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Benchmarking a Foundation for Improving Psychological Safety in Teams

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Abstract

Psychological safety is emerging in the literature as a gateway to creating high performing teams and high team satisfaction. Studies have demonstrated that psychological safety is a key ingredient in the ability of teams to perform to a higher degree than they otherwise would be able to. In this research, we continue to expand the assessment of psychological safety in senior capstone teams to include data from engineering programs across four different institutions to provide a sense of the experiences on capstone design teams and impacts interventions may have. We also begin to explore approaches to improve psychological safety in senior capstone teams by focusing on improving students' awareness of their ethics (the principles that guide their choices). The approaches include exploring the connection between personal values, personal story, and principles (or personal ethics) and students' behaviors that can affect psychological safety on teams.

Introduction

Within this work we examine ethics as the collection of principles that we use to motivate us and help us make decisions and guide our interactions with those around us and work that we do. Therefore, our ethic is made up of the principles that motivate, inform, and guide our daily lives. From this standpoint, the discussion on ethics development should extend beyond why the Challenger exploded or the causes behind the Hyatt Regency Bridge failure.

If we apply the four domains of Leadership Model [1], the development of a leadership ethic not only includes discussions about avoiding project failures, and being honest stewards of projects in general, but includes discussion on how we develop personal principles to guide our self-awareness as well as principles that guide our interaction with our teams. It is this final portion that is the subject of the current work. How do we help students develop principles that guide them to create positive teaming experiences?

During Google's Quest to define the attributes of successful teams, they highlighted work by Amy Edmondson as the starting path to create a learning organization. A learning organization is a classification of team function where everybody is working and learning and disclosing all facts to help the team learn and improve from small risks that were taken [2]. The research of Edmondson noticed that certain teams within the same hospital produced very different outcomes for the patients they oversaw. As she observed more closely why certain teams could become a learning organization, she noticed that the teams did seven things positively. From the seven items she created a survey that a team could use to guide a reflection on where they are in their growth towards becoming a learning organization.

The seven survey items that Edmonson created are included in the appendix of this paper, but can be summarized into the following categories of scenarios commonly encountered in teams: making mistakes, asking for help, taking small risks, discussing tough issues, respecting the contribution of others, helping members feel like they belong, and supporting each other in team tasks. Teams that achieve positive outcomes in each of these areas actively create what Edmonson coined psychological safety in a team. We agree with Edmondson that psychological safety is not all that a team needs to do, but that it is critical to creating a high-performing team so that the team can successfully accomplish all its goals.

Leaders can create the space for psychological safety on their teams in several different ways. Nguyen et al. found that when leaders build strong relationships with employees, feelings of psychological safety increase and turnover decreases [3]. A leader who demonstrates a learning mindset--which involves humility and curiosity--when working with their teams on challenging problems also promotes psychological safety in their teams [4].

With these thoughts in mind, we began to be curious about the state of psychological safety and student engineering teams. This work in progress builds upon two pilot studies presented previously and expanded to include data from additional universities [5,6]. In addition to being curious about benchmarking the psychological safety of student engineering teams, we were also curious to understand if we can improve psychological safety on underperforming teams. Each of the universities participating in this study provides leadership or teaming development training to students in some way. Therefore, we are curious if these efforts lead to improvements in psychological safety in engineering capstone teams.

Approaches at Each Institution

Various approaches were undertaken at four institutions to consider the impact of psychological safety. The four institutions selected represent different sizes of engineering programs as well as different student body populations which we feel may impact the level of psychological safety in teams. James Madison University (JMU) and Rose-Hulman Institute of Technology (RHIT) represent relatively small engineering programs that are predominantly white with engineering student populations of approximately 550 and 1,200 respectively. Cal Poly Pomona (CPP) is a Hispanic-serving institution with a large minority population of Asian Pacific Islander students. The engineering program has 6,000 undergraduate students. Texas A&M University (TAMU) has 19,000 undergraduate students from a variety of backgrounds. As a result of these differences, there were differences in the approach used to encourage the fostering of psychological safety on teams across our programs. Some of these approaches were more hands on while some were more observational.

