Retrospective Multi-year Analysis of Team Composition Dynamics and Performance within a Yearlong Integrative BME Laboratory Sequence

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Abstract

Undergraduate Biomedical Engineering majors at the University of Virginia must take a core yearlong integrative laboratory sequence, typically during their third year in the program. Students are randomly assigned into teams of 3-4 students in the first semester of this sequence, whereas they are allowed to self-select teams in the second semester. At the end of both semesters, students complete mandatory peer evaluations that are used in calculating participation scores each term for every student in the course. Throughout more than a decade of teaching this sequence, the instructors anecdotally observed that many teams remained together in the spring after having been randomly sorted into teams in the fall semester. However, a rigorous quantitative analysis of the impact of team assignment method on team performance and participation assessments has not been conducted. In the present study, we have evaluated team composition over a six-year period, five of which included randomizing the teams in the first semester and then allowing students to self-select in the spring. In an intervention year, we allowed students to self-select both semesters, providing a comparative group with which to investigate the impact of team formation approach on dynamics and performance throughout each academic year.

We analyzed data from 139 student teams, consisting of 522 students total, calculating the percentage of each team remaining together from the first to the second semester of the sequence (excluding students who took the course out of sequence). We then examined correlations between the team retention and a variety of factors, including instructor-assigned team participation scores, student self-assessments of team performance, performance on team lab reports, and performance on weekly lab quizzes and final exams. In the five years of the study in which students were randomized into teams in the fall semester before choosing their own teammates in the spring, there were 122 teams with an average size of 3.66 students each. Over these five years, 28% of teams retained all of their original student members from the fall to the spring semester, and 45% of teams retained over half of their original members. In the intervention year in which students self-selected both semesters, 53% of teams retained all original members throughout the year, and 71% retained over half of their original members. Our analysis of team composition and performance over the five control years of this lab sequence revealed a weak but significant positive correlation between team retention and average team participation score and self-assessments ($p < 0.005$), but no correlation with the other performance metrics (e.g. report scores, exams, etc.). Team scores were not necessarily predictive of whether students chose to remain together the second semester. However, with only two exceptions, every team in which all of the students remained together both semesters exhibited very high average participation scores. In the five control years, the participation averages for each class increased in three out of five years and remained approximately the same in the other two years. In the intervention year in which students self-selected both semesters, the participation scores from peer evaluations actually decreased significantly from the fall to the spring semester, despite a significantly higher team retention rate.

The sequence of assigning randomized teams in the first semester prior to allowing self-selected teams in the spring semester appears to yield improved participation overall relative to allowing

students to self-select both semesters. This work has implications for improved strategies for assigning of the teams in the fall semester to ensure success throughout the year.

Introduction

The ability for engineering students to work together in teams is a critical skill recognized both by employers [1] and by our accreditation board [2] (Criterion 3.5). Undergraduate biomedical engineering (BME) majors at the University of Virginia work extensively in teams in multiple core courses: not only in an introductory design course and in the senior capstone design sequence, but also in a yearlong junior-level integrative laboratory course sequence. The lab sequence is noteworthy because of its intensive nature (4 hours/week in lab, plus 10-20 hours/week outside of lab on analysis and writing of reports, as self-reported by students on evaluations). As our program grew rapidly very soon after it was established (from ~35 students in the first graduating class of the major 15 years ago to ~90-100 students per year for the past several years), most students no longer had the opportunity to get to know all of their classmates, and anecdotally they have shared that they typically work within study groups and work groups that are limited to a small network of close friends in most courses. Our program's intensive laboratory sequence provides a good opportunity for students to work with those whom they may not know, both to build a broader peer network and to develop improved teamwork skills. As a result, for over a decade we have randomized students into teams in the first semester of the lab, and then we allow students to self-select teams in the spring semester given that by that point (mid-junior year) we assume that they know with whom they work best.

A wealth of literature exists on the impact of team formation approach on student performance and team dynamics (e.g. [3-6]). While there is some disagreement among publications, recent findings suggest that student performance, team performance, and metrics of effort and student persistence in a collaborative learning classroom may be unaffected by the mode of team formation, whether instructor-designed, student-selected, or randomly assigned, whereas team gender diversity was higher in designed teams vs. self-selected or randomized [7]. The majority of students (85%) in the prior study were satisfied with team formation, regardless of approach, and there were no meaningful differences among student satisfaction survey data. However, it is unclear whether these results from a relatively limited set of in-class interactions in a collaborative learning setting would translate to the immersive teamwork required in our BME lab sequence.

