Journal of the Scholarship of Teaching and Learning, Vol. 17, No. 3, July 2017, pp.19-33.
doi: 10.14434/josotl.v17i3.21158

Does Team Formation Impact Student Performance, Effort and Attitudes in a College Course Employing Collaborative Learning?

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Abstract: The literature on team-based learning emphasizes the importance of team composition and team design, and it is recommended that instructors organize teams to ensure diversity of team members and optimal team performance. But does the method of team formation actually impact student performance? The goal of the present study was to examine whether different team formation methods would affect individual and team performance outcomes and student attitudes in an undergraduate general education course. Across three different sections of the same course, teams were either designed by the instructor, by the students, or randomly by a computer program. We found that teams designed by the course instructor were more diverse, but that students in these teams performed no better than their peers in self-selected or randomly assigned teams. Because student performance was similar regardless of team formation method, these findings suggest that student formed teams can be a reasonable option for instructors to consider when planning a team-based course.

Key Words: collaboration, higher education, team formation, flipped classroom

Introduction

Collaborative Learning

Collaborative learning is a form of active learning that encourages student-student interaction in the learning environment (Prince, 2004). Broadly defined, collaborative learning is a method of learning that involves sharing knowledge, experiences, and authority, in which students teach and learn from each other and develop a positive interdependence (Panitz, 1999). Structuring the learning environment in this way helps students appreciate multiple perspectives, provides students with opportunities to learn team work skills, and encourages individual students to make personal contributions to their academic experience (Barkley, Cross, & Major, 2005).

The benefits associated with the implementation of collaborative learning activities have been extensively documented (for reviews see, Haidet, Kubitz, & McCormack, 2014; Johnson & Johnson, 2009; Laal, Naseri, Laal, & Khattami-Kermanshahi, 2013; Springer, Stanne, & Donovan, 1999). Highlighting some of these key benefits, studies have found improvements in critical thinking skills (Gokhale, 1995; Sanchez, Rivas, & Moral, 2015), improved test scores (Crouch & Mazur, 2001; Hake, 1998), and improved retention of course material (Ruhl, Hughes, & Schloss 1987). Even beyond improved test scores, Carmichael (2009) also noted that collaborative activities energized students and increased student engagement with the material and with each other. Similarly, after having students work in small groups to think about and try to solve real-world issues, Chace (2014) found that this type of activity helped foster deeper learning and

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engagement with course material, and gave students the unique opportunity to work together with peers to use scientific evidence to make real policy changes at their college. Other positive effects of collaboration include increased enjoyment of the material, higher student self-esteem, and improved attitudes towards diversity (Johnson & Johnson, 1986).

When considering the impact of collaborative learning activities, it is important to take into account how group learning has been designed and implemented in the course. For example, a group activity can be short term (e.g., organized around specific assignments for a single class or limited number of class periods); or more long term, over the course of an entire semester or year, contributing to the formation of small "learning communities" within the class (Barkley et al., 2005). Using the latter approach is believed to generate greater student learning effectiveness, and is considered a "transformative use of group" (Michaelsen, Knight, & Fink, 2004). Moreover, when groups are used in a transformative way, students not only learn the content and how to use it, but they also learn about themselves, how to interact with others on major tasks, and how to keep on learning after the course is over (Fink, 2004).

Approaches for Team Formation

Many researchers have suggested that different knowledge, skills, and abilities of team members are important for optimal team compositions. Mixing together students with diverse knowledge, skill sets, and abilities has been thought to allow a team's members to bring their unique skills to the team to provide the team with a broadest skill set (Oakley, Felder, Brent, & Elhajj, 2004; Muchinsky & Monahan, 1987). Belbin (1993) suggested that if the team effectiveness is a function of a set of interdependent roles, the high levels of complementary fit would result in higher levels of performance. Similarly, Michaelsen et al. (2004) suggested that for teams to function effectively they should be as diverse as possible so that the students' assets and liabilities are evenly distributed among different teams. Instructors are encouraged to consider attributes such as student work experience, courses previously taken, demographic representation, and attitude toward group work, among others. These authors suggested that most students do not intuitively have enough information or the inclination to wisely form groups; so the task must always be the responsibility for the instructor (Michaelsen et al., 2004). However, such instructor-based team formation requires knowledge of individual student qualities such as group work style, background knowledge of the field, academic strength, language skills, and the like, and often these data are unavailable or difficult to obtain, particularly as students change into and out of classes early in the academic term (Gillies & Boyle, 2010).