At RHIT, freshman students were directly introduced to psychological safety through an intervention implemented in their Introduction to Engineering course. The students were introduced to three attitudes to practice psychological safety in one, 1.5-hour active class presentation on the first day of the freshman design class immediately after students were placed into teams. The attitudes introduced include (1) every idea has the potential to contribute to a positive outcome, (2) questioning an idea can provide valuable insight, and (3) applying the brake can be productive. Students practiced the three attitudes using role play activities. There were no additional formal reinforcements though there may have been further discussions with instructors during the course [6]. Specific intervention materials can be obtained from Engineering Unleashed KEEN Card #3679. Freshman design students were surveyed at the end of their class, and we plan to survey them again as they progress through capstone design.

In addition to this direct teaching of psychological safety, leadership and teamwork skill development are threads throughout our curriculum. In their first term on campus as freshman through senior design, students receive and have opportunities to practice both leadership and teamwork skills. This training begins with having students take the My Colorful Portrait personality test in a first year, first term course, and includes guidance on creating team norming documents, ways to motivate team members, etc. In courses with teamwork (project-based courses or laboratory courses), students receive additional training and reflection opportunities to reinforce these attitudes and skills.

At JMU, freshmen engineering students are introduced to psychological safety in a first-year engineering elective course as a two-week module. Psychological safety was also reinforced in the spring semester of their first year and in the fall semester of their second year. The students in the leadership development program also received instruction during their third and fourth years as they mentored incoming first-year engineering students.

During the study period, JMU ended the leadership development program so a subset of the engineering students who took a particular section of engineering management received instruction on psychological safety during their second year. We distributed the survey for this study to the cohort of students completing their senior capstone during Spring 2023. This allows us to compare the impact of having psychological embedded in the program versus not having access to that training.

TAMU has over 19,000 undergraduate engineering students (approximately 4,500 seniors) spread across 15 departments, so assessing all senior capstone students is not feasible. For this iteration of our research, we collected responses from students in as many different departments as possible, recognizing that the distribution of the survey is instructor dependent.

At TAMU, all undergraduate engineering capstone projects are completed as team assignments, so students have the opportunity to develop and practice teamwork skills. However, the instruction provided on psychological safety and effective teamwork varies greatly from department to department and even from instructor to instructor. TAMU has a selective leadership development program that includes instruction and practice in related skills such as self-awareness, empathy, and listening, but only 32 students from the whole college are selected for it each year. Therefore, our hypothesis is that most students in capstone teams receive minimal instruction related to psychological and effective teamwork.

At CPP, all students participating in the senior capstone course are asked to complete a university-wide assessment. The teamwork survey was included in that university assessment to all engineering students participating in the senior capstone. We also distributed a companion survey to faculty to find out how many currently teach teamwork principles. This survey showed that most faculty provided students with training to set team norms (i.e. how to complete a team contract or team MOU), and how to hold meetings, but no specific training was consistently applied across the college beyond these two topics.

At CPP, two exceptions are the Aerospace (ARO) and the Industrial and Manufacturing engineering (IME) programs. In the ARO program, students receive a self-awareness assessment (Smalley Index Test or "Four Animals Personality" assessment) during their Freshman intro to ARO course. During their second year, they build on this knowledge by applying it to team assignments and team communications. Senior year, ARO students receive lessons on Maslow's Hierarchy of needs, Model Based Systems Engineering (MBSE) team collaboration and design culture, as well as other project-specific teamworking tools (such as setting schedules and holding each other accountable).

In the IME program, all students receive a two-part leadership seminar covering the "9 pillars of leadership" taught by an outside consultant, and workshops on "Identifying and Validating Personal Values" and "Building Team Trust." They are broken into groups where they work through various industry cases in teams then submit reflections on the teamwork experience and offer thoughts on how to improve. This teamwork cycle happens six (6) times over a given semester.

Survey Items

To measure psychological safety, we use the seven-item survey created by Edmondson [7] which uses a 7-point Likert scale to rate agreement with each item. Edmondson phrases items 1, 3, and

5 negatively, and the responses are reverse-coded (designated with an R below) such that a score of 1 converts into 7, 2 into 6, and so forth. Using positive and negative statements was intentional to ensure that participants read through each question and did not simply default to writing the same number for each item. The survey items include:

1. If you make a mistake on this team, it is never held against you. (R)
2. Members of this team can bring up problems and tough issues.
3. People on this team never reject others for being different. (R)
4. It is safe to take a risk on this team.
5. It is easy to ask other members of this team for help. (R)
6. No one on this team would deliberately act in a way that undermines my efforts.
7. Working with members of this team, my unique skills and talents are valued and utilized.

