

Impact of Team-Building Activities and Personality on Student Learning Outcomes in Capstone Design Course*

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This research explores the impact of team-building activities (TBAs) and student personality traits on student outcomes in engineering capstone courses. Using students' self-reported data consisting of 137 senior engineering students from 32 student teams and corresponding student learning outcomes spanning two years, we analyze whether students' personality types, based on the DISC model, influence their selection of TBAs, and whether both the personality traits and TBAs affect student outcomes in teamwork and problem-solving. Cramer's V analysis and regression analysis were used to assess these. Findings indicate that activity-based TBAs are associated with better problem-solving outcomes while personality traits had no statistically significant correlation on either outcome. This research provides insights into how TBAs can be structured to improve educational outcomes in large capstone design.

Keywords: capstone design; team building; student outcomes; personality type

1. Introduction and Background

Teamwork is a vital component of both academic and professional success as it fosters better communication and problem-solving and leads to group effectiveness in achieving a shared goal. To ensure that engineering students appreciate the importance of teamwork, it is desirable to provide them with experiences of working in teams as well as tools to improve teamwork.

Team-building activities (TBAs) are frequently employed to enhance team dynamics and have been proven to boost team performance [1–6]. However, in large capstone courses, several factors influence the choice of appropriate TBAs: logistical challenges in implementing them across multiple sections and instructors, sustainability, resource allocation for hundreds of students annually, and the time commitment required from students compared to the perceived benefits of the activity. These constraints make it difficult to balance educational effectiveness with practical feasibility.

Design/build exercises and collaborative hands-on problem-solving exercises were found to improve group attraction which encompasses enjoyment in working with the group, confidence in their group, and feeling like the group accomplished something [1]. Evaluation of four different types of TBAs led to findings suggesting that tactile design/construct projects were more effective than a verbal problem-solving activity at improving a variety of team metrics [2]. While design/construct

projects require more consumable resources (e.g., waste generated when hundreds of students build paper or balloon towers), they also appear to yield better results than a hypothetical problem-solving activity. However, regardless of TBA type, half or more of the participants indicated that they knew their teammates better, that TBAs improved engagement with their team, and that TBAs resulted in better preparedness to manage conflict within the team [2]. In contexts outside of capstone design, a variety of different TBAs have resulted in improved elements of team behavior. Activities such as preparing and eating meals together [7] or playing team video games [3,4] can lead to improved team function. An environment with “happy” music may improve mood and lead to an increase in cooperative behavior [5]. In summary, while various team-level intervention activities, both related and unrelated to capstone-design, have been shown to enhance team effectiveness, the literature favors interactive hands-on TBAs.

A systematic review of team formation in capstone design [9] revealed multiple dimensions that need to be considered while forming capstone teams including student skills, student preferences, client preferences, educational-context constraints. The instructor's time-involvement varies significantly based on the approach followed. Different approaches tend to encourage different learning outcomes and varying degrees of student ownership [9]. Clearly, there is an art and science to team formation in capstone design course. However,

when the constraints of discipline and course meeting times are considered, efforts to optimize teams may be stymied. Instead of optimizing team assignments, highly constrained instructors may be better served by investigating the use of TBAs to help assigned teams perform the best they can.

This research is a continuation of prior work in which the relationship between the attributes of the student self-selected TBAs and student performance was examined for one year worth of data [8]. A statistically significant impact of the type of TBA on individual students' teamwork, oral communication, and design & problem-solving scores was reported [8]. Additionally, a significant effect of the activity location (on or off campus) on problem-solving scores was observed [8]. However, the prior study had a limitation in not studying the interaction between individual student attributes such as personality type and the choice of TBA. This limitation obfuscates whether the student's choice of TBAs was itself influenced by individual students' personality types. The data were also from only one cohort of students, casting doubt on whether the correlations were representative of the larger student body.

