Psychological Safety as an Effective Measurement in Engineering Classrooms

Mr. Behzad Beigpourian, Purdue University

Behzad Beigpourian is a Ph.D. student and Research Assistant in Engineering Education at Purdue University. He earned his master's in Structural Engineering from Shahid Chamran University in Iran, and his bachelor's in Civil Technical Teacher from Shahid Rajaee Teacher Training University in Iran, Tehran. He has been official Technical Teacher at Ministry of Education in Iran from 2007 to 2018, and received many certificate in education such as Educational Planning, Developing Research Report, and Understanding School Culture. During these years, he has taught construction courses in several technical schools. Mr. Beigpourian currently works in the CATME project, which is NSF funding project, on optimizing teamwork skills and assessing the quality of Peer Evaluations.

Mr. Frank Luchini,

Frank Luchini has five years experience in industry working as a Process/Design/Project Engineer. He recently returned to academia to earn a PhD in Engineering Education at Purdue University. He will be completing a Master in Engineering Education in May and starting as a Assistant Professor at Trine University in August 2019. He earned a BS in Mechanical Engineering and a BA in Arts and Humanities from Michigan State University.

Dr. Matthew W. Ohland, Purdue University, West Lafayette

Matthew W. Ohland is Professor of Engineering Education at Purdue University. He has degrees from Swarthmore College, Rensselaer Polytechnic Institute, and the University of Florida. His research on the longitudinal study of engineering students, team assignment, peer evaluation, and active and collaborative teaching methods has been supported by the National Science Foundation and the Sloan Foundation and his team received Best Paper awards from the Journal of Engineering Education in 2008 and 2011 and from the IEEE Transactions on Education in 2011 and 2015. Dr. Ohland is an ABET Program Evaluator for ASEE. He was the 2002–2006 President of Tau Beta Pi and is a Fellow of the ASEE, IEEE, and AAAS.

Dr. Daniel M. Ferguson, Purdue University, West Lafayette

Daniel M. Ferguson is CATME Managing Director and the recipient of several NSF awards for research in engineering education and a research associate at Purdue University. Prior to coming to Purdue he was Assistant Professor of Entrepreneurship at Ohio Northern University. Before assuming that position he was Associate Director of the Inter-Professional Studies Program [IPRO] and Senior Lecturer at Illinois Institute of Technology and involved in research in service learning, assessment processes and interventions aimed at improving learning objective attainment. Prior to his University assignments he was the Founder and CEO of The EDI Group, Ltd. and The EDI Group Canada, Ltd, independent professional services companies specializing in B2B electronic commerce and electronic data interchange. The EDI Group companies conducted syndicated market research, offered educational seminars and conferences and published The Journal of Electronic Commerce. He was also a Vice President at the First National Bank of Chicago [now J.P. Morgan Chase], where he founded and managed the bank's market leading professional Cash Management Consulting Group, initiated the bank's non-credit service product management organization and profit center profitability programs and was instrumental in the breakthrough EDI/EFT payment system implemented by General Motors. Dr. Ferguson is a graduate of Notre Dame, Stanford and Purdue Universities, a special edition editor of the Journal of Engineering Entrepreneurship and a member of Tau Beta Pi.

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Behzad Beigpourian, Franklin Luchini, Matthew W. Ohland, Daniel M. Ferguson

Department of Engineering Education, Purdue University

Abstract

This research full paper investigates that to what extent the psychological safety can predict conflict and cohesion in teams.

Background The primary goal for engineering instructors after forming teams is increasing the effectiveness of teamwork. They want all students participate in the projects, learn from the project, and bring their idea into teams. This effectiveness depends on team dynamics. Whereas faculty have used several team outcomes to monitor team dynamics, psychological safety appears to be a useful but underused measurement.

Purpose/Hypothesis This study measured the relationship between psychological safety and other teamwork outcomes such as team's conflict, and the team's cohesion. If they are related, psychological safety can be used as an early warning of team dysfunction.

Design/Method We used simple linear regression to find out to what extent the conflict and cohesion can be explained by psychological safety. We conducted two set of simple linear regressions. The first regression was related to the individual's scores and the second regression was for team's average scores.