Instructor-designed teams are advocated for by many experts, but there are additional methods available to form effective student teams for instructors in courses employing student teams. For example, Shen et al. (2007) have listed various examples of team formation methods, which can roughly be grouped into three categories: a) the students choose their own teams; b) the instructor forms the teams based on certain pre-determined criteria, e.g., class order, personality type, learning styles, majors, gender, nationality; and c) a random team member selection process is employed. Of these three types of team formation approaches, which type of grouping yields the best student performance and most positive student attitudes in a team-based class? This question has been frequently debated within the literature with little consensus, as there is evidence to justify and support the use of all three of these strategies (e.g. Bacon, Steward, & Anderson, 2001; Bacon, Stewart, & Silver, 1999; Chapman, Meuter, Toy, & Wright, 2006). The goal of the

present study was to examine how different team formation strategies affect student course performance outcomes and student attitudes in a team-based, undergraduate general education course.

Methods

Participants

A total of 185 undergraduate students from three separate sections of a general education college science course participated in this study. Using composite SAT scores (i.e. total combined score on the math, verbal, and writing sub-sections) as a proxy for academic achievement readiness, there were no differences between the three sections. Likewise, the average grade point average (GPA) of students in each section was computed at the conclusion of the semester in which the course was taken, and average student performance among sections was similar. There was, however, variation across the three sections with respect to the gender and ethnicity distributions, as well as the number of students enrolled. Details of the enrollment numbers, course design, and student demographics can be found in Table 1.

Table 1

A Summary of Course Enrollment, Course Design, and Student Demographics

Team formation method	No. of teams	TAs	No. of students (F, So, J, Sr)	% female	% under-represented minority	Avg. GPA	Avg. composite SAT score
Designed	11	A, B	87 (20, 27, 17, 22)	31%	24%	3.23	1765
Self	11	A, C	71 (24, 29, 11, 7)	55%	38%	3.27	1767
Random	5	B, C	27 (7, 13, 2, 5)	33%	48%	3.21	1800

Procedure

Course description

The course was offered at a large public university in the Northeast United States. The course content focused on human molecular genetics with contemporary examples from the popular media. Students taking the course earned general education credit in the area of biological sciences, one of the four areas required of all undergraduates at the institution. Three separate sections of the course were taught by the same instructor, and three teaching assistants (TAs) denoted A, B and C were present with the primary instructor for each class meeting, and were assigned in different combinations among sections, see Table 1.

The course was structured as both a flipped course and as a team-based course. The flipped content included prerecorded online lectures, online homework, and reduced in-class lecture time.

The team-based content included team projects, readiness assessments, peer review, and in-class team work. All sections had these course elements in common.

All sections met one time per week for a 75-minute face-to-face session, which was half the usual class time dedicated to similar courses. Online homework and five to seven prerecorded lectures were assigned to be completed prior to class. The prerecorded lectures were designed to cover specific individual topics, and recordings ranged from 5 to 15 minutes in length. These recordings were tightly tied to each week's class content as well as to online homework delivered through the OWL (Online Web Learning) homework system (Hart, Woolf, Day, Botch, & Vining, 1999). The online homework assignments were available for the week prior to an upcoming class. All homework questions provided specific feedback about correct and incorrect answers. Students earned credit for homework depending on accuracy, but these assignments could be repeated as often as desired, thus allowing persistent students who did not understand the concepts upon first homework attempt to obtain full credit. In addition to the OWL homework, students also completed online quizzes (individual readiness assessments, iRAs) prior to class throughout the semester to gauge individual mastery of the course material.

