The Relative Importance of Team Dynamics in Predicting Effective Teamwork Behaviors

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***Abstract*— Understanding how psychological dynamics in teams influence the effectiveness of students' teamwork behaviors improves instructors' ability to manage student teams. This research study explored the relative importance of three measures of team dynamics in predicting five behavioral dimensions of effective teamwork. Data were collected from 1780 students in a first-year engineering course in Spring 2020, and 1638 students' data remained after removing multivariate outliers. Relative weight analysis via RWA-Web was conducted for this study as it revealed the pure and independent contribution of each predictor for criterion variables. Results showed that the combination of conflict ($R2 = 0.00293$, $p < .05$), cohesiveness ($R2 = 0.00126$, $p < .05$), and psychological safety ($R2 = 0.00254$, $p < .05$) explained 0.0067 of the variances in five teamwork behavior constructs. On the one hand, these results show that compared to psychological safety and cohesiveness, conflict was the most significant factor influencing teamwork behavioral effectiveness. On the other hand, the results also reveal that all three of these measures have extremely low predictive power. Therefore, while this work might suggest that instructors need to pay closer attention to monitor the conflict in student teams to improve their teamwork skills, the results are confounded by the low variability in ratings overall. Most teams report high ratings – a mean greater than 4 on a 5-point scale once the behavioral scale is converted to numeric values. Noting that our greatest concern lies with identifying and remediating dysfunctional teams, the RWA analysis will be repeated on a sample restricted to teams showing some evidence of dysfunction, which will be reported in the full manuscript.**

Keywords—teamwork, team dynamics, teamwork behavioral effectiveness, relative importance analysis

I. Introduction

Providing team-based learning experiences helps students develop collaboration, communication, and conflict management skills that are critical for career development [1]. Understanding team dynamics and effective teamwork behaviors helps instructors manage and facilitate student teams to promote collaborative learning. Many studies have focused on how various psychological dynamics influence teamwork outcomes, such as team learning, performance, and creativity [2–4] or the interrelationships among team dynamics [5], little research directly draws on the relationship between team dynamics and teamwork behaviors. This study included three independent team dynamics – psychological safety, cohesiveness, and conflict – and five dependent variables of teamwork behavioral effectiveness. Psychological safety is defined as a consensus reached by team members that the team is safe for interpersonal risk-taking [6]. Cohesiveness or cohesion refers to team members sharing common goals and values coming together as a whole when involved in teamwork [7], which is operated in three dimensions: task attraction, interpersonal cohesiveness, and task commitment [8–9]. Team conflict, broadly defined as "discrepant views" among team members [10], can be categorized into the relationship, task, and process conflicts [11]. The Comprehensive Assessment Team Member Effectiveness (CATME) instrument was used to collect and measure self- and peer-evaluations of teamwork behavioral effectiveness, which includes five dimensions: Contributing to the team's work; Interacting with teammates; Keeping the team on track; Expecting quality; Having relevant knowledge, skills, and abilities (KSAs) [12]. All measurement instruments are provided in Appendix A for reference.

We studied the relative importance of psychological team dynamics, including psychological safety, team cohesiveness, and conflict in predicting team members' peer-perceived teamwork behaviors. Specifically, the research question of this study is: which of team dynamic attributes mostly contributes to predicting teamwork behavioral effectiveness? Using simple linear regression, Beigpourian et al. asserted that psychological safety was the most significant indicator to identify dysfunctional teams [5]. Therefore, this research hypothesized that compared to team cohesiveness and conflict, psychological safety had the most relative importance in explaining the variances of teamwork behavioral effectiveness. The findings of this work have the potential to inform instructors to pay special attention to the most important team dynamics construct of students to better help students develop teamwork skills and manage teams to benefit students from collaborative learning.