2. Research Question

This research extends prior work [8] by investigating whether student personality traits may influence the choice of TBAs and how both these personality traits and attributes of self-selected TBAs correlate to capstone student outcomes, particularly teamwork and problem-solving, in the context of a capstone course. This research also builds on the previous work [8] by including two years of data, rather than just one, providing a broader and more comprehensive analysis. The research questions address in this paper are:

- RQ1: Does choice of TBA correlate with student outcomes related to teamwork and problem-solving?
- RQ2a: Does a student's DISC personality type influence choice of TBA?
- RQ2b: Does a student's DISC personality type correlate with student outcomes related to teamwork and problem solving?

3. Methodology

Data from the fall-spring 2022–23 and fall-spring 2023–24 project cohorts in Rochester Institute of Technology's (RIT) Multidisciplinary Senior Design (MSD) engineering capstone program were analyzed. This included complete records of 137 students on 32 teams. A single student-level record consisted of DISC personality scores, team's

chosen TBA, and scores on teamwork and problem solving rubrics.

3.1 DISC Personality Assessment

Students complete a DISC Personality Assessment, a widely recognized psychometric tool used to evaluate individual behavioral styles [10], for the capstone course. The DISC model categorizes personality into four distinct dimensions: Dominance, Influence, Steadiness, and Compliance. These dimensions reflect an individual's typical patterns of interaction in work and team settings, making it a relevant tool for understanding student behaviors in engineering education contexts. The DISC assessment yields a percentage score for each of the four behavioral styles, and was offered as a self-administered online survey at the start of the academic term [11]. The DISC assessment results were self-reported by the students in an assignment.

The students reported the DISC results in diverse formats. Some students reported the exact scores while others only reported the highest-scoring dimension of their personality. Other students felt that more than one dimension was a strong constituent of their personality and reported multiple dimensions. By preprocessing this data, binary indicators were created to represent the presence (1) or absence (0) of each DISC dimension for each student. Among the students who reported raw DISC scores, all scores within five percentage points of the maximum score were coded as presence of that dimension. Each of the four DISC personality dimensions were used as categorical input parameters to predict numeric scores of outcomes in teamwork and problem-solving tasks. If a student did not submit DISC dimensions, they were dropped from the study.

3.2 Team-Building Activity

At RIT, capstone projects are executed by multidisciplinary student teams. The capstone director elicits student's project preferences before the beginning of the capstone course. The final team assignment is a manual process with an objective of assigning students with necessary skills (as defined by client and negotiated by engineering-discipline faculty) while optimizing for student preferences. Team assignments rarely consider preferences among friends to work together, so typical teams are comprised of students who are working together for the first time in their capstone.

Since students can still add/drop classes through the first week of each semester, teams are not finalized until the second week of class. At the beginning of the second week, students complete an online module about how teams work together, and complete individual DISC assessments. After

discussing their individual DISC results within teams during class, teams choose and complete a TBA. Some examples of TBAs were provided to help students decide an activity suitable for them, and teams were asked to submit a brief summary of their TBA as an assignment. These assignments are ungraded but encouraged. There is a wide variety of options available to students, both on- and off-campus. On-campus options include: dining halls, gymnasium/recreational facilities, performing arts, spectating at intercollegiate sports events, walking trails, and gaming spaces. Off-campus options in our medium-sized metropolitan area include: a wide variety of restaurants and bars, movie theaters, performance venues, parks, shopping, and recreational activities. Off-campus options require some type of transportation, but most upper-class students live off campus already.