An early class period included a segment in which each team determined three to five important characteristics of a good team member. After teams reported their lists, the whole class came to a consensus list. These four or five characteristics, which were slightly different between sections, were used as the basis of subsequent peer reviews in which team members rated their team members, including themselves, on each of the characteristics. All of these reviews had the common characteristics of communication, attendance and preparation, participation and accountability. Three such reviews were completed during the semester. The last two of the three counted toward the course final grade.

Class sessions typically started with a 20 minute team readiness assessment (tRA) of pre-class material content. The remainder of the class included about 30% instructor lecturing, with the rest of class time focused primarily on team practice with course concepts and material beyond that offered online. Team work in class was facilitated by the instructor and two teaching assistants who roamed the classroom to respond to team questions as needed. Exceptions to this pattern were for the first class session, which introduced the course structure, and two in-class exam sessions.

Team formation

Each section used a different method to form the teams that then worked together throughout the semester. The instructor-designed teams (Designed) were formed by placing students into teams based on their responses to a personality survey, their year in college, gender, and their major. When forming Designed teams, the instructor's goal was to maximize team member diversity. Student-formed teams (Self) were allowed to assemble in class as the students preferred. Random team formation was accomplished by the use of group-forming software in the course learning management system, Moodle. The two larger sections had more teams to keep the average number of team members per team approximately equal. Each section was informed of the method of team formation to be used in the section prior to the formation of teams, and students were given the opportunity to change sections prior to team formation if they preferred a different team style or a different meeting day. Two students moved from the Designed teams section to the Random teams section.

Measures

Student performance measures

Student performance in the course was evaluated at multiple levels—individual performance, team performance, and effort—corresponding the different elements of the course design, as outlined above. The sections that follow provide detailed descriptions of the way in which these measures were calculated for the purpose of this study. A summary of these measures can be found in Table 2.

Table 2

Summary of Key Study Variables

Measure	Components of the Measure
Individual performance	Exam and iRA averages
Team performance	tRA, project and peer review averages
Effort	OWL homework and bonus averages
Diversity	Personality traits, class year, and male/female team composition

Individual performance. The individual performance score includes measures that reflect the outcomes for assessments completed by students working alone. This measure was calculated by computing the average of exam and iRA scores for each student. Prior to computing the individual performance average, the exam and iRA scores were both re-scaled such that the maximum score of each assessment was 100.

Team Performance. The team performance score includes measures that reflect the outcomes for assessments completed through collaborative work among team members. This measure was calculated by computing the average of tRA scores, project grades, and peer review averages for a team. Prior to computing the team performance average, the tRA scores, project grades, and peer review averages were all re-scaled such that the maximum score of each assessment was 100.

Effort. The effort score includes two measures that reflect student persistence in the course, with greater effort represented by higher scores. These two measures were the OWL homework score and the bonus score. As previously described, the OWL homework was designed such that repetition of the exercises would result in full credit. This is a measure of persistence because students received feedback on the homework exercises once submitted and students could repeat them as often as they wished (prior to the assignment due date). The bonus score measured student persistence in that students had the option to complete several surveys, and completion of each survey generated a small amount of bonus credit (0.5% of the total course score).

Team diversity

The diversity score reflects the combination of three separate measures of diversity: student personality, class year, and gender. Each measure included in the diversity measure had a maximum of 1, thus when combined, the maximum possible diversity score was 3, with higher

scores indicating greater team diversity. The calculation of the separate components of the diversity measure are described below.

Student personality diversity score. Personality was assessed with a self-report survey (designed specifically for this course) which provided twelve separate personality types for student selection. These twelve types fell into four broad personality trait categories: leadership, creativity, practicality, and diplomacy. Each of the four categories contained three of the personality types. The degree of diversity based on personality traits was computed as the number of different personality traits on the team divided by the total number of student responses from the team.