Throughout more than a decade of teaching this sequence, the instructors anecdotally observed that many teams remained together in the spring after having been randomly sorted into teams in the fall semester. However, a rigorous quantitative analysis of the impact of team assignment method on team performance and participation assessments has not been conducted. In the present study, we have evaluated team composition over a six-year period, five of which included randomizing the teams in the first semester and then allowing students to self-select in the spring. In an intervention year, we allowed students to self-select both semesters, providing a comparative group with which to investigate the impact of team formation approach on dynamics and performance throughout each academic year.

Course Description and Assessments

The lab sequence at the University of Virginia and its assessment has been described previously in detail [8]. Briefly, however, this junior-level core lab sequence builds on prerequisites including chemistry, physics, computational BME / numerical methods, biomechanics, biotransport, physiology, cell & molecular biology, and statistics (with BME signals and systems as a co-requisite). Modules in the course range from cell culture and techniques in molecular biology (e.g. Western blots, qPCR, immunofluorescence, microscopy) to mechanics to bioinstrumentation, imaging, tissue engineering, and targeted drug delivery. Students spend one hour per week in a common lecture and then four hours per week in their respective lab section. Each module lasts approximately two weeks in duration, after which a comprehensive lab report is due in which the students prepare figures and write their results, as well as answer specific discussion questions about each module. Students also take individual weekly pre-lab quizzes and end-of-semester comprehensive written final exams each term. Students also completed ungraded anonymous end-of-course evaluations through the learning management system.

Peer assessments and student surveys on team performance and formation

At the end of each semester, every student must also submit peer evaluations wherein they rate themselves and their team members. (See appendix for example peer evaluation forms from the fall and spring semesters.) These evaluations, in combination with instructor and TA observations and input, form the basis for team participation grades each semester. The peer evaluation forms each semester ask the students to rate themselves and their teammates on a variety of metrics, including actively contributing in-lab, willingness to work outside of lab on analysis and reports, quality of contribution to the lab reports, and overall attitude with respect to the team. Students also are asked to rate how they believed their team functioned during the semester on a scale of 1-5 (1 = worst, 5 = best). In the peer evaluation administered at the end of the spring semester, we also poll the students on whether they prefer randomly assigned teams (as in the fall semester), self-selected teams (as in the spring semester), or a combination of the two, as we do currently. The team function self-assessment from both semesters and the survey of team formation preference from the spring semester were tabulated for this study.

Team formation

Except for the one intervention year, teams in the first semester of the lab sequence were randomized, with no guided design goals or constraints aside from team sizes being maintained between 3-4 students each. In two of the years (including the intervention year), we did allow teams of 5 students. But based on instructor observation and student feedback (and evidence from the literature based on “social loafing” theory, e.g. [9-10]), smaller teams are preferable, so we expanded our lab station capacity and for the past several years have allowed only teams of 3 or 4 students. In the six years examined in the present study, there were two teams that split up (one due to a personality issue on the team, and the other because a student withdrew from the course leaving only two team members who were subsequently reassigned to two different 3-student teams in the section). The final team composition for those two teams was analyzed for the purposes of this study.

In the spring semester, the students self-selected into their own teams. For the first three years of the study (including the intervention year), self-selection occurred during the first lab section, and teams of 3-4 formed (or 5 in the two years we allowed teams that large). In the event that a pair of students really wanted to work together but could not do so because all other teams had formed (i.e. no other lab stations were available), then preference was given to the larger pre-formed teams, and the 2-student pairs would be split up and added to any available 3-student teams. Over the last three years of the study, a shared Google Spreadsheet was sent to the section prior to the start of the first lab, along with the student roster, and students filled in the teams of pre-set sizes such that all teams consisted of either three of four students each. Having a pre-filled team spreadsheet prevented possible awkward situations the could occasionally occur when students self-assembled spontaneously in the lab. In both approaches of self-selection, typically about half to three-quarters of the teams would have been pre-formed with students who had networked outside of class, and the remaining students who had not previously joined a team would fill in any available slots. The students are not assigned specific team roles in either semester, although most teams naturally develop their own *de facto* roles, at least informally.