All team submissions, across the two academic years included in the study, were read by the research team to better understand the unique TBAs undertaken by each individual team to identify emerging categories. Two categorical themes emerged: where they took place (location) and what kind of activities they were (type). For location, two categories, On-campus and Off-campus, were used. In the academic year 2022–2023, two teams did their TBA virtually. Students from these two teams were dropped from the study. For type, the TBAs were split into two groups: those involving just consuming food and drinks (labelled “meals”) and all other kinds of TBAs (labelled “activity”). Examples of “meal” included lunch on campus, dinner at a nearby bar, going out for ice cream, or getting coffee. Examples of “activity” included board games, video games, apple picking, rock climbing, disc golf, hiking, miniature golf, pool, bowling, a tour of the fire department, karaoke, sitting around a fire pit, visiting a cat café, and watching football. Students from just 3 teams did not complete TBA. This sample size was too low for any statistical tests hence those students were dropped from the study. If their team did not complete the assignment or did not report it, then those students were dropped from the research study. If a team’s description included elements of both meal and activity, it was categorized as an activity.

3.3 Student Outcome Measures

For continuous improvement of the capstone course offering, students are regularly assessed at the end of each semester for the two-course sequence against the ABET criteria 1–7 [12]. Each team’s advisor assesses student outcomes in the capstone project context using a set of AACU VALUE rubrics [13] which have been mapped to

ABET 1–7 for this course. These rubrics help keep scoring consistent, with detailed level descriptions. The rubrics contain different numbers of criteria, so prior to analysis all rubric scores are scaled to range from 0–10. Based on prior work, the problem-solving and teamwork outcomes were chosen [8]. Some project advisors only submitted one of the two rubrics or failed to submit rubrics for every student on a team. In these cases, all available rubric data was included in the analysis.

3.4 Statistical Analysis

Before any predictive analysis, to examine the relationships between categorical variables within the dataset, Cramér’s V test was employed [14]. Cramér’s V is a measure of association between two nominal variables, giving a value between 0 and 1. This test is an adaptation of the chi-square test and was conducted to quantify the degree of association between various categorical variables such as ‘Intervention Type’, ‘Intervention Location’, Year, and personality traits (i.e., Dominance, Influence, Steadiness, Compliance). A heatmap was generated to visualize the results, where the intensity of greyscale represents the strength of the association between each pair of variables. The computation of Cramér’s V was executed using SciPy library in Python [15].

For predictive power and for determining statistical significance, ordinary least squares (OLS) regression was selected for this analysis, as it is a well-established and widely understood method and is often used as a baseline model for exploratory work. Its interpretability and broad application across various fields also facilitate comparison with similar studies. OLS provided a straightforward approach to estimating the linear associations between predictors (TBA attributes and personality traits) and outcomes (‘Problem Solving’ score and ‘Teamwork’ score), making it an appropriate choice for initial analysis in educational research. The model included seven predictors: ‘Intervention Location’, ‘Intervention Type’, Year, and four personality traits (Dominance, Influence, Steadiness, Compliance). Off-campus location and activity type were considered in the reference model and the impact of on-campus and meal-type were evaluated. The analysis was executed using Python’s ‘statsmodels’ library [16].

4. Results

4.1 Intervention Attributes

As seen in Fig. 1, 97 students chose meal type TBAs while only 40 students chose activity type TBAs, with the proportion of meal TBAs being significantly different from a random choice of 50% (p-