Class year diversity score. The degree of diversity based on student class years was computed as the number of different class years found on a team divided by 4. For example, a team that had at least one freshman, sophomore, junior, and senior would have a class year diversity score of 1, while a team consisting of only freshman would have a class year diversity score of 0.25.

Gender diversity score. The degree of diversity based on the distribution of males and females on a team was computed as:

$$Gender\ diversity = 1 - \frac{|\ Number\ of\ males - number\ of\ females\ |}{Total\ number\ of\ team\ members}$$

Student attitudes and preferences

Several end-of-semester survey questions were designed to assess how students felt about the team-based aspects of the course. Students were asked how satisfied they were with the way in which teams were formed, whether they would have preferred teams to be formed in an alternative way, how successfully their team worked together, whether they worked with other students to complete non-team course assignments, and whether they felt connected to other students in the course. These questions were included as part of a voluntary course questionnaire.

Results

The goal of this study was to examine how different team formation strategies affect student course performance outcomes and student attitudes in a team-based course. Within the educational literature there is considerable emphasis on ideal team characteristics and team formation strategies, and it is often recommended that instructors organize the teams to maximize diversity of team members with the goal to improve team performance. In this study, we compared three different approaches to forming teams within a team-based learning course in order to determine whether these different team formation strategies affect student and team outcomes.

Student Performance

We examined student performance in the course in terms of individual performance, team performance, and effort. Individual performance and effort reflect the outcomes on assessments completed by students working alone, whereas team performance reflects the outcomes of assessments completed collaboratively. As such, analyses for individual performance and effort consist of 185 observations (one data point per student), while the analyses for team performance

consist of 27 observations (one data point per team). We used the Kruskal-Wallis test to examine whether there were statistical differences in the student performance measures depending on the three different team formation strategies used in each section.

Supporting the idea that the way teams are formed affects team diversity, we found that the distributions of diversity scores differed depending on the manner in which groups were created, $H(2)$ 14.87, p = .001. We used Mann-Whitney tests with a Bonferroni correction applied for multiple comparisons (α = .0167) to determine which sections differed from one another. Designed teams were more diverse than Self teams (U = 20, z = -2.67, p = .007) and Random teams (U = 1, z = -3.01, p = .001). Additionally, Self teams were more diverse than Random teams (U = 4, z = -2.66, p = .005). See Figure 1 for a graphical representation of these results.

But does team formation strategy, and consequently, the increase in team diversity, affect student performance in the course? First, focusing on individual performance, we did not find evidence that the different team formation methods within each of the three sections affected coursework that students completed on their own, $H(2)$ = 2.20, p = .33. That is to say, we did not find an advantage for any particular team formation method; numerically, students across all sections performed quite similarly on the individual aspects of the course. Likewise, we did not find evidence that team formation method affected effort, $H(2)$ = 2.39, p = .30. Finally, looking at team performance—where arguably the impact of the different team formation methods would be at its strongest—we again found no statistically significant differences in performance across the three sections, $H(2)$ = 3.90, p = .14. A summary of these results can be found in Figure 2.