II. Methodology

Data was collected in a 16-week first-year engineering course at a large Midwestern public research-intensive university in Spring 2020. The collection and use of data were granted by this university's IRB under protocol number 0903007824. The sample contained 1780 students, which included the whole cohort of students enrolled in the class. Sample demographics and missing data pattern were summarized in Tables 1 and 2 in Appendix B, respectively. Besides students' self-reported demographics, such as their gender, race, GPA, etc. collected during the first two weeks of the course, self- and peer-evaluation results of CATME teamwork behavioral dimensions, team cohesiveness, conflict, and psychological safety were gathered during the week 11-12. All team dynamics scales were constructed as Likert scales and could be aggregated as average scores ranging from one to five, except for psychological safety with a range of one to seven. All aggregated scores were considered to be continuous. Only peer-assessed teamwork behavioral effective scores on each team member were included in computed averages. Data from teams with responses from fewer than three members were discarded (teams typically had four members) [13–14]. After processing the raw data, we conducted Hawkin's test for missing completely at random

(MCAR) using the "MissMech" R package in R 4.0.2 [15–16]. The test rejected the MCAR hypothesis at 95% significance level. Due to the high response rate of 95.62%, scale-level missingness, and relatively large sample size, the pairwise deletion technique was applied for missing data.

Multivariate Relative Importance Analysis (RIA) (also referred to as Relative Weight Analysis, RWA) was used for this study. According to Tonidandel & LeBreton [17], relative weights analysis examined the proportionate contribution of each predictor's usefulness in predicting the model taking into account both the unique variance explained by that predictor and its combination with other predictors in the model. Compared with standardized regression coefficients and zero-order correlations, relative weight analysis considered "the direct effect of each predictor and its joint effect with other predictors when portioning the predictable criterion variance among them [18, p2]" to provide more informative insight of the relative importance of each predictor. Therefore, RWA-Web was used to conduct to explore the relative importance of the three measurements of team dynamics in explaining the variance of teamwork behavioral effectiveness [17]. This method calculated the raw relative weight (summed up to overall R2) and the relative weight rescaled as a percentage of predicted variance (summed up to 100%) in the criterion variable attributed to team dynamics variables. The significant test of one predictor variable differing from others was also available. Bias-corrected and accelerated (BCa) bootstrap intervals were used to test whether each predictor of team dynamic constructs statistically contributed in predicting the criterion variances of teamwork behavioral effectiveness and to test whether a given predictor was significantly different from others [19]. In this study, confidence intervals for the individual relative weights and all corresponding significance tests were based on bootstrapping with 10,000 replications at 95% confidence level.

III. Results

Table 3 in Appendix B displayed the means, standard deviations, skewness, and kurtosis for all measured scales and their respective correlations and internal consistencies. All scales had good internal consistency (Cronbach's α ranged from .62 to .77). Conflict (M = 1.26) and psychological safety (M = 6.11) were clustered around the end of the scale, which indicated that students generally perceived a lack of conflict and felt safe in the teams. Previous studies of these constructs have shown that they meet the requirements to be treated as consensus measures [20]. The absolute values of skewness and kurtosis for all scales fell within 2, so the univariate normality assumption was met [21]. The CATME teamwork behavioral effectiveness showed moderate to strong correlations, while the team psychological dynamic attributes showed weak correlations. Though team conflict and cohesiveness were not statistically correlated to any teamwork behavioral effectiveness, psychological safety was. These correlation patterns provided the foundation to perform multivariate relative weight analysis, estimating the relative importance of team dynamics constructs on teamwork behaviors. Additionally, multivariate normality and multicollinearity were checked via the "MVN" and "car" R package in R 4.0.2 [16], [22–23]. All three multivariate normality tests (Mardia, Henze-Zirkler, and Royston) suggested the dataset was not multivariate normal. However, based on the use of a relatively large sample, the data were treated as multivariate normal noting that while this could prevent the RWA analysis from yielding significant results, it would not invalidate significant results. The square root of the variance inflation factor of three team dynamic variables ranged from 1.00 to 1.03, representing that no multicollinearity existed [22].

A weighted linear combination of the three team dynamic variables explained only 0.0067 of the variance in the five CATME teamwork behavioral effectiveness constructs (R2 = 0.0067), with low predictive power. As summarized in Table 4, conflict, psychological safety, and cohesiveness explained 0.00293 (43.54%), 0.00254 (37.78%), and 0.00126 (18.68%) of the predicted variances in the five teamwork behavioral effectiveness attributes, respectively. All three predictors were statistically significant in predicting the criterion variances. Additionally, conflict, which had the largest relative weight, was shown to be statistically different from cohesiveness and psychological safety at the 95% confidence level.