Results

Overview of Team Composition

Over the six-year period of the study (including the intervention year when students self-selected teams both semesters), we analyzed data from a total of 139 student teams in the fall and 130 teams in the spring, consisting of 524 students total (average team size was ~3.76 students/team in the fall). Out of this pool, we excluded 11 students (2% of total) who took the course out of sequence or skipped a year or more between semesters—e.g. after studying abroad or taking some other leave of absence—leaving a total of 513 students. Student demographics for this cohort included 48% women and 5.5% underrepresented minorities (URM). The five control years totaled 439 students among 122 fall teams (114 spring teams), while the intervention year consisted of 74 students among 17 fall teams (16 spring teams). The discrepancy in number of teams from fall to spring was due to slight variations in enrollment per lab section each term, and in the last four years of the study there were more fall teams because we created a summer version of the first semester of the lab (identical to the fall semester in terms of assessments and in randomizing teams). These summary data are compiled in Table 1 below.

Table 1. Summary statistics of team composition and demographics over a 6-year span.

				# of teams[1]	
Year	**# students**	**# women**	**# URM**	**Fall**	**Spring**
2012-2013[2]	74	39	6	17	16
2013-2014	84	39	3	23	22
2014-2015	89	43	3	24	24
2015-2016	95	42	6	26	23
2016-2017	85	44	5	24	23
2017-2018	86	39	5	25	22
TOTAL:	**513**	**246**	**28**	**139**	**130**

[1] Discrepancy in number of teams each term due to slight enrollment differences in sections, and from 2014-present to the existence of a summer section duplicating the fall version.

[2] Intervention year, when students self-selected teams both semesters.

Research Questions, Study Factors, and Definition of Team Retention Metric

In this study, we were primarily interested in evaluating whether specific factors correlated with team performance (either assessed by the instructor or self-assessed by the team), and especially whether any of these factors were predictive of students remaining teammates from the fall semester (when randomized into groups) to the spring semester (when self-selected). Factors that we examined included fall semester team size, instructor-determined fall participation scores (based on peer evaluations), student-assigned team function scores, pre-lab quiz average, lab report average, and final exam average (all from the fall). We also examined student survey results from their spring peer evaluation when they were asked if they could go back in time and take the sequence over again, would they prefer randomly assigned teams (as in the fall for the control years), self-selected teams (as in the spring), or a combination of the two approaches, as we did in all five control years. We were thus able to analyze whether any of the above factors were predictive of student team formation preference at the end of the year.

To quantify the extent to which teammates remained together from the fall to the spring together, we defined a "team retention percentage" metric as the fraction of the original fall semester team who remained teammates in the spring semester (excluding students who took the sequence out of order or skipped a year). For example, if a fall team consisting of 4 students had 3 students go on to continue as teammates in the spring while the fourth student joined a different team, the team retention percentage (TRP) = ¾ = 75%. If none of the students were teammates the following semester, we counted the students as themselves "remaining," so from a team of four, the TRP would be ¼ = 25%. It should be noted that computing the latter case as 0% rather than 25% or 33% (for teams of 3) does not have an impact on the overall results, since ultimately the TRP becomes effectively a categorical variable rather than a continuous quantitative factor.

Once the TRP is calculated for each team, we can then compute the fraction of teams in any given fall semester for which a particular threshold remains together in the spring semester. In particular, we were interested in the fraction of teams with 100% retention (i.e. the entire team remained together both semesters), as well as teams with >50% retention (i.e. 3 or more teammates remaining together). We then compared the retention outcomes for each year (including the intervention year with both semesters being self-selected) with the preferred group formation approach indicated by the students in the final survey (Table 2).

Table 2. Preferred group formation approach from final survey and team retention percentage.

Academic		Preferred group formation approach			Percentages for each preference			Percent of teams with:	
Year	Total	Assigned	Combo	Self-selected	Assigned	Combo	Self-selected	100% ret.	>50% ret.
2012-2013[1]	74	22	10	42	30%	14%	57%	53%	71%
2013-2014	84	33	41	10	39%	49%	12%	43%	70%
2014-2015	87	14	35	38	16%	40%	44%	17%	21%
2015-2016[2]	94	22	40	32	23%	43%	34%	31%	42%
2016-2017[3]	85	9	56	20	11%	66%	24%	13%	33%
2017-2018	86	10	69	7	12%	80%	8%	36%	56%

[1] Intervention year

[2] Unusual year in that there were more 3-student teams in the fall, then seven 5-student teams in spring

[3] First year that the end-of-year preference survey explicitly included "combination (as we've done it)" on question