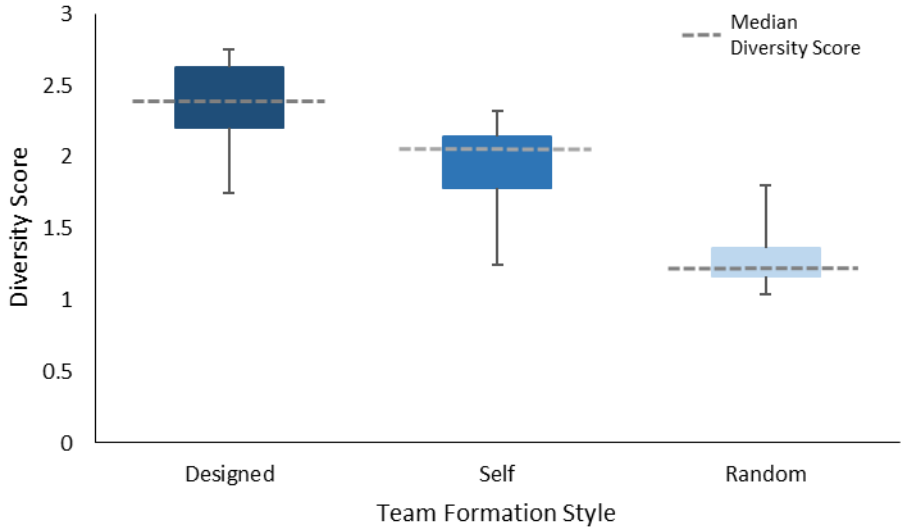

Figure 1. Team diversity as a function of team formation method. This graph depicts the diversity score distributions for each of the three course sections. The median diversity score is marked with a dashed horizontal line, the box represents the 25th and 75th percentiles, and the bars indicate the minimum and maximum values. Larger scores indicate greater diversity.

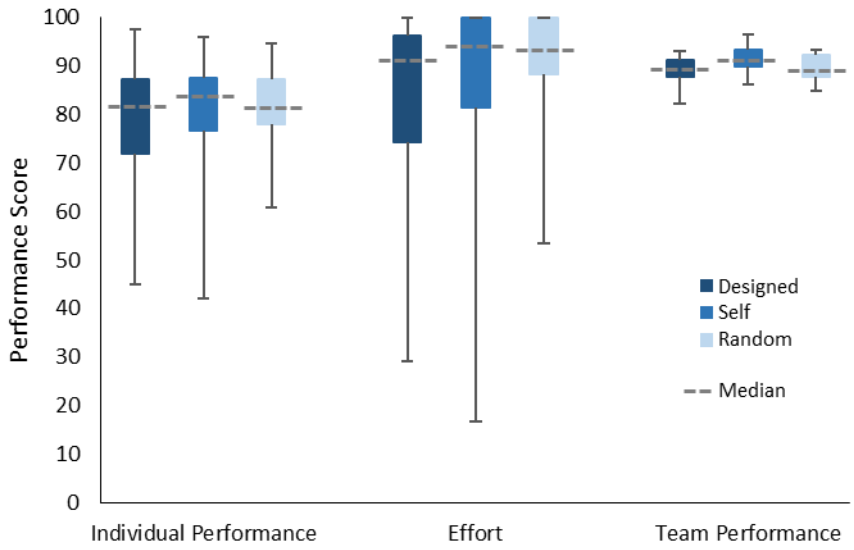

Figure 2. Course performance as a function of team formation method. This graph depicts the distributions of individual performance, effort, and team performance scores for each of the three course sections. The median score is marked with a dashed horizontal line, the box represents the 25th and 75th percentiles, and the bars indicate the minimum and maximum values.

Student Attitudes and Preferences

In addition to course performance outcomes, we were also interested in student attitudes and preferences regarding the team-based aspects of the course, and whether there were any differences in these attitudes and preferences depending on the different ways that teams were formed in the three course sections. It is important to note that because survey completion was voluntary, we do not have responses from all students in each section of the course. Nonetheless, here we present the findings from the sample of students who responded to the survey (51% of Designed, 57% of Self, and 41% of Random). Because responses to these questions were categorical and the sample size was relatively small, these data were analyzed using Fisher's exact tests. Key findings are discussed below, and for a complete summary of student responses to these questions see Table 3.

Most students (85% of all respondents) were satisfied with the way in which teams were formed within each section, and there were no statistical differences in the satisfaction rates among the three sections (p = .78). However, there was variation in student preferences for how teams should be created (p = .001). A plurality of respondents from Designed teams (48%) responded that teams should be selected randomly, while most respondents from Self teams (66%) felt that teams should be chosen by students. Respondents from Random teams were fairly evenly split in their opinions, with a slight preference for random selection (6 students, or 55% of respondents) over student-chosen teams (4 students, or 36% of respondents).