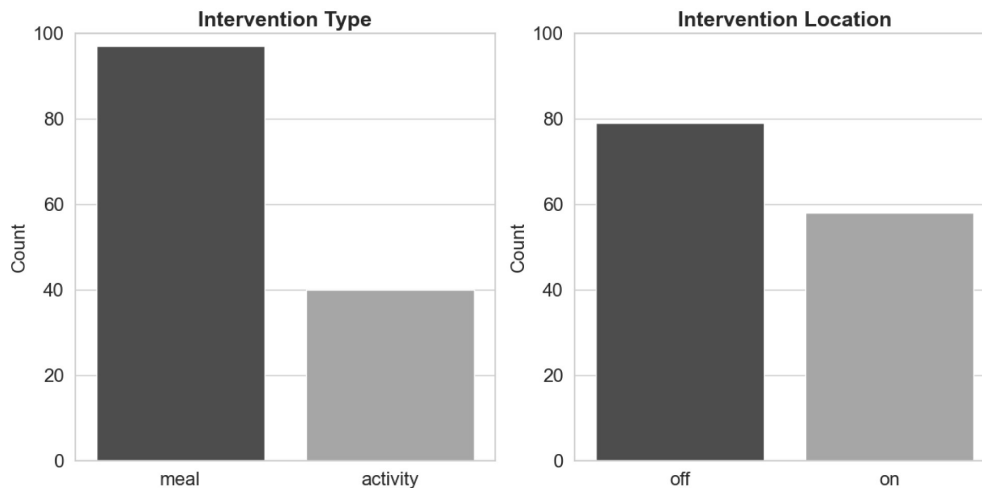


Fig. 1. Distributions of students across Intervention Attributes.

value < 0.001). With respect to the TBA's location attribute, 79 students chose off-campus location while 58 students chose on-campus location, with the proportion of off-campus TBAs not significantly different from a random choice of 50% (p-value = 0.087).

Based on the availability of a wide range of options for TBAs as discussed section 3.2, a null hypothesis can be made that each combination of type and location of TBA is selected by an equal number of students. Applying chi-square goodness of fit test to test the number of students in each of the four combinations yields a χ^2 value is 33.95 which is greater than threshold χ^2 of 7.815 ($\alpha =$

0.95, dof = 3). Thus, we reject the null hypothesis and conclude that the distribution of students across TBA combinations is not uniform. The distribution of students with respect to combination of type and location attributes of TBA is provided in Table 1.

Similarly, Fig. 2 shows the distribution of DISC personality traits among students. One notable observation is the low incidence of Influence trait among the student population under this research study.

4.2 Descriptive Statistics of Output Measures

The descriptive statistics for the 'Teamwork' and

Table 1. Distribution of students across Intervention Attributes

	Off-campus		On-campus	
	Count	Percentage	Count	Percentage
Activity	33	24.1%	7	5.1%
Meal	46	33.6%	51	37.2%

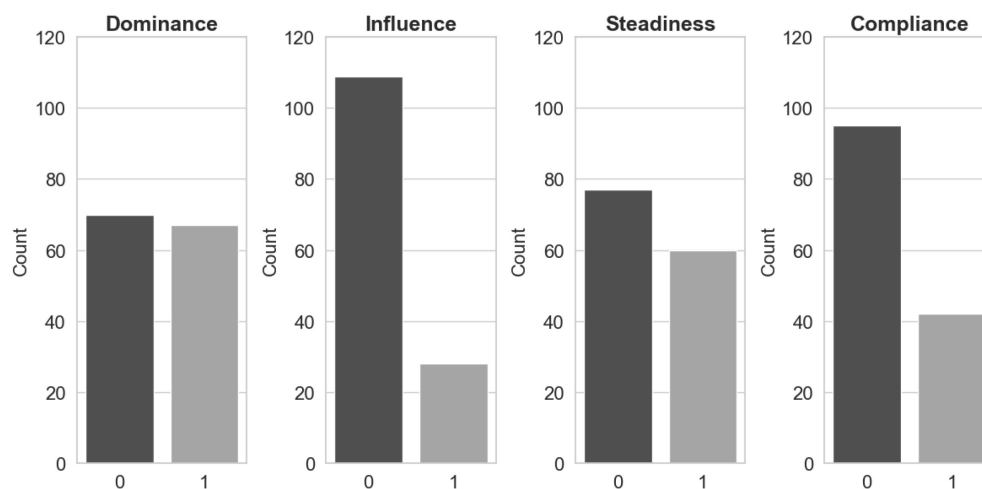


Fig. 2. Distribution of DISC personality (1= Presence; 0 = Absence).