Results Psychological safety significantly predicted conflict and cohesion both in individual-level and team-level. Feeling more psychological safety significantly increase cohesion and decrease the conflict.

Conclusions Psychological safety is a very promising measure of team dynamics, and we suggest using it to identify dysfunctional teams with low cohesion and high conflict.

Keywords Psychological safety, conflict, cohesion, teamwork

Introduction

In 2016, Google stated that psychological safety was one of its five key contributing factors to a successful team [1]. Kahn [2, p708] defined psychological safety as 'feeling able to show and employ one's self without fear of negative consequences to self-image, status, or career' , and Edmondson [3, p350] defined it as 'shared belief held by members of a team that the team is safe for interpersonal risk taking'. In this paper, we explored the advantage of measuring "Psychological Safety" in engineering teams because there is a potential for this metric to be used by educators as a way to measure student comfort and inclusion on a team project.

We searched for literature written about psychological safety and teams in STEM education. Although we might miss existing papers, our literature research provided hits that psychological safety is underutilized as a measure of team dynamics because we did not find too much study about psychological safety in the engineering context. Lenberg and Feldt [4] performed a quantitative study that used two separate multiple linear regression analyses on 38 team performance reviews in software engineering at industry. Their results showed they could use psychological safety to predict self-assessed team performance. In a similar study, Schepers et al. [5] performed a quantitative study that used multilevel regression analysis that showed a positive relationship between perceived tutor support and perceived peer support on psychological safety in the adoption of groupware technologies (softwares using by number of different users). The main takeaway from their study is that they were able to demonstrate that psychological safety plays an important role in successful educational groupware implementation. While these two studies were the examples that directly related to STEM education, several other studies using psychological safety to understand non-STEM student teams provide valuable insight.

Some studies used psychological safety in a qualitative case study as one variable to validate the incorporation of strengths-based, talent-focused approaches for twice-exceptional learners [6], [7]. Twice-exceptional learners were defined as students that are both exceptionally gifted in some area and have a disability. They determined a psychologically safe environment was shown to be important for student growth, especially for twice exceptional students, because such an environment allows students to let down their guard and begin to participate in their education [6]. Van Gennip, Segers, and Tillema [8] performed a quantitative study with almost 70 male participants from a small technical college. They found that students in a peer-assessment setting have higher psychological safety than those in a traditional instructor-only assessment setting. Mu and Gnyawali [9] studied how synergistic knowledge development (SKD) affects student performance using psychological safety as a metric. SKD is the process by which member of a group integrate the diverse perspectives of all the members in a constructive way. Their research confirmed a positive relationship between psychological safety and SKD, where high psychological safety results in high SKD. This finding is also supported by the work of Broussard, La Lopa, and Ross-Davis [10] and Xu and Yang [11] who both built on previous research by studying the relationship of psychological safety and SKD in multidisciplinary teams. These results show how students develop knowledge when synthesizing diverse perspectives in a group. Schaubroeck, Lam, and Peng [12] concluded in their study of 89 teams from Hong Kong and 102 from the United States that psychological safety and team potency have additive effects on team performance, but that high team potency does not necessarily mean there is a high level of psychological safety. With these articles referencing psychological safety having a positive relationship to team learning and team performance in various professional and academic settings, we can hypothesize that the tool will likely be valid in engineering classrooms and that the research is worth pursuing. Based on the results from provided literature, we decided to investigate the relationship between psychological safety and other

team outcomes to see whether psychological safety can be good measurement to see whether there is a problem in a team.

Scope and research questions

If teams in the engineering classrooms have low cohesion and high conflict, teams might fail to get desired results in term of the learning from the project or completing the project appropriately. On the other hand, our literature review shows that the psychological safety is a good prediction for team performances but most research are not in the context of engineering education. If we can show that measuring psychological safety can predict the measurement of conflict and cohesion, we can prove that psychological safety is a good team outcome measurement for engineering teams and suggest this measurement to engineering instructors if they want to measure the effectiveness of teams only with one set of questions. So, we investigated these research questions in this study:

- To what extent does psychological safety in individual students (or teams) predict the perception of team cohesion by individual students (or teams)?
- To what extent does psychological safety in individual students (or teams) predict team conflict (or conflict between students)?

