Relationship between team building activities and capstone student performance

Abstract

Team building activities are popular interventions during early stages of team development. At the Rochester Institute of Technology (RIT), in the multidisciplinary capstone course with an average cohort size of around 350, the students on a particular capstone project team may not be mutually acquainted and thus may benefit from such team building activities. Prior literature has studied the effectiveness of various instructor-directed team building activities on student teams. However, our students are generally eager to spend class time working on their projects and often see in-class activities as a distraction rather than an important part of their growth. Instead, the student teams are now allowed to choose an intervention based on team consensus. In this paper, the relationship between attributes of the chosen intervention and student performance, as measured using a series of AACU VALUE rubrics, was studied using statistical measures.

The analysis revealed a statistically significant effect of *type* of team building activity on teamwork, oral communication, and design & problem solving scores of individual students on the team. Also, a statistically significant effect of *location* of team building activity (on or off campus) on design & problem solving score was observed.

Background

Team building activities are a common tool used to improve team dynamics, and have been shown in general to improve team function [1], [2], [3], [4], [5], [6]. In a large capstone course several factors come together to constrain the type of team activity that makes the most sense: the logistics of implementation across many sections and instructors, sustainability, and use of resources for nearly 500 students per year, and time required of the students relative to the perceived impact of the activity.

Williams, et al. [2] evaluated four activities and found that tactile design/construct projects were more effective than a verbal problem-solving activity at improving a variety of team metrics. They found that while design/construct projects required more consumable resources (e.g., waste generated when hundreds of students build paper or balloon towers), they yielded better results than a hypothetical problem-solving activity. Still, all activities in this study resulted in half or more of the participants indicating improved engagement with their team, agreed that they were prepared to handle conflict within the team, and they knew their teammates better as a result of the activity. Similarly, Johnson, et al. [1] found that both a design/build exercise and a collaborative hands-on problem-solving exercise both improved what they described as group attraction: enjoying working with the group, confidence in their group, and feeling like the group accomplished something.

In addition to the engineering-focused design/construct activities, research in other fields has shown that activities such as preparing and eating meals together [5] or playing team video games (TVG) [3], [4] can lead to improved team function. Kniffin, et al. studied firehouses, where conditions are favorable for work groups/shifts to perform activities of daily living

together and found that cooking meals together lead to increased cooperative behavior and eating meals together improved overall work performance. Keith [4] demonstrated that TVG had a significant impact on team cohesion, leading to improved team performance, and that this impact was greater than traditional team building activities related to team goal setting and planning activities. A related study [3] showed that the focused immersion aspect of TVG was the most significant contributor to the improved performance. Listening to "happy" music [5] may also improve mood and lead to an increase in cooperative behavior.

In the capstone design course that is the subject of this paper, working out the team dynamics is a one-time activity. However, studies of team function over time show that – as expected – team effectiveness may vary over the duration of a long project. While capstone design is far less intense than long duration space missions (although students may claim otherwise), studies of the performance over time of teams operating in extreme situations has shown that crews' abilities to think divergently and make choices as a group decreased over time, while ethical decision making and ability to execute tasks stayed relatively constant and increased, respectively [7].

In summary, a variety of different team-level intervention activities, including both those focused on design challenges and those unrelated to engineering design, have been demonstrated to improve team effectiveness. Given the constraints of our particular course – e.g., hundreds of students, a desire to minimize waste, and student resistance to using in-class time – along with evidence that many different types of team activities have been shown to positively impact teams, we have opted to allow students to choose their own activities and investigate which, if any, improved student performance in a team.

Research Question

The focus of this research was to determine what attributes of self-selected team building activities are impactful. Specifically, we studied whether the type of activities and the location at which the activities were carried out have effects on teamwork, oral communication, and design & problem solving measures using AACU VALUE rubrics at the end of the first semester of a two-semester capstone design course.

Methodology

Students' self-selection of team building activities

During the first week of class, students can add and drop classes, so teams are finalized at the end of that week. At the start of the second week, students complete an online learning module related to team dynamics. After discussing this module as a group in class, teams are instructed to identify and perform a team building activity with their team, although the assignment does not contribute to the course grade. The following guidance, including some examples, was provided to students

> *"Before your first design review, complete an activity together as a team, and submit a single document where you answer the questions (1) how did you select the activity, (2) how did you ensure no team members felt left out, and (3) what is one new thing each team member learned about your team as a result of the activity. Include a photo*

of your team doing the activity embedded in the document. If your activity requires a video (e.g., you decide to make a video together...), submit the video as a separate file.