Data Processing

The typical way to show results from a 7-point Likert scale is to show the values in distribution bars. Visualizing in this way is helpful for research when measuring impact, but less helpful for informing decisions based on the survey results. In this work, we converted the responses into percentages to establish a single numerical value from each survey response between 0 and 1.0. We can then convert this value into a letter grade. For example, a student who responds to the psychological safety items with a score of seven to six items and a score of six to one item (on a 7-point Likert scale), receives a “score” of 34 out of 35 possible points. As a percentage, this is computed as 0.97 or 97%. We assigned “grades” of A, B, C, D, or F based on the traditional break lines (A > 90, 90 < B < 80, 80 < C < 70, 70 < D < 60, and F < 60). With these results, we could look at the "grade distribution" and set goals for the percentages of A & B grades (i.e. > 0.80) versus C, D, and F (< 0.80) that one might desire.

In addition to analyzing each survey response, we also analyzed the data resulting from each question individually. We computed the average score for each question and compared the scores across universities, and within university programs, comparing control populations with those who had a teamwork intervention of some kind.

Data Analysis Methods

We make statistical comparisons using the parametric, two-tailed, student t-test. This approach is described by Adler & Roessler [8] and was implemented using the T.TEST function in Excel. Finally, for all data except for data from JMU, we used a bootstrap technique to estimate the population of the psychological safety score from each student. This technique samples, with replacement, all the average psychological safety scores from each student across a sample, then computes the average psychological score from all results. From the resampled data we compute the 95% confidence interval for the mean psychological score across all programs. This method is outlined by Efron [9].

Benchmark Results & Comparison Between Programs

Table 1 shows the data summarizing the psychological safety in each program and across all participating universities including the psychological safety descriptive statistics for each university and for all universities' data combined.

Table 1. Summary of Psychological Safety data from each university

University	*N*	Mean	Median	Std Dev
JMU	46	74.5	*75.7	*9.83
RHIT	133	82.3 ±0.45	85.7	13.3
CPP	190	78.3 ±0.32	80.0	14.4
Overall	369	80.4 ±0.30	82.9	14.1

** JMU Data is aggregated per question, not per student. At present we are awaiting the data from TAMU and expanded data from JMU to be included in the future.*

JMU Data

The results of the JMU were aggregated per question, not per student, then shared to be analyzed with this study. Therefore, we analyzed the results per question, but can only provide the overall mean (standard, not bootstrapped). A total of 46 students responded to the survey, generating an overall mean of 74.5. The standard deviation of 9.83 is reconstructed from the question aggregate data to represent individual students. Given the state of this data, we cannot determine if the mean of the JMU data are significantly different from the overall mean data.

Let us assume that the JMU mean of 74.5 is significantly lower than the overall mean of 80.4. Edmondson & Lei [10] reported that companies who started teaching and measuring psychological safety in the workplace observed an increase in negative feedback about their organization's teams because the team members felt safe to do so. Therefore, a low psychological safety score would not necessarily mean that a team is falling short of their ability to build a safe space, but that they could be on the path to improvement.

As noted earlier, all of the students participating in this survey were part of the intervention group (these students received teamwork instruction during their first three semesters in the program). The graduating cohort of Spring 2024 will be the first group of students who completed their degrees without intentional teamwork training in the first three semesters and leadership development training in their last four semesters. Once we have the data from the Spring 2024 cohort we will be able to statistically compare any differences between the control and intervention groups at JMU.

RHIT Data

RHIT data show a bootstrapped mean of 82.3 and a standard deviation of 13.3. We compared the overall data (80.4) with the all RHIT data mean (82.3) using the student t-test and we compute the probability, $p = 0.103$. Therefore, we cannot say the two data sets are statistically different.

The Civil and Environmental Engineering department implemented the intervention outlined in the beginning of this paper. Using the student t-test once again to compare the control data (from the Mechanical Engineering and Chemical Engineering departments, N = 72) and intervention data (from the CE department, N = 61), the mean for the RHIT intervention group is 84.8 as compared to the RHIT control group mean of 80.7. Comparing these results using a t-test, we find $p = 0.068$, so again we cannot conclude that they are statistically different at $\alpha = 0.05$.

At RHIT, an intimate learning environment exists due to its size and culture. It is possible no significant differences were noted because students felt that teams were safe enough without psychological safety training. Additionally, the control group in the RHIT data was strictly the students that did not receive the psychological safety training. Students across campus receive various forms of leadership training that could impact the data.