IV. Conclusion

This study utilized multivariate relative weight analysis to explore the relationship between three team psychological dynamic attributes and five CATME behavioral dimensions of teamwork effectiveness. All three team dynamic variables explained a statistically significant amount of variance in the five criteria as none of the 95% CIs for the tests of significance contained zero, with the most important variables being conflict (RW = 0.00293, RS-RW = 43.54%), psychological safety (RW = 0.00254, RS-RW = 18.68%), and cohesiveness (RW = 0.00126, RS-RW = 37.78%). Counter to the hypothesis that psychological safety would have the most significant influence on the five teamwork behavioral variables, conflict contributed the most in predicting criterion variance as the rescaled relative weight is 43.54%, which was tested to be significantly higher than the other two factors.

V. Discussion

This work contributes to inspiring instructors to use instruments to measure and infer the teaming experiences of students during the pandemic period. In the traditionally residential classroom, instructors could more easily access students to observe their teamwork behaviors and promote cooperative learning. However, the online-based platform hinders students' team-based learning and instructors' opportunities to interact with students. This phenomenon is more problematic in large-size classrooms. Our results suggest that data collected under different teaching modes may contribute to the discrepancy of the most significant team psychological dynamics influencing teamwork proposed as psychological safety by Beigpourian et al. [5] but conflict in this study. Even though both studies collected data from first-year engineering student teams at the same institution and same course, the sample used by Beigpourian et al. was collected during a traditional residential class, whereas the sample in this study was collected in a semester where learning made an emergency shift to virtual instruction mid-semester. Instructors are informed by this research to adjust their team management practices to assess students' perceptions on teamwork attitudes and behavioral effectiveness to better understand student teaming experiences and adjust pedagogical interventions to maximize students' potentials in the era of online learning.

Moreover, the findings of this work suggest that instructors should pay special attention to the monitor student teams' attitudes in conflict to better understand their

teamwork behaviors, which ultimately influences the team's performance, especially in the middle of a semester. Jehn & Mannix [24] showed that teams with different performance levels had different strategies for dealing with team conflict, and higher performing teams generally reported a lower level of conflict. Higher performing teams could benefit from addressing conflict and eventually reaching consensus, whereas conflict in lower performing teams could be more destructive than educational. Student self-reported conflict scores could serve as an indicator to guide and inform instructors to provide additional intervention and assistance with those unhealthy teams to bring team members back on track. Therefore, students could benefit from developing teamwork behaviors and skills and manage teams to help students with collaborative learning.

This study has several limitations. First, team dynamics attributes were self-reported and teamwork behavioral effectiveness was calculated based on peer ratings. The data might not represent true scores. Second, this work only used quantitative data. Both previously indicated limitations could be addressed by conducting qualitative studies, such as focus groups and semi-structured interviews to confirm the findings of this work or through expert observation to obtain true scores. Third, only one round of peer evaluation data was used in this study, whereas longitudinal study would describe the change of relative weight of team psychological dynamics attributes during the whole team experience. Fourth, despite the availability of demographic data, this study did not disaggregate them to explore potential variability among groups based on race/ethnicity, sex, citizenship, and GPA. Lastly, because the sample data consisted of a whole cohort of the first-year engineering students who had different instructors, the different strategies used in the emergency online learning mode might result in instructor effects that weakened the analysis. Researchers are encouraged to study the effectiveness of using teamwork related instruments to guide the adjustment of teaching practice and the influence on student team performances.

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APPENDIX

A. Measurement Instrument Questions

a) ***Team Conflict*** [24]*:*

Scale: 1 = None or Not at all; 2 = Little or Rarely; 3 = Some; 4 = Much or Often; 5 = Very Much or Very Often

Task Conflict

• How much conflict of ideas is there in your work group?

• How frequently do you have disagreements within your work group about the task of the project you are working on?

• How often do people in your work group have conflicting opinions about the project you are working on?

Relationship Conflict

• How much relationship tension is there in your work group?

• How often do people get angry while working in your group?

• How much emotional conflict is there in your work group?

Process Conflict

• How often are there disagreements about who should do what in your work group?

• How much conflict is there in your group about task responsibilities?