Perhaps not surprisingly, the largest TRPs on average occurred in the intervention year when students self-selected both semesters, when 53% of teams had 100% of students remain together both terms, and 71% of teams had >50% retention from fall to spring. Additionally, the majority of students at the end of the year indicated that they preferred self-selected teams (although it should be noted that they had not been on randomized teams and thus did not have that experience for comparison, unlike the subsequent five control years). For the five control years, 28% of teams retained all of their original student members from the fall to the spring semester (TRP = 100%), and 45% of teams retained over half of their original members (TRP > 50%). These outcomes constitute a 2-by-2 contingency table (columns are the fraction of teams with TRP = 100% vs. TRP < 100%, and rows are the intervention vs. control), and the two groups (intervention vs. control) were found to be significantly different from one another using Barnard's test ($p = 0.038$).

The median fall participation score for the teams in the intervention year (self-selected) were significantly less than the median participation score for those teams during the control years (Mann-Whitney two-tailed $p = 0.0153$). The median participation score per team during the control years was 0.833 (n=122) out of a max of 1.0, and the median score for the teams in the intervention year was 0.563 (n=17) (Figure 1).

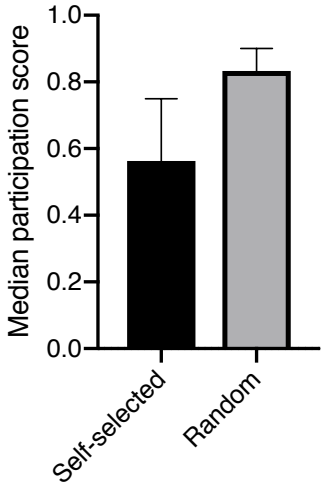

Figure 1. Median fall participation score for intervention year (students self-selected in fall) vs. the five control years (students were randomly assigned into teams in the fall semester).

In addition to examining differences in participation scores for students in the intervention year vs. the control years, we also compared average scores on three other graded deliverables in the course: lab report averages (per team), quiz averages (individual), and final exam averages (individual). Final exams and quizzes are almost identical from year to year, with only slight changes to specific details rather than changes in the concepts covered. While the mean lab report score was slightly higher in the control years (83.75 in the intervention year with self-selected teams vs. 86.69 in the randomized-team control years), this difference was not significant (Welch's two-tailed t-test $p = 0.1571$). Similarly, no significant difference was observed in students' quiz scores in the intervention year vs. the control (84.9 and 85.1, respectively, Welch's two-tailed t-test $p = 0.8727$). However, we did observe a significant difference between the mean final exam scores for these two populations, with the students in the

intervention year scoring significantly lower on average (80.02) than those students in the randomized control years (86.66, Welch's two-tailed t-test $p < 0.0001$).

We also compiled all of the individual student data in the control years for those students who were part of fall teams with TRP = 100% vs. those students with TRP <= 50% (excluding those >50% and <100%). We then compared the fall to the spring instructor-assigned team participation scores for the students in each of those two populations. There was no significant difference observed in the participation scores from fall to spring among for the students who were part of teams with 100% retention. However, there was a significant difference from fall to spring in participation for students whose TRP was 50% or less (paired t-test $p = 0.0005$). Participation scores for this population of students were on average ~15% higher in the spring relative to the fall. Interestingly, there was no corresponding difference observed from fall to spring for this population of students (TRP <= 50%) for the self-assessed team function score (paired t-test $p = 0.5856$).

Multiple Linear Regression for Analyzing Predictors of Team Performance and Retention

We compiled all of the fall team data from the five control years (122 teams total) and averaged the following factors on a team-by-team basis: team size, instructor-assigned participation score, student self-assessed team function score (1-5 Likert response to the survey question, "Overall, how well would you rate how your team, as a whole, functioned this semester?"), quiz average, lab report average, final exam average, and average of student responses from the end-of-year survey question regarding what sort of team formation approach they prefer (1 = randomly-assigned, 2 = combination of assigned in fall and self-selected in spring, 3 = self-selected). We then performed multiple linear regression for these factors as predictors of team participation. As might be expected, student team function scores and instructor team participation scores were correlated (linear regression $R^2 = 0.5184$), so in subsequent multiple linear regression analysis, only one of these was examined to avoid issues with multiple collinearity.