Moreover, it should also be noted that this data is from freshman design students at RHIT. Students receive additional leadership training over the course of their terms. It will be interesting to see as the freshman transform into seniors, how their feelings about psychological safety change. Once we have obtained data from students in senior design, we can again compare the data to the other universities' data contained herein.

Cal Poly Pomona Data

CPP data show a bootstrapped mean of 78.3 with a standard deviation of 14.4. We compared the overall data (80.4) with the all CPP data mean (78.3) using the student t-test and we compute the probability, $p = 0.36$. Therefore, we cannot say the two data sets are statistically different.

The departments that had implemented a system to instruct students in teamwork (Aerospace, Industrial and Manufacturing) are considered the intervention group. These were compared with the control group that makes up the departments without structured teamwork training (Civil and Construction Management, Electrical and Computing Engineering, Electro-Mechanical and Electronic Systems Engineering, and Mechanical Engineering). There are a total of N=297 survey responses from all CPP students with 66 responses in the intervention group and 231 responses in the control group. The mean for the CPP intervention group is 84.4 and 77.6 for the CPP control group. Comparing these results using a t-test, we find $p = 0.0002$, so we can conclude that they are statistically different at $\alpha = 0.05$.

Question Analysis

Table 2 compares the average score per survey item overall. This table displays where there may be significant differences between a given question and the overall score at an institution.

Table 2. Psychological Safety score reported by each question and each institution as well as the overall score for each question.

	Q1	Q2	Q3	Q4	Q5	Q6	Q7
	Handling Mistakes	Tough Issues	Rejecting Others	Taking Risk	Asking for Help	Undermine Others	Value Others
JMU	70.9	77.4	76.1	76.1	68.9	73.8	80.0

RHIT	79.3	79.6	89.6	79.5	83.4	82.1	82.9
CPP	78.8	77.4	87.1	74.4	77.6	81.2	82.6
Overall	78.0	78.2	86.6	76.5	78.6	80.6	82.4

If we apply these results to our interventions, we can see opportunities at each institution. Overall, we can see that we collectively could use more training around helping students learn to take small risks on teams and (simultaneously) encourage those who do take small risks. At the campus level, each of the institutions with data may consider the following:

JMU – Opportunities at JMU include providing instruction to help teams encourage and support those who make mistakes, creating training that helps students learn how to best support each other when they make mistakes, creating training on respecting and appreciating differences among team members, and encouraging them to ask for help when needed.

RHIT – At RHIT, opportunities include creating a learning experience to improve how teams handle mistakes, talk about tough issues, and take small risks. There are certainly opportunities for students to develop these skills because the students surveyed here were freshman design students—they will receive additional training and practice opportunities as they progress through their college careers.

CPP – At CPP, opportunities include creating learning experiences that help students support each other when they make mistakes.

Conclusions

The data show that the mean psychological safety score across all programs is 80.4 ± 0.30 with a standard deviation of 14.1. We see this as an acceptable benchmark for potentially predicting psychological safety in engineering capstone teams. The comparison between the control and intervention data at CPP reveals a significant difference given the limited methods of establishing a true control and intervention group. Future work will be needed to create a better study on how to measure the impact of specific interventions. At this time, the conclusion we make is that if we do invest effort in improving psychological safety it appears we can make a positive difference.

There are many factors at play in these data that will need to be addressed in future work. One helpful perspective is that once people are trained to foster psychologically safe environments and put these skills into practice, more issues may be reported as noted by Edmondson & Lei [10]. We may be seeing this phenomenon in the data reported by JMU. Their students received potentially the most leadership development training from their first year until their capstone experience, and yet they reported lower levels of psychological safety.

Where we have seen improvement in psychological safety scores, we do not see a specific type of intervention stand out. At CPP, there were a variety of lessons taught in the Aerospace and Industrial and Manufacturing Engineering departments where students reported a significant improvement in psychological safety. This means that training may not need to focus directly on improving psychological safety but could address a variety of teamworking challenges that encourages teams to build positive environments where psychological safety can flourish.

Future Work

Future work will focus on creating a more rigorous test to allow us to differentiate which interventions may have an impact on psychological safety scores. We can also benefit by conducting student focus groups to understand if the mean psychological safety score is sufficient to generate other positive team outcomes such as building relationships with team members and generating positive team experiences. We expect that this approach will also help us produce more refined teamwork interventions that can be distributed to other universities. We will continue to collect data to inform the psychological safety benchmark for all engineering teams. We hope that the benchmark provided here can provide an assessment goal for each campus as they build their continuous improvement programs.

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