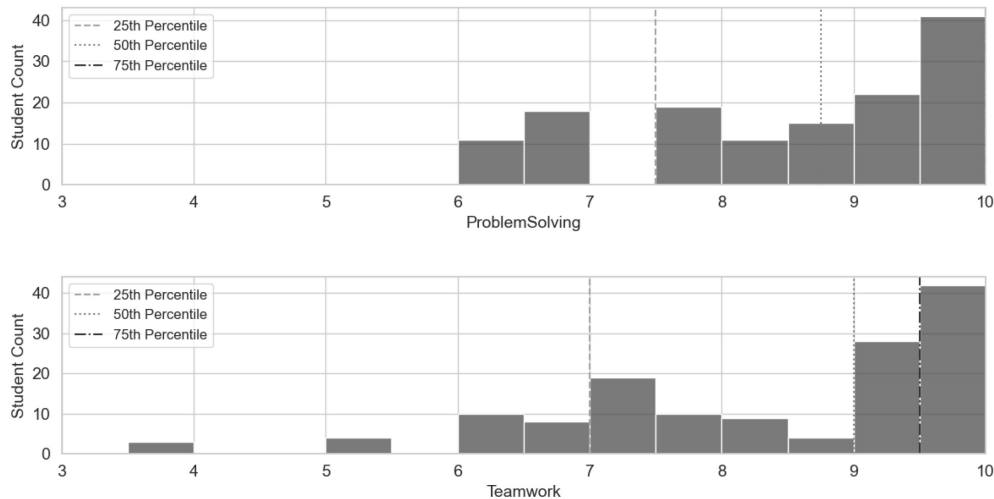


Fig. 3. Distribution of Student outcomes in Problem Solving and Teamwork.

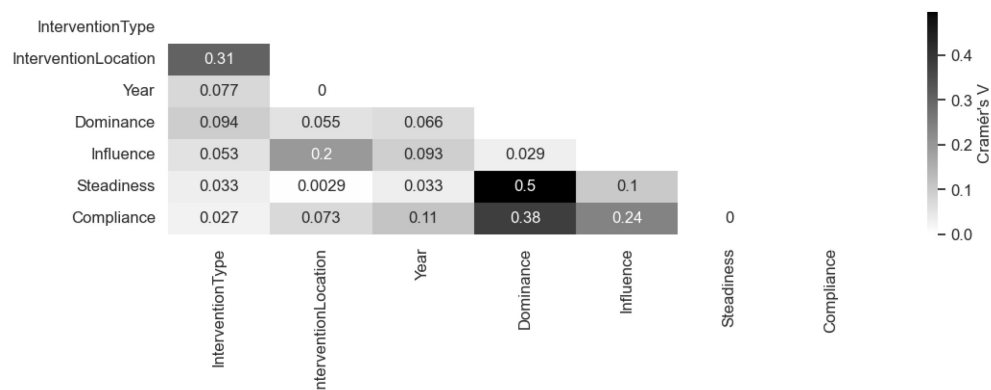


Fig. 4. Cramér's V analysis for association between categorical variables.

'Problem Solving' scores across the student distribution are described in Fig. 3. Distribution of Student outcomes in Problem Solving and Teamwork Fig. 3. For Teamwork, the mean score was 8.19, with a standard deviation of 1.6. For Problem Solving, the mean score was slightly higher at 8.53, with a lower standard deviation of 1.3, suggesting less variability in this measure compared to Teamwork. The minimum and maximum scores, along with the interquartile ranges, are presented in Fig. 3.

4.3 Correlation Analysis of Categorical Variables

As seen in Fig. 4, the association between most input variables had low values of Cramér's V suggesting minimal or negligible relationships. However, there are a few notable exceptions. The highest degree of association was observed between the Dominance and Steadiness variables, with a Cramér's V value of 0.5, indicating a moderately high relationship. Other significant associations include a moderate relationship between Compliance and Dominance (Cramér's V = 0.38) and between Intervention

Location and Intervention Type (Cramér's V = 0.31). Given that 88% of the students opting for an on-campus TBA opted for a meal, the relationship between location and type is not surprising.