Results from the multiple linear regression (MLR) revealed no predictors of participation score or team score, including exam averages, report averages, team size, URM percentage, percentage of women, or gender diversity metric. The gender diversity metric was taken from [7] and was calculated as follows:

$$gender\ diversity = 1 - \frac{|\#males - \#females|}{total\ \#\ team\ members}$$

Next we examined whether there were any predictors (including participation / team scores) on team retention. Team self-score (and, when included instead, participation score) was weakly but significantly predictive of retention ($p = 0.0025$), and the end-of-year preferred grouping approach was weakly negatively predictive of retention ($p = 0.0063$)—i.e. teams who remained together from the randomly-assigned fall semester were more likely to prefer assigned teams or a combination of assigned in the fall and self-selected in the spring, rather than self-selected for both. If the preferred grouping approach is taken as the dependent variable, the only factor that was predictive was team retention ($p = 0.0058$, weakly negatively correlated, as was the case when TRP was the dependent variable). Interestingly, all other metrics of performance like report grades, exams, etc. were not at all correlated with participation scores, team function

survey responses, or retention, nor were demographic factors like team size, URM %, gender diversity score, or percentage of women on the team. However, linear regression of fall participation score of teams in the control years with 100% retention almost invariably had high average instructor-assigned participation scores (>= 0.75/1.00), with only two exceptions out of the 34 teams that met the criterion of TRP = 100% (Figure 2). Additionally, in the intervention year, no factor was found to be predictive TRP.

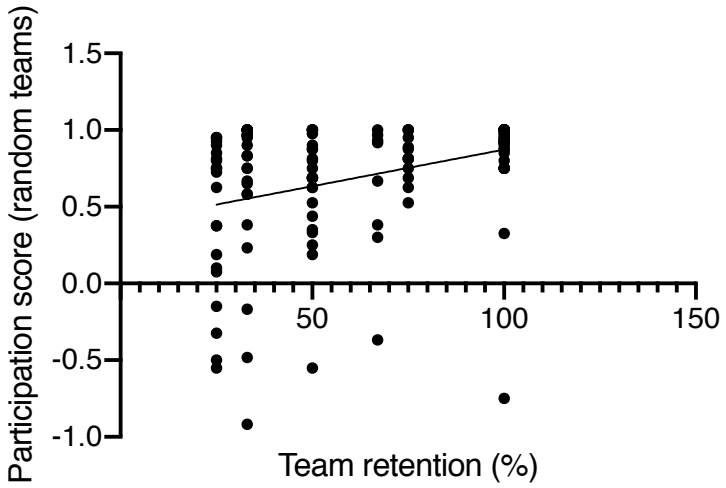

Figure 2. Linear regression of fall participation score vs. TRP for the five control years (R^2 = 0.108). Only two teams with 100% retention exhibited relatively low participation scores.

Analysis of Student Course Evaluations and Comments

At the end of each term, students completed anonymous course evaluations answering multiple questions relating to the course and to the instructor. We have analyzed the aggregated course-specific and instructor-specific metrics, and we have listed all of the free-response student comments from each of the semesters that mentioned team formation one way or the other (total of 11 in both intervention and control years). Quantitative responses were based on a 5-point Likert response (5 = strongly agree, 3 = neutral, and 1 = strongly disagree) to statements specific to the course (e.g. “I learned a great deal in this course,” “Overall, this was a worthwhile course,” etc.) and specific to the instructor (e.g. “Instructor was well-prepared for class,” “Overall this instructor was an effective teacher,” etc.). Mean responses reflect a weighted average based upon the number of students assigning a specific score.

The weighted average for the fall semester mean course evaluations for the five control years was 4.13 and 4.37 for the instructor. For the intervention year, the course mean was 3.79 (instructor mean 4.22). Other than allowing students in the fall semester to self-select into teams, no other changes were made in the intervention year (e.g. to specific modules, other instructors, assessments, etc.) relative to the control years.

These quantitative results are consistent with some of the free responses student comments provided on the evaluations. We tabulated all comments in the control years that specifically

mentioned group selection (fall semester). Note that these were in a free response section of the evaluation and were not prompted or solicited in any way.

Student comments in control years (emphasis added):

- "This is a very demanding class. **I love the way of randomly assigning groups** as that increases my chances of knowing and working with different people. In my opinion it's also a fairer way of grouping especially given the very important role of teamwork in this course."
- "I really enjoyed this class and I learned a lot including lab techniques and working in groups. ... Fortunately I had no huge problems with my group! **(we are actually good friends now)** Thank you for the great class and I look forward to next semester!"
- "**Randomizing the groups--good call.**"
- "Historically [course name] lab is the class BMEs tend to complain about, but overall I enjoyed the class. I liked the experiments we did and **enjoyed meeting up with my groupmates; it was a good dynamic**."