When asked about teams' abilities to work together—overall, and then specifically on the tRAs and team projects—responses there were no statistically significant differences across the three sections for each of these questions (all p values > .18). Collapsing across the different sections, with respect to opinions on overall team performance, most students (52%) reported that "it was good most of the time." For the tRAs, most students (61%) indicated that teams worked

together very well and everyone contributed while the remaining students (39%) felt that team performance was okay, but not everyone contributed. Opinions for team work on the projects were also divided between these two options, as just over half (51%) felt that their teams performed "very well, and everyone contributes" on projects and just under half felt (48%) felt that their team performance on projects was "okay, but not everyone contributes."

The ways in which students reported interacting with each other in the course outside of the required team-based activities varied depending on the course section ($p = .001$). Most students from Designed teams (39%) did not interact with each other to complete coursework (e.g. homework or exam study) outside the required team-based activities. However, most respondents from Self teams (51%) reported that they worked with some of their team members on coursework, and respondents from Random teams were split between no interaction with peers (4 students, or 36% of respondents) and interaction with some teammates (5 students, or 45% of respondents). Feelings of connectedness with other students in the course also differed depending on the course section ($p < .001$). Respondents from Self teams and Random teams reported that they felt connected with their team members (80% and 64%, respectively). About a third of students from Designed teams also reported feeling connected to their teammates (34%), but their connections also seemed to extend beyond their teams, as respondents from Designed teams most frequently reported that they felt connected with their team and others (43%).

Table 3

Student Attitudes and Preferences Regarding the Team-based Aspects of the Course

Question and Answer Options	Designed (N = 44)	Self (N = 41)	Random (N = 11)
Were you satisfied with the way that teams were formed?			
No	16%	12%	18%
Yes	84%	88%	82%
Given the choice, how would you prefer to form teams?			
Chosen by students	23%	66%	36%
Designed by the instructor	30%	10%	9%
Randomly chosen	48%	24%	55%
What is your opinion on the success of your team's ability to work together?			
It is excellent	30%	39%	18%
It is good most of the time	55%	49%	55%
It is good some of the time, but there have been problems	14%	12%	18%
Most of the time it is not good at all	2%	0%	9%
How has your team worked together on the tRAs?			
Very well, everyone contributes	66%	63%	36%
Okay, but not everyone contributes	34%	37%	64%
How has your team worked together on the team projects?			

Very well, everyone contributes	48%	59%	36%
Okay, but not everyone contributes	50%	41%	64%
Not well, we don't all work together	2%	0%	0%
Have you worked on other course content (e.g. homework or exam study) with other students in the course?			
No	39%	29%	36%
Yes, with all of my team members	7%	17%	9%
Yes, with others in the course not on my team	27%	0%	9%
Yes, with some of my team members	18%	51%	45%
Yes, with some of my team and others in the course	9%	2%	0%
Do you feel connected with other students in the course?			
No	20%	15%	9%
Yes, to my team and others	43%	5%	9%
Yes, to my team	34%	80%	64%
Yes, to non-team members	2%	0%	18%

Discussion

With this study, our goal was to examine the impact of different team formation strategies on student course performance outcomes and student attitudes in a team-based course. The broader thesis of this work is the idea that students can be successful in team-based courses even when the instructor does not design the teams—which is an idea that runs counter to some leading perspectives in the current literature on this topic. Comparing across three different sections of the same course, we did not find statistically significant differences in individual performance, effort, or team performance depending on whether teams were formed by the instructor, by students, or randomly by the learning management system. Also, while there does not seem to be student consensus for one particular team formation method across the three sections, it is worth noting that when asked what method they would prefer given the choice, none of the three course sections chose instructor-designed as the leading method. Data from this course suggest that the instructor-designed method of team formation, which is also more complicated for the instructor to implement, is not favored by students nor does it confer a measurable advantage.