4.4 Regression Analysis

The regression model for 'Problem Solving' yielded an R-squared value of 0.155, indicating that approximately 15.5% of the variability in problem-solving scores can be explained by only the predictors included in the model. The overall model was statistically significant, with an F-statistic of 3.386 and a p-value of 0.00237, suggesting that the predictors collectively have a significant impact on problem-solving scores. More importantly, among the individual predictors, TBAs of meal type showed a significant negative relationship with problem-solving scores ($\beta = -1.052$, $p < 0.001$), indicating that this type of intervention is associated with lower problem-solving scores compared to the reference category. No other predictor including personality type was statistically significant based on a p-value threshold of 0.05.

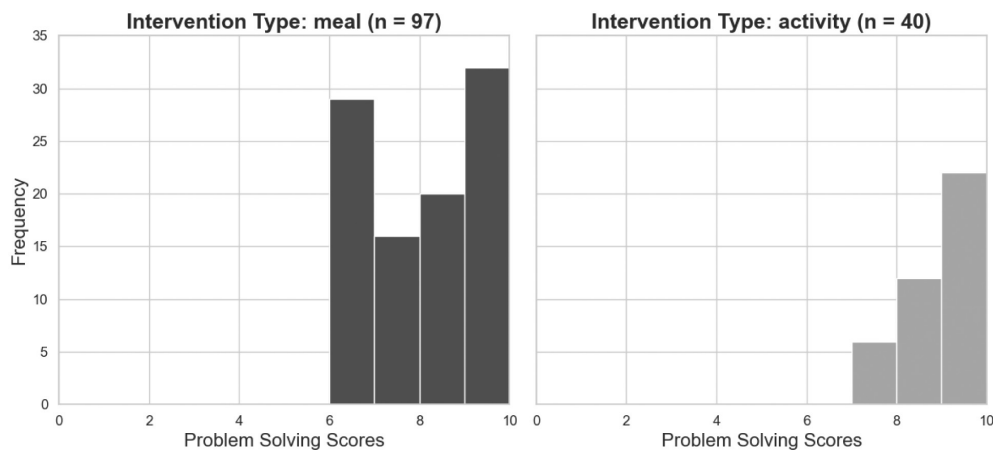
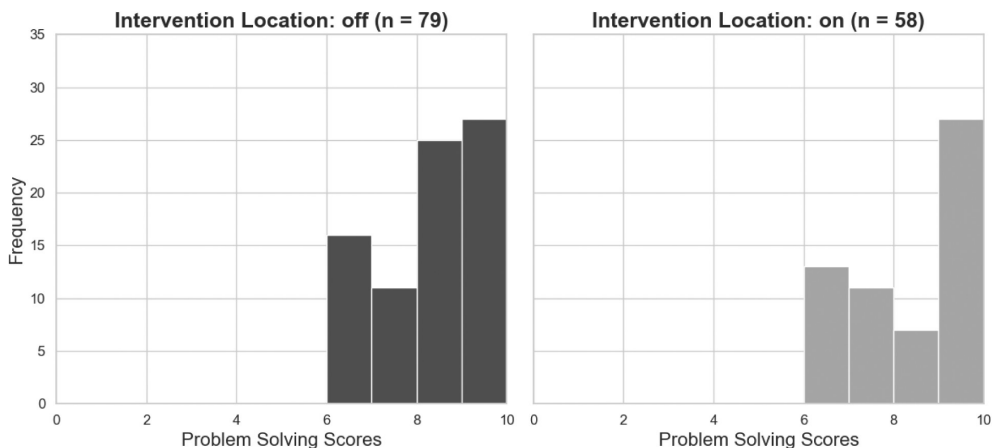
Table 2. Results of Regression Analysis

	Problem Solving		Teamwork	
	Coefficient	p-value	Coefficient	p-value
Intercept	9.1132	0.000	9.2055	0.000
Intervention Location (on-campus)	0.3778	0.110	-0.5013	0.090
Intervention Type (meal)	-1.0517	0.000	-0.3180	0.302
Year (2023–2024)	-0.0176	0.941	-1.048	0.001
Dominance	-0.0100	0.972	0.0858	0.810
Influence	-0.1076	0.710	-0.1082	0.765
Steadiness	0.3196	0.225	0.3381	0.304
Compliance	-0.3350	0.233	-0.0013	0.997