This activity doesn't need to be project-related - in fact, I encourage you to pick something NOT project-related. It should be something simple that your team does together: playing a board game, eating a meal together, volunteering somewhere together, etc...your choice. A small selection of board games and other activities is available to borrow from the MSD office, if that's helpful."

Submissions from students in the 2022-23 cohorts were examined and the team building activities were characterized in two ways: the *location* and *type* of activity. Location was classified as On-campus, Off-campus, Virtual, or for teams not completing the assignment, None. The team building activity types students described fell into two rough categories: consuming food, and a very wide variety of other activities that were *not* eating. Examples include board games, video games, apple picking, rock climbing, disc golf, hiking, miniature golf, pool, bowling, fire department tour, karaoke, fire pit, visit a cat café, and watching football. Given the relatively low numbers, and for the sake of this preliminary study, activities involving food consumption were classified as Meal and other activities were all categorized as "Activity" and will be referred to as such in this paper: capital A, Activity. Similar to the location classification, a team not completing the assignment is marked None.

Evaluation of Student Performance

As part of our routine continuous improvement assessment, we evaluate students against some of ABET 1-7 [8] at the end of each semester of the two-course sequence as outlined in Table 1. The assessment of project outcomes was performed by each team's advisor using a selection of AACU VALUE rubrics [9]. The advisors are most familiar with the overall performance of their teams and can provide a holistic assessment. The use of detailed rubrics helps to ensure consistency in scoring. The score for each rubric was scaled to be between 0 and 10. In some cases, an advisor only submitted one or two of the three rubric score sheets, resulting in different *n* for each. Based on the results published in the literature, we hypothesize that there may be impacts in the areas marked in Table 1: use of the design and problem-solving process, effective oral communication, and teamwork.

Data Analysis

The above methods yielded a catalogue of interventions at the team level and rubric evaluations at the student level. Using the known mapping of students to teams, the data was linked at an individual student level, i.e., team building activities are mapped to student performance. The resultant dataset, with activity type and location as categorical independent variables and oral communication, teamwork, and design & problem solving scores as numerical ordinal dependent variables was then subjected to statistical analysis.

Table 1. Assessment process and expected impact from team building activity.

Learning Outcome	Method of Assessment (AACU Rubric)	Expected Impact?
1. Identify, formulate, solve…	n/a (non-AACU rubric)	
2. Apply engineering design…	**Problem Solving (VALUE rubric rows 1-4)**	**X**
3. Communicate effectively…	**Oral Communication** Written Communication	**X**
4. Recognize ethical and professional responsibilities…	Ethical Reasoning	
5. Function effectively on a team…	**Teamwork**	**X**
6. Develop and conduct experiments..	n/a (non-AACU rubric)	
7. Acquire and apply new knowledge…	Foundations and Skills for Lifelong Learning	

Analyzing by activity type, out of the 49 capstone teams for which we have AACU VALUE rubric scores, 31 teams self-selected having a meal together as a team building activity and 16 teams decided to engage in an Activity. Analyzing by activity location, 23 teams decided to perform the team building activity off-campus, 21 teams decided to stay on-campus and three teams undertook virtual team building activities. Lastly, two teams either did not participate in a team-building activity, or participated but did not submit the assignment describing the activity.

Exploratory data analysis was conducted to visually represent and comprehend the overall distribution and patterns within the rubric score data. Figures 1-3 show the data as boxplots.