If answer to these questions are yes, engineering instructors can rely on the psychological safety for measuring the performance of teams and find which team might have problem before problem become critical.

Methods

We used the Edmondson's [3] seven-item questionnaire for the purpose of this paper. These questionnaires are included in appendix A because the scale is likely unfamiliar to many readers. This seven-item questionnaire is an effective and well tested method for determining psychological safety in team settings, and most studies about psychological safety has used this measurement [13].

Participants of Study

Participant of this study are from an engineering class in a large public university in the Southwest, and 96 students participated in this study. Our inclusion criteria for the participants of study were students who are in this class, worked in the teams of three or four students, and completed all the questionnaires. Students who did not complete the study or did not answer all outcome questions removed from the study and we analyzed our data based on 80 remaining participants including 25 teams. In Table 1 and Table 2, we present more detail about the data.

Table 1. Gender frequency

Gender	Number	Percent (%)
Female	28	35
Male	51	63.8
Declined to answer	1	1.3

Table 2. Race frequency

Race	Number	Percent (%)
Asian	18	22.5
Black	1	1.3
Hispanic	15	18.8
White	43	53.8
Other	1	1.3
Declined to answer	2	2.6

Data/Variables

The data was collected using CATME which is comprehensive assessment of team member effectiveness [14]. In CATME, students evaluate the performance of their peers and themselves. In addition to the peer evaluation in CATME, instructors can collect various team process and outcome data using CATME. In this study, we collected data about psychological safety, conflict and cohesion in the middle of semester. Students participated in five peer evaluations and we collected the data from third peer evaluation because one and second peer evaluation is early for showing conflict and problems. We also wanted to research the situation which students are in the middle of semester and what is their perception in this stage of peer evaluation. CATME automatically calculates the adjusted mean for each question using the Likert scale, accounting for reverse-coded questions. Psychological safety uses seven-point Likert scale and conflict and cohesion are each five-point Likert scales. In addition to using Edmondson [3]' seven-item questionnaire for psychological safety, CATME includes Jehn and Mannix [15]'s questions for measuring conflict, and measures of cohesion from Carless and de Paola [16] and Loughry and Tosi [17]. In appendix A, we provided all questions and sub-questions collected by CATME and used in this study.

Results

In this paper, we used simple linear regression to measure the relationship between psychological safety and the perception of students about team outcomes (conflict and cohesiveness). We explored this relationship for individual and as a consensus variable for each team using the average value for scores in each team outcome.

1. **Measuring the Relationship Based on Students' Score**

For measuring the relationship of psychological safety with the perception of students from team outcomes (conflict and cohesiveness), we conducted simple linear regression to find out to what extent the perception of psychological safety can predict the perception of conflict and cohesion in individuals. We first checked our dataset to see whether they met the assumptions of simple linear regression. We checked normality of residuals, linearity, homoscedasticity, and absence of multicollinearity and concluded that our data met all assumptions.

Two simple linear regressions were calculated to predict conflict and cohesion based on psychological safety. For conflict, a significant regression equation was found ($F(1,78) = 25.088$, $p<.000$), with an R^2 of .243. Also, for cohesion, a significant regression equation was found ($F(1,78) = 77.363$, $p<.000$), with an R^2 of .498. Here, we provided the predicted equations for measuring conflict and cohesion in individuals based on the amount of psychological safety in individuals:

Perception of Cohesion in Individuals = 1.489+0.447(Psychological safety in Individuals)

Perception of Conflict in Individuals = 3.409-0.302 (Psychological safety in Individuals)

In both equations, the amount of psychological safety reported by individuals had a significant relationship to their perception of conflict and cohesion. While we cannot prove causality, it would be reasonable to assume that increasing the psychological safety of an individual would decrease their perception of conflict and increase their perception of cohesion.