Similarly, the regression analysis for the ‘Teamwork’ outcome yielded an R-squared value of 0.127, indicating that approximately 12.7% of the variance in Teamwork scores can be explained by the independent variables included in the model. The overall model was statistically significant, with an F-statistic of 2.689 and a corresponding p-value of 0.0124, suggesting that the predictors as a group are significantly related to the ‘Teamwork’ scores. Among the predictors, the categorical factor year

had a significant effect. The 2023–2024 cohort had poorer Teamwork scores ($\beta = -1.048$, $p = 0.001$). None of the other predictors were significant at a level of statistical significance ($\alpha = 0.05$). Table 2 provides the details of the regression analysis with bold font for statistically significant results.

In the Cramer’s V analysis, a moderate association was found between intervention type and intervention location. The regression analysis indicated that intervention type is a statistically sig-

**Fig. 5.** Distribution of Problem Solving scores of students across meal and activity type of TBAs.**Fig. 6.** Distribution of Problem Solving scores of students across on-campus and off-campus location of TBAs.

nificant predictor of problem-solving performance. This necessitates further analysis to confirm that statistical significance of TBA intervention type attribute is not confounded by TBA intervention location. As illustrated in Fig. 5 and Fig. 6, intervention type appears to more effectively differentiate problem-solving scores. The chi-square test revealed that the distribution of problem-solving scores for the intervention type “meal” is significantly different from that of the intervention type “activity” (p -value < 0.005). In contrast, the chi-square test for intervention location showed no significant ($\alpha = 0.05$) difference in the distribution of problem-solving scores of students between off-campus TBAs and on-campus TBAs (p -value = 0.0605). These additional tests confirm TBA intervention type to be a statistically significant predictor of problem solving scores of capstone students.

5. Discussion

This study explored how attributes of TBAs (on-campus vs. off-campus; meal vs. activity) and individual personality traits (Dominance, Influence, Steadiness, Compliance) influence students' outcomes in terms of problem-solving and teamwork abilities in capstone projects. Our findings contribute to understanding how student personality traits and team-building interventions affect collaborative project-based learning in an engineering education.

5.1 Choice of Team-Building Activity

Based on the Chi-Square test discussed in section 4.1, the distribution of chosen TBA is not uniform with the combination of on-campus meal accounting for 37% of the student-selected TBAs. This combination represents the TBA that requires minimal effort and time commitment, offering a low-resistance option for teams. This suggests that many students opt for convenient TBAs when given an option to self-select.

5.2 Influence of Team-Building Activities on Student Outcomes

The results demonstrate that the type of TBA has a significant relationship with problem-solving skills. Meal-based TBAs were negatively associated with problem-solving scores ($\beta = -1.052$, $p < 0.001$), suggesting that such activities may not be as effective more hands-on or collaborative TBAs. This finding aligns with prior research showing that design/construct projects tend to improve a variety of team metrics [1]. The findings further the body of research by directly comparing them with non-collaborative activities (e.g., just having a meal together).

On the other hand, the type of TBA does not have a significant correlation with teamwork skills. This could be attributed to the fact that even less-interactive activities, such as having meals, can foster a sense of camaraderie and informal bonding, which may enhance teamwork but not necessarily impact the more technical aspects of problem-solving.

These results suggest that while meal-based TBAs may build social cohesion, they may not provide the structured interaction needed to develop problem-solving skills. Alternately, students who struggle with problem solving skills may be more inclined to choose activities that require less planning and decision making: everyone needs to eat, but going off-campus to play mini golf requires planning. This finding could inform instructors and course designers to prioritize activity-based TBAs for engineering student design teams, particularly for improving problem-solving skills. Since location was not significant, the added complexity or expense of off-campus travel should not be a barrier to teams undertaking more fruitful TBAs.