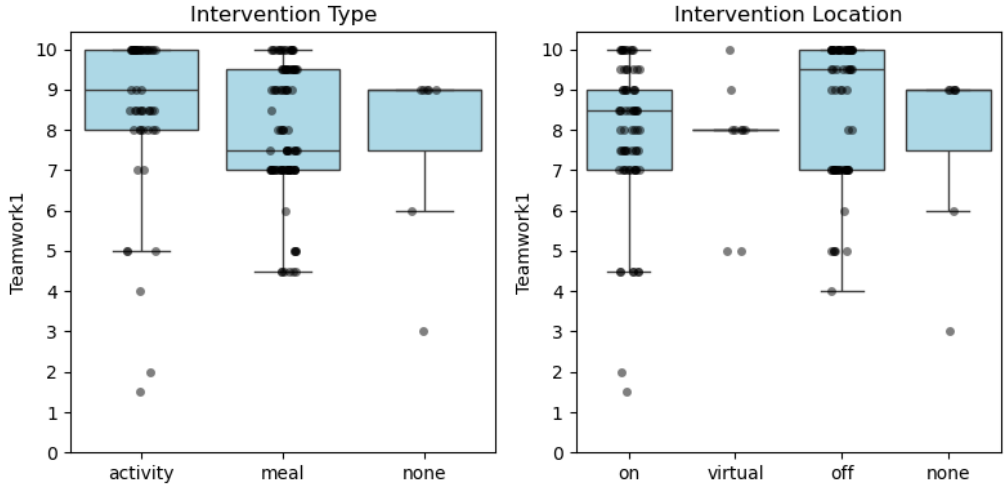

Figure 1: Data visualization for Teamwork rubric results, sorted by type and location

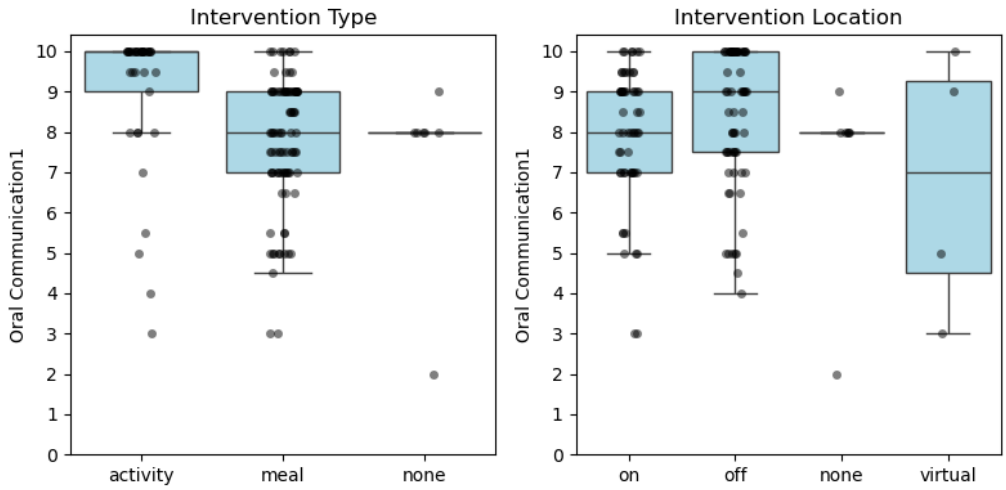

Figure 2: Data visualization for Oral Communication rubric results, sorted by type and location

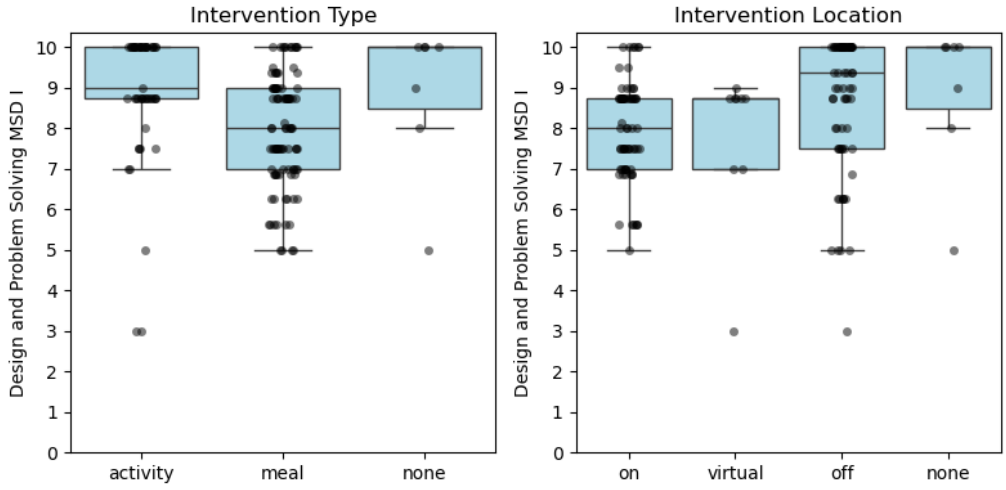

Figure 3: Data visualization for Design & Problem Solving rubric results, sorted by type and location

Next, to assess the normality of the distribution, the Shapiro-Wilk test was applied. Based on the results that the data did not follow a normal distribution, a Kruskal-Wallis test, a non-parametric test for comparing more than two independent samples, was selected to test the statistical significance of differences in teamwork, oral communication, and design & problem solving scores based on various type and location of the team building activity. In cases where statistical significance was identified, a post-hoc Dunn test was conducted for pairwise comparisons between each level of the independent categorical variables, ensuring a comprehensive understanding of the observed differences. Tables 2-4 describe the results of these tests.