Despite the total number of students in the intervention year being almost an order of magnitude less than the number in all of the control years, roughly twice as many students made comments regarding group formation that year as they did in all five control years combined. Here are the unsolicited intervention-year comments on the anonymous evaluations (emphasis added):

- "[Course name] is an incredibly challenging course. And it requires you to be the most productive version of yourself. **However, group dynamics are probably the most challenging and trialing aspect of the course above all. I think it would be extremely useful for the instructors to put more thought and effort into the assigning teams** based on specific criteria because students would work better together, and more importantly get more out of [course name]."
- "**Letting the groups choose their own teams was a big mistake** and although I blame most of our group's failure on that, there was not enough time devoted to first explaining the background of the lab and the purpose of our experiments before jumping right into them."
- "**I liked picking our groups** because it meant you could pick a group with a similar work habit (timing wise) and maybe even a more well rounded group (analyzers, writers, researchers etc.). I really hope that we get to pick our groups next semester also."
- "Please allow us to pick groups again in the spring!"
- "Groups should be selected randomly in the spring semester."
- "Don't let people pick groups."
- "I would recommend random groups just because it was awkward at first picking groups"

Out of the seven unsolicited comments regarding group formation, only two were positive regarding self-selected teams in the fall semester, and the rest were negative.

We also compiled non-anonymous feedback students wrote in their spring end-of-year survey when they were asked to state whether they preferred randomly assigned teams, self-selected teams, or a combination of the two. Despite not explicitly listing "combination" as an option for the first four years of the survey, many students still wrote that in as their preferred approach.

Below are some representative comments from students who preferred assigned, self-selected, or the combination.

Comments from students who preferred randomly assigned teams:

- I would choose assigned teams. I think sometimes not being w/friends can increase productivity. I was in the weird circumstance where even randomly assigned teams put me w/my friends. We worked well together, but obviously was tension between members b/c we didn't want to hurt our friends' feelings on certain things.
- I would prefer randomly selected teams; I was on a team w/2 friends and I felt like an outsider.
- Assigned -- everyone feels more obligated to do work if you're strangers, otherwise friends are too relaxed and slack off
- Assigned; My group this semester was basically random (only people w/out a group) and we worked way better together than my group last semester which I chose. [intervention year comment]
- Assigned groups, so that friendships don't get in the way of choosing

Comments from students who preferred self-selected teams:

- Self selected teams. I was lucky and got the team I wanted during the fall semester, and we kept the same team in [the spring], but I have heard horror stories about random teams from other groups.
- [Multiple comments about wanted to work with people they know and know they work well with.]

Comments from students who preferred the combination as we currently do it:

- The team I am with by choice this semester is the same team I was randomly assigned last semester. I think the way it's set up is perfect. Random assignment is great, because I never would have picked this team to start with last semester, but we found we worked really well together, so when it came time to pick teams for this semester, we knew what worked for us!
- I think the combination works well. First it lets you / forces you to get to know new people and it also forces you to work with people you know and don't know. I think it is a good experience for the workplace.
- Each method had its benefit so I do like combination. Having a random team may seem bad at the time but it's a lot harder to "crack down" on a friend for being late with work.
- I prefer the combination. It was nice to be assigned a team at first because it allowed me to work with people I didn't know already, which is beneficial to just working with friends. I liked the freedom of choosing a team 2nd semester, once we knew our strengths and weaknesses as team members.

As indicated in Table 1 previously, most students in the control years have preferred the combination of random teams in the fall and self-selected in the spring, with only one year (2014-2015) as the exception when more students preferred self-selected teams.