5.3 The Role of Personality Traits in Team Performance

Personality traits measured by the DISC assessment did not significantly impact teamwork or problem-solving scores in our sample. None of the four DISC dimensions (Dominance, Influence, Steadiness, Compliance) showed significant predictive power for either student outcomes problem-solving or teamwork. This implies that while personality traits may influence interpersonal dynamics within teams, they do not necessarily translate into measurable differences in student outcomes in the context of capstone design student teams.

One explanation is that the effects of personality may be moderated by other factors not captured in this study, such as team composition, task complexity, or the role of the instructor in facilitating team interactions. Further, the binary coding of DISC dimensions might have potentially obscured more nuanced relationships between personality and performance.

5.4 Interaction Between TBAs and Personality Traits

No significant interaction was found between personality traits and the choice of TBAs suggesting that students' DISC personality profiles did not significantly influence their preferences for TBAs. This finding, coupled with lack of statistical significance of personality traits in regression analysis, could imply that the influence of TBAs on student outcomes is more universal, with the nature of the activity itself.

5.5 Extraneous factors affecting Student Outcomes

In this study, the academic year emerged as a statistically significant predictor of teamwork scores. While the primary research questions focused on the impact of TBAs and personality traits on student outcomes, the year was included as a blocking factor, a common approach in longitudinal studies. To achieve more accurate predictions of student outcomes, it would have been necessary to investigate other factors, such as year-specific trends or characteristics unique to each cohort.

5.6 Implications for Capstone Course Design

The results of this study provide important insights for educators involved in capstone courses. Our findings suggest that while all TBAs may be beneficial, the type of TBA matters. Activity-based TBAs, particularly those that require hands-on collaboration, appear to be more effective at enhancing students' problem-solving abilities. This insight could be used to guide the design of team-building interventions, particularly in large capstone courses where logistical constraints may limit the variety of activities that can be implemented. In contrast, meal-based TBAs may be more appropriate for building initial rapport among team members, which can still contribute positively to teamwork but may not translate into improved problem-solving skills. Course instructors might consider using meal-based TBAs early in the team formation process to foster social bonds, followed by more structured, activity-based TBAs as teams begin working on more complex tasks.

Finally, for instructors who are constrained by project-specific staffing needs or section registration and are not able to optimize teams based on other factors, these results can guide instructors toward activities that help teams to improve their problem solving performance.

6. Limitations and Future Work

There are several limitations to this study. First, the low R-squared values in our regression models (15.5% for problem-solving and 12.7% for teamwork) suggest that other factors not captured in this

study may be influencing these outcomes. Further, ordinary least square regression is often a baseline regression model which is sensitive to data distribution. Additional studies could use a more suitable regression model and explore additional variables, such as team size, task difficulty, or the role of the instructor, to better understand the factors that contribute to successful student outcomes.

Also, the use of binary indicators to represent DISC dimensions may have oversimplified the complexity of personality traits, limiting our ability to detect subtle but meaningful differences in how personality influences team dynamics. Future research should explore more detailed methods of capturing personality traits, potentially using continuous scores or a more nuanced classification system.

7. Conclusion

This research investigated the influence of TBAs and personality traits on teamwork and problem-solving outcomes among capstone design students. Findings showed that activity-based TBAs significantly improved problem-solving score compared to meal-based TBAs, though no significant effect was found on teamwork score. Personality traits, as measured by the DISC model, did not significantly impact either outcome.

These results suggest that activity-based TBAs are more effective for developing problem-solving skills, while meal-based TBAs may still foster team cohesion. Educators designing capstone courses should consider a balanced approach integrating appropriate TBAs to support various aspects of capstone project including teamwork and problem-solving.

In the future, with a more robust dataset more sophisticated statistical models should be explored to understand additional factors such as instructor involvement which may affect student outcomes in capstone context.

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