Given that the literature on team formation strategies suggests that diversity plays a key role in the success of a team, we examined the level of diversity on the teams formed with the three different styles. As expected, teams designed by the instructor to be diverse were in fact more diverse than teams formed by students and teams formed randomly by a computer. Surprisingly, student-formed teams were more diverse than teams formed randomly. One must bear in mind that our criteria for quantifying diversity on the teams was based on a specific set of three characteristics: team member personality differences that related to team activities (leadership, creativity, practicality, and diplomacy), years in college, and student gender. We acknowledge that there are many ways to define and measure diversity within student teams, and other measures of diversity may have returned different comparisons of relative diversity between the teams created in these three course sections. Furthermore, we also acknowledge that the operationalization of

diversity is critically important for understanding the impact of team composition on student performance, and consequently, for making recommendations for team design. Systematic comparisons of different ways of conceptualizing diversity are needed, and we hope that this study, and others in the future, will contribute to a more specific and perhaps more nuanced understanding of how to form teams in the classroom.

Prior to discussing the attitude data, we again want to point out that this survey was optional for students, and as a result, only about half responded. Although incomplete, we still feel it is important to summarize and share the opinions of the students who did respond, and we emphasize that these views may not be representative of those who chose not to complete the survey. Overall, students who responded to the survey were satisfied with the way teams were formed, and comparing across sections, satisfaction levels were similar. Since each of the sections used a different method of team formation, this result suggests that students are comfortable with any of the three styles of team formation, perhaps because they have little experience with team formation in a course setting. Importantly, student attitudes toward the collaborative work done by teams are likely to play a major role in team success, and when comparing across sections, we find that students from teams using instructor design, student formation, or random selection all have similar and rather positive opinions about the ability of the team to work together on a variety of team-focused tasks such as collaborative quizzes and team projects.

It was particularly encouraging to find that the vast majority of students across all three methods of team formation reported some degree of connection to their peers in the course. This is promising, as it shows that all three team formation methods can foster feelings of connectedness among students. It is also noteworthy that students in designed teams reported connections beyond their team. This finding highlights a potential benefit of instructor-designed teams, in that students may be encouraged to form a wider range of connections with peers in their courses. At the same time, students in self-formed teams seem to capitalize on their team relationships and take advantage of team member support outside of class to a greater extent than their peers in instructor-designed teams. The increased extent of out-of-class interactions for student-formed teams appears not to play a strong role in overall team success relative to other types of teams, but it does suggest that team formation style may impact student interaction patterns beyond what happens in team activities in class. This would be an interesting empirical question to be investigated with future work in this domain.

Given that instructors in team-based courses find design of teams burdensome and somewhat time consuming during the early sessions of a course, our findings that student-designed teams performed similarly to instructor-designed teams on three separate measures of student performance suggest that a simple and easy to implement strategy for team formation is to allow students to make up their own teams. This method of team arrangement was much easier for the instructor to implement, and was met with no resistance from students, unlike the two other methods of team formation for which a small number of students asked to be assigned to particular teams with each other and expressed disappointment when denied this opportunity.

In summary, our comparison of three team formation methods within three sections of the same team-based course did not provide evidence to support the claim that students in more diverse, instructor designed teams outperform their peers or experience higher levels of achievement in the course. That being said, it is also important to note that we do not contend that instructor-designed teams are not beneficial or that forming teams in this way is not worthwhile, as these claims go beyond the scope of this paper. Rather, we find it encouraging that regardless of how teams were

formed in this course, students seemed to achieve similar performance outcomes. Moreover, having students form their own teams reduces resistance to team formation, is easy for the instructor to accomplish, and it consumes almost no class time. Therefore, based on these findings and observations, we argue that student formation of teams is a viable option for instructors to consider, and more research on the necessity of instructor-designed teams is warranted.

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