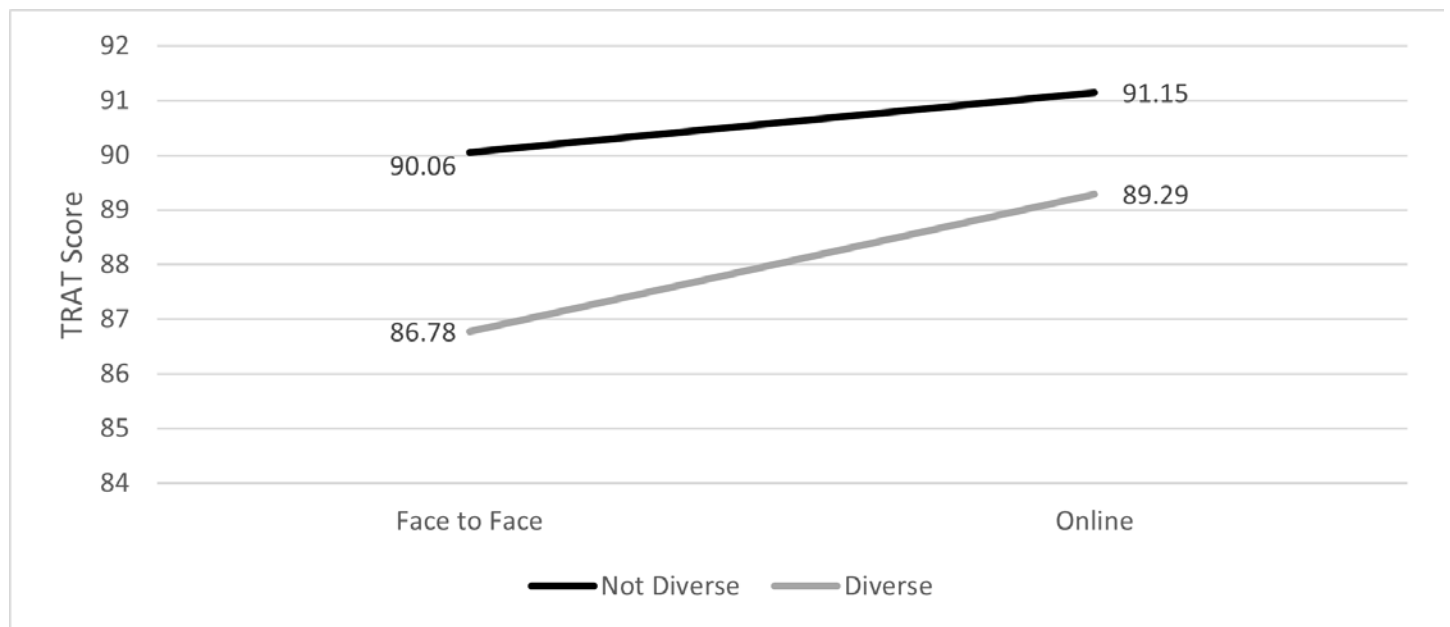


Figure 5

TRAT by diversity and class format treatments on aggregate



Summary

This study was a first look at how diversity-focused team formation and class format impact individual and team-learning and satisfaction outcomes. We find that the class format has a much bigger impact on student outcomes than diversity-focused team formation. Future studies should consider the long-term implications of intentional team formation, perhaps across multiple classes/semesters. It might also be interesting to collect data on students' perceptions of diversity to determine if unconscious bias is a factor in lower peer evaluations for diverse teams. While COVID-19 provided a nice opportunity for a natural experiment, it is undeniable that online learning has changed in our post-pandemic world. Academic integrity is hard to measure; future studies might consider students' perceptions of integrity in an online space. The costs of cheating are reduced in an online environment and the rewards are great. Measuring the benefits and costs of individual performance might be a fruitful area of inquiry and further help us determine how best to teach in this highly technological age.

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TEAM FORMATION AND LEARNING

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