A combination of Microsoft Excel and Python was used to process the data. For statistical analysis the stats module of SciPy library was used. Other python libraries used for data wrangling and visualization include Pandas, Matplotlib, and Seaborn.

Results and Discussion

The Shapiro-Wilk test results indicated a non-normal distribution for all data, leading to the decision to use the non-parametric Kruskal-Wallis test for statistical significance. The analysis in Table 2 revealed a significant effect of activity *type* on teamwork, oral communication, and design & problem solving scores. No statistically significant effect was identified between activity *location* with either teamwork or oral communication scores. However, activity location was a statistically significant factor in distinguishing design & problem solving scores of the students.

Table 2. Kruskal-Wallis Test Results

	P-Value (activity Type)	P-Value (activity Location)
Teamwork	0.008	0.176
Oral Communication	0.000	0.312
Design & Prob. Solving	0.000	0.001

1) Teamwork

A post-hoc Dunn test confirmed that students engaging in Activity performed better in teamwork compared to those sharing a meal at a statistical significance level ($\alpha = 0.05$). Out of a maximum score of 10, the median score for teamwork for those engaging in Activity was 9.0 while those just sharing a meal (Meal) was 7.5 (Table 3). This evidence suggests that non-meal (Activity) based team-building activities may improve the ability of the team-members to work together compared to meal-based team-building activities (Meal).

2) Oral Communication

A post-hoc Dunn test also confirmed that students engaging in an Activity performed better in oral communication at a statistical significance ($\alpha = 0.05$). Out of a maximum score of 10, the median score for oral communication for those engaging in Activity was 10 while those just sharing a meal (Meal) was 8.0 (Table 3). This evidence suggests that an Activity may improve the ability of the team-members to perform better in oral communication compared to Meal.

3) Design & Problem Solving

A post-hoc Dunn test also confirmed that students sharing a meal (Meal) performed worse in design & problem solving at a statistical significance $\alpha = 0.05$. Out of a maximum score of 10, the median score for design & problem solving for those sharing a meal (Meal) was 8.0 while those engaged in an Activity was 9.0 and those not undertaking a team building activity was 10 (Table 3).

Further, per Table 2, in the case of design & problem solving scores, the activity location was statistically significant ($\alpha = 0.05$). Mean and median scores for each state of the location parameter are given in Table 4.

Table 3. Mean and median rubric scores, by activity *type*

	Teamwork		Oral Communication		Design & Prob. Solving	
	Median	Mean	Median	Mean	Median	Mean
Activity	9.0	8.52	10.0	9.00	9.0	8.89
Meal	7.5	7.96	8.0	7.72	8.0	7.95
None	9.0	7.71	8.0	7.29	10.0	8.86

Table 4. Mean and median rubric scores for Design & Problem Solving, by activity *location*

Design & Problem Solving	Mean	Median
On-campus	7.96	8.0
Virtual	7.75	8.75
Off-campus	8.65	9.375
none	8.86	10.0

Limitations and Future Work

The AACU rubrics were filled out by 20 different project guides for 70 capstone teams of which some evaluations were only partially complete and hence removed. The final dataset had students from 49 capstone teams. Although a clear rubric was defined for AACU metric evaluation, some inter-guide bias is possible and was not possible to control owing to the post-hoc nature of the analysis of unbalanced, not normally distributed data.

Out of those 49 capstone teams, only two teams with a total of seven students did not undertake a team building activity. This reduced the statistical power comparison with no team building activity (None).

While the results presented here do show significant correlation between choice of team activity and student outcomes, the capstone environment is complex, and it is unrealistic to think that a brief team building activity during the early days of a two-semester capstone course is the sole contributor to these outcomes. It is likely numerous other internal and external factors faced by teams will also influence outcomes.

In the future, the study of the interaction between individual student attributes such as personality type and team building activity attributes may yield actionable insights into personalizing team building activities based on student team composition.

Further, this study can be extended by studying the impact of team building activities on team level metrics like collective intelligence [10] rather than limited to individual student level metrics.

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