Discussion

In summary, when initially randomized and then allowed to self-select teams the following semester, a majority of the team remains together 45% of the time (and the entire team remains together 28% of the time). We found a weak but significant positive correlation between peer evaluation based team participation scores and whether students remained together from the fall to the spring semester. However, there does not appear to be any correlation between other performance or demographic metrics and team retention, and there are no correlations between factors for teams that self-formed both fall and spring during the intervention year. For teams select-selecting both years (i.e. intervention year), participation scores actually dropped slightly. Students in the intervention year also scored significantly lower on the final exam than those in the control years. One possible interpretation of the both the reduced participation and exam performance in the self-selected intervention year (supported anecdotally by anonymous student comments that year) may be that students were less likely to hold their teammates—who were often also already their friends—accountable in their contribution to the analysis and writing of the reports. Several students in later surveys who preferred randomized teams specifically mentioned the higher level of accountability and resulting improvement in overall team engagement as an advantage of random teams. If students did not all participate fully in the data analysis and writing of the reports, those students would ultimately be disadvantaged on the comprehensive final exam, possibly leading to the lower average observed in the intervention year relative to the control years.

The sequence of assigning randomized teams in the first semester prior to allowing self-selected teams in the spring semester appears to yield improved participation overall relative to allowing students to self-select both semesters. A majority of students prefer either randomizing both semesters or randomizing in the fall and then self-selecting in the spring. This result is consistent with a recent study assessing the impact of team formation (designed teams, random teams, and student self-selected teams) on performance and student effort and attitudes. Most of the students in the designed teams and randomized teams preferred randomization, whereas two-thirds of students initially in self-selected teams preferred self-selected teams [7]. That finding is consistent with the strong preference for self-selected teams in the intervention year, despite the outcomes being slightly worse (and opinion of the course being worse).

Future work would be to create another intervention (likely in only one section out of three) in which students are semi-randomly assigned into designed teams that take into account one of two factors: GPA (binning students with common GPAs to make sure that there is not a large discrepancy amongst team members) and schedule (i.e. enabling students to find time outside of lab to work on analysis and reports). Several students over the years have indicated anecdotally to instructors that scheduling is one of the bigger challenges with random teams. Additionally, students in the fall semester could also be binned according to their self-perceived leadership style, whether they are better at “big picture” vs. details, and their time-scale expectations for working on team reports (e.g. last-minute vs. well ahead of time). This work thus has broader implications for improved strategies for assigning of the teams in the fall semester to ensure success throughout the year.

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Appendix – Peer Evaluation Forms

FALL PEER EVALUATIONS OF TEAM MEMBERS [mandatory]

Note that your name will be kept strictly confidential. Please be <u>HONEST</u>, even if you have negative feedback.

1. In the left column of the table, enter the names of your team members, and rate them with scores of 1 to 5 (where **1 = poor** and **5 = excellent**). If you can't remember the last name of the team member, then the first name will be sufficient.

Names of team members	Contribution to in-lab activities	Willingness to help w/reports	Quality of contri-bution to lab reports	Overall attitude w/ respect to team
_*Rate yourself here* →_____	☐	☐	☐	☐
_____	☐	☐	☐	☐
_____	☐	☐	☐	☐
_____	☐	☐	☐	☐

2. Overall, how well would you rate how your team, as a whole, functioned this semester?

_____ (choose a number between 1 & 5, with 1→poor and 5→excellent)

3. What do you consider to be the optimal team size in this course? (2, 3, 4, 5, etc.?)

4. Feel free to add any additional comments regarding your team, specific team members, team dynamics, optimal team size, etc.

SPRING PEER EVALUATIONS OF TEAM MEMBERS [mandatory]

Please note that your name will be kept strictly confidential. Please be <u>HONEST</u>, even if you have negative feedback. Time spent on these evaluations will <u>not</u> count toward your 3-hr exam limit (so complete these *after* you have finished the rest of the exam).

1. In the left column of the table, enter the names of your team members, and rate them with scores of 1 to 5 (where **1 = poor** and **5 = excellent**). If you can't remember the last name of the team member, then the first name will be sufficient.

Names of team members	Contribution to in-lab activities	Willingness to help w/reports	Quality of contribution to lab reports	Contribution to final project	Overall attitude w/ respect to team
_*Rate yourself here →*__	☐	☐	☐	☐	☐
_____	☐	☐	☐	☐	☐
_____	☐	☐	☐	☐	☐
_____	☐	☐	☐	☐	☐

2. Overall, how well would you rate how your team, as a whole, functioned this semester?

_____ (choose a number between 1 & 5, with 1 → poor and 5 → excellent)

3. If you had to go back in time and retake this lab sequence (gulp!), which method of team selection would you prefer: Assigned teams (as in the fall), self-selected teams (as in the spring), or a combination (as we currently do it)? Why?

4. Feel free to add any additional comments regarding your team, specific team members, team dynamics, optimal team size, etc.