• How often do you disagree about resource allocation in your work group?

b) Team Cohesiveness

Scale: 1 = Strongly Disagree; 2 = Disagree; 3 = Neither Agree nor Disagree; 4 = Agree; 5 = Strongly Agree

Trask Attraction [8]

• Being part of the team allows team members to do enjoyable work

• Team members get to participate in enjoyable activities

• Team members like the work that the group does

Interpersonal Cohesiveness [8]

• Team members like each other

• Team members get along well

• Team members enjoy spending time together

Task Commitment [9]

• Our team is united in trying to reach its goals for performance

•. I'm unhappy with my team's level of commitment to the task (scale reversed)

• Our team members have conflicting aspirations for the team's performance (scale reversed)

c) Psychological Safety [6]

Scale: 1 = Very Inaccurate; 2 = Inaccurate; 3 = Slightly Inaccurate; 4 = Uncertain; 5 = Slightly Accurate; 6 = Accurate; 7 = Very Accurate

• If you make a mistake on this team, it is often held against you. (scale reversed)

• Members of this team are able to bring up problems and tough issues.

• People on this team sometimes reject others for being different. (scale reversed)

• It is safe to take a risk on this team.

• It is difficult to ask other members of this team for help. (scale reversed)

• No one on this team would deliberately act in a way that undermines my efforts.

• Working with members of this team, my unique skills and talents are valued and utilized.

B. Tables

TABLE I. SAMPLE DEMOGRAPHICS

	n (mean)	***% (Standard Deviation)***
Gender		
Male	1356	76.481
Female	407	22.955
Declined/Other	10	0.564
Race		
White	867	54.540
Asian	445	25.099
Hispanic	173	9.757
Declined	56	3.158
Other	132	7.445
International?		
Yes	368	20.756
No	1405	79.244
Academic Standing		
Freshman	1637	92.329
Sophomore	95	5.358
Junior	38	2.143
Senior	3	0.512
GPA	**3.366**	**0.512**

TABLE II. MISSING DATA PATTERN FOR TEAM DYNAMICS SURVEY AND TEAMWORK EFFECTIVENESS SURVEY RESULTS

	# of missing data	***# of total sample size***
CATME DIM C	22	1.236
CATME DIM I	22	1.236
CATME DIM K	22	1.236
CATME DIM E	22	1.236
CATME DIM H	22	1.236
Team Conflict	66	3.708
Team Cohesiveness	66	3.708
Psychological Safety	66	3.708
Complete Missingness	78	3.708

Note. The total sample size is 1780.

TABLE III. MEANS, STANDARD DEVIATION, SKEWNESS, KURTOSIS, PEARSON CORRELATIONS, AND RELIABILITY (CRONBACH'S ALPHA) OF ALL MEASURED VARIABLES OF TEAM DYNAMICS AND TEAMWORK EFFECTIVENESS

	Mean	**SD**	**Skew**	**Kurtosis**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1.Dim C	3.98	0.56	-.31	.03	***.62***							
2.Dim I	4.00	0.53	-.23	-.36	.68**	***.63***						
3.Dim K	3.93	0.53	-.15	-.29	.70**	.70**	***.63***					
4.Dim E	4.00	0.50	-.21	1.07	.67**	.67**	.67**	***.64***				
5.Dim H	4.12	0.50	-.29	-.03	.70**	.56**	.58**	.58**	***.65***			
6.Conflict	1.26	0.27	1.07	.67	.029	.041	.042	-.031	.046	***.78***		
7.Cohesiveness	3.03	0.19	-.03	.36	.003	.021	.043	-.002	-.024	-.017	***.77***	
8.Psychological Safety	6.11	0.51	-.05	.12	.097**	.090**	.068**	.073**	.080**	-.243**	.063*	***.77***

Note. * $p < 0.05$, two-tailed; ** $p < 0.01$, two-tailed; **bold and italicized numbers represent attributes' Cronbach's alpha reliability**

TABLE IV. SUMMARY OF RELATIVE WEIGHT ANALYSIS OF THE RELATIONSHIP BETWEEN TEAM DYNAMIC AND BEHAVIORS

Predictor	RW	CI-L	CI-U	RS-RW (%)
Conflict	0.00293*	0.000170	0.00499	43.54
Cohesiveness[a]	0.00126*	0.000170	0.00230	18.68
Psychological Safety[a]	0.00254*	0.000717	0.00431	37.78

Note. *RW* raw relative weight (within rounding error raw weights will sum to R^2), *CI-L* lower bound of confidence interval used to test the statistical significance of raw weight, *CI-U* upper bound of confidence interval used to test the statistical significance of raw weight *RS-RW* relative weight rescaled as a percentage of predicted variance in the criterion variable attributed to each predictor (within rounding error rescaled weights sum to 100%)

* $p < 0.05$

[a] The raw relative weight for this variable differs significantly from the raw relative weight obtained for Conflict.