2. **Retesting these Relationship using team consensus measures**

We repeated all the procedure another time for teams' aggregated outcomes. This time, we used the average of students' scores in each team as a team's score. After confirming the assumptions for regression in this approach, we conducted simple linear regression for team-level outcomes to find out to what extent the psychological safety in teams can predict the conflict and cohesion in the teams.

Two simple linear regressions were calculated to predict conflict and cohesion based on psychological safety. For conflict, a significant regression equation was found ($F(1,23) = 7.492$, $p<.012$), with an R^2 of .246. Also, for cohesion, a significant regression equation was found ($F(1,23) = 34.704$, $p<.000$), with an R^2 of 0.601.

Here, we provided the predicted equations for measuring conflict and cohesion of teams based on the amount of psychological safety in the teams:

Perception of Cohesion in team = 1.277+0.485 (Psychological safety in team)

Perception of Conflict in team = 3.129-0.256(Psychological safety in team)

In both equations, the average psychological safety of a team was significantly related to the average perception of conflict and cohesion.

Discussion

In this paper, we investigated the extent to which the psychological safety can explain the perception of students and teams about team outcomes (conflict and cohesion). The results showed significant result which means asking psychological safety questions can explain the conflict and cohesion in teams. In individuals, losing 1 point in the psychological safety means decreasing 0.45 point of perception of students about cohesion and increasing 0.30 in the perception of conflict. Also, when considering teams, adding 1 point to the average psychological safety of teams means 0.49 point more cohesion and 0.26 less conflict in teams. These results proving that psychological safety can explain team outcomes for instructors, and confirmed the result of Lenberg and Feldt's [4] study about predicting the self-assessed team outcomes by psychological safety. However, they assessed the job satisfaction and team performances as team outcomes and proved it in the context of engineering teams in the industry. But, we got the same result for the first-year engineering students in the university and used conflict and cohesion as team outcomes. So, asking psychological safety in teams will have two benefits for engineering instructors. First, they can make sure that everyone in the class feeling safe in teams. Second, receive a warning that there might be a problem in term of conflict, cohesion, or both.

Conclusion

Engineering instructors would like to facilitate teams and find dysfunctional teams. Instructors need to identify dysfunctional teams which might have a conflict or do not have enough cohesion. Then guide the teams to address the issue as early as possible. Nonetheless, sometimes finding the dysfunctional teams is not an easy task. Instructors will not succeed in doing that if they do not have access to the appropriate information for monitoring students during teamwork. One way to find dysfunctional teams is asking sets of questions about conflict, cohesion, and psychological safety. However, if they want students to ask set of questions separately for each team outcome, it will take too much time. So, asking single set of questions might be interesting for instructors who have a concern about asking too much questions. Furthermore, some team processes measures are unclear. For example, if teams feel conflict, instructors may be unsure whether is detrimental conflict as some scholars propose [18]–[20] ,or it is productive as other scholars suggest [21]–[23]. So, there is a need

for an effective measurement to find dysfunctional teams and does not waste too much time of students. We suggest that the evidence provided reveals that psychological safety is a good proxy for a variety of team process and outcome variables. Asking just seven questions in the psychological safety can predict conflict and cohesion in addition to the psychological safety.

Limitation and future works

In this study, we only used the quantitative data. However, CATME includes peer to peer comments which could be used for further studies to find some relationship between comments and the psychological safety of students. We also only investigated the third peer evaluation for this paper. It would be interesting to check the student feedback in later peer evaluations after instructors have attempted to remediate dysfunctional teams. Finally, checking the relationship of psychological safety with other outcomes as satisfaction can be another study.

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Appendix A

Question Type	Sub-Question
Psychological Safety [3]	If you make a mistake on this team, it is often held against you. (reversed scale)
	Members of this team are able to bring up problems and tough issues.
	People on this team sometimes reject others for being different. (reversed)
	It is safe to take a risk on this team.
	It is difficult to ask other members of this team for help. (reversed scale)
	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.
Conflict [15]	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?
	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?
	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? (reversed scale)
	How often do you disagree about resource allocation in your work group? (reversed scale)
Cohesion [16], [17]	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
	Team members like each other
	Team members get along well
	Team members enjoy spending time together
	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
	Our team members have conflicting aspirations for the team's performance