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Exploring Personal Cultural Orientation as an Antecedent of Psychological Safety in Teams of First-Year Engineering Students

Siqing, Wei and Matthew W., Ohland
Engineering Education, Purdue University
Wei118@purdue.edu

ABSTRACT

CONTEXT

While international students bring their unique values, attitudes, and knowledge as team assets when collaboratively solving engineering problems, it is critical to better understand if all members feel safe and respected within their teams.

GOAL

Although prior literature has shown the key role of cultural diversity of teammates on team outcomes, such as creativity and effectiveness, the prevalent outcome-oriented research has missed the opportunity to articulate its effect on team processes or dynamics, particularly psychological safety. As team members with different cultural orientations might communicate and participate in teamwork in different ways, a perceived lack of a safe team environment might particularly inhibit international students from fully contributing to their teams.

METHODS

Using panel data collected from around 1700 first-year engineering students in a team-based course, we apply Structural Equation Modeling (SEM) to investigate and quantify how individual engineering student embedded cultural values associate with perceived psychological safety.

OUTCOMES

Results show that interdependence, social inequality, and ambiguity intolerance were significantly associated with psychological safety in first-year engineering students when working in teams.

IMPLICATIONS

This work inspires future research exploring the mediation factors between personal cultural orientations and other team dynamics constructs; it also provides practical suggestions for instructors teaching team-based curricula.

KEYWORDS

teamwork, psychological safety, culture, cultural diversity

Introduction

Engineering education scholars have expended much effort to understand how to train engineering students' teamwork effectiveness, but there has been less focus on team dynamics, the interactions among team members that drive team success. Chowdhury and Murzi (2019) synthesized interventions for ensuring effective engineering student teamwork and summarized 11 attributes that contribute to team effectiveness, such as shared goals and values. Borrego and colleagues (2013) systematically reviewed literature from Industrial/Organizational Psychology to inform the best practices in engineering student project teams and suggested a focus on five team effectiveness constructs: interdependence, social loafing, team conflict, trust, and shared mental models. Treating teams as open and complex systems, McGrath, Arrow and Berdahl (2000) identified three levels of team dynamics: local dynamics (based on interaction in group activities), global dynamics (team-level phenomena that shape local dynamics), and contextual dynamics (system-level factors that affect global dynamics). In a review of Hofstede's cultural values framework, Kirkman et al. (2006) demonstrated that cultural orientations had main effects on a wide range of outcomes, such as decision-making, leadership, conflict management, and individual behavior relating to group process and personality, at individual, group/organizational, and country levels. Kirkman et al. (2006) further argued that cultural orientations also served as an important contextual contingency condition that moderated relationships of individual behaviors relating to group processes such as the relationship between group working modality (i.e. working in an ingroup, outgroup, or alone) and individual performance (Earley, 1993).

There is considerable support from researchers and practitioners that psychological safety is the most useful and effective construct to measure and monitor team dynamics and outcomes (Bergmann & Schaeppi, 2016) as it is strongly related to team conflict and team cohesiveness (Beigpourian, Ferguson, et al., 2019; Beigpourian, Luchini, et al., 2019). Psychological safety refers to a team member's perception that the team is safe for interpersonal risk-taking (Edmondson, 1999). Psychological safety was shown to effectively minimize embarrassment anxiety of team members (Edmondson, 1999), and equip them with confidence and comfort to contribute to the team with less doubt and concern (Van den Bossche et al., 2006), facilitating better team outcomes and satisfaction (Edmondson & Lei, 2014; Newman et al., 2017).

Thus, we contend that engineering students are not immune to the impact of culture values or orientations when working in teams. However, many of them are unable to achieve a relatively high level of intercultural sensitivity to remediate the potentially negative influence of cultural diversity (Thompson & Jesiek, 2010). A lack of experience and understanding of cultural differences among members lead to a lower level of psychological safety resulting from either the inability or unwillingness to engage effectively with other students (Downey et al., 2006). Meanwhile, a low level of psychological safety prevents members from achieving effective teamwork and positive teaming experiences (Edmondson, 1999). The impact of cultural differences in the classroom is intensified when using active and collaborative pedagogies (LaFave et al., 2015). As citizens of a country might possess various cultural characteristics different from each other, Hofstede's national-level cultural values are conceptually and empirically invalid at individual level (Bond, 2002; Oyserman et al., 2002; Sharma, 2010).

Synthesized from prior literature, it was argued that Hofstede's constructs of cultural values should be perceived as continua at national level, but the ends of each continuum should be separately evaluated at individual level, evident by studies focusing on individualism-collectivism dimension (Earley & Gibson, 2002; Kirkman et al., 2006; Oyserman et al., 2002; Triandis, 1995). Thus, Sharma (2010) developed and validated the personal cultural orientation instrument to reliably and validly measure the individual cultural differences rooted from Hofstede's five-dimension cultural value framework. Sharma illustrated Hofstede's five dimensions should be expanded into ten individual factors, namely, independence (IND) and interdependence (INT), power (POW) and social inequality (IEQ), risk aversion (RSK) and ambiguity intolerance (AMB), masculinity (MAS) and gender equality (GEQ), and tradition (TRD) and prudence (PRU). For parsimony, the specific definitions are skipped in this article.

We argue that PCO guides engineering student behaviors in ways that inhibit learning in teams when they worry about threat risk or interpersonal embarrassment (Argyris, 1982; Singh, Winkel, & Selvarajan, 2013). Specifically, Edmondson (2003) pointed out four interpersonal risks in teams: (1) asking a question and being seen as ignorant; (2) admitting mistakes or calling attention to potential errors or failures and being seen as incompetent or being punished; (3) being overly criticized for past or present actions; (4) asking for feedback and being seen as intrusive. To avoid interpersonal risk and maintain social harmony, people with different cultural traits might respond and behave bounded by the individual perceived team climate. For example, students with higher independence are more likely to speak out and lead the team conversation compared to those with higher interdependence who might prefer listening to others' input first. Research showed the differences in status were associated with psychological safety (Bienefeld & Grote, 2014; Nembhard & Edmondson, 2006) and manifested in an engineering education context (Secules, 2019; Secules et al., 2016). Students with more tolerance for power hierarchy might hold their input and wait for voices of the one having best knowledge and abilities if not themselves. Extending from results showing that the presence of strong demographically based divisions of in-group and out-group status induced greater psychological safety (Lau & Murnighan, 2005), we would contend that cultural orientation would also lead to such division and thus influence psychological safety. Furthermore, psychological safety was found to moderate the relationship between national diversity and team innovation and performance (Gibson & Gibbs, 2006; Kirkman, Cordery, Mathieu, Rosen, & Kukenberger, 2013).

Responding to the call for more research on the cultural antecedents of psychological safety (Edmondson & Lei, 2014; Newman et al., 2017), this work seeks to reduce the knowledge gap of how individual personal cultural orientation is related to psychological safety. The findings of this work could inspire future studies to inform pedagogical practice in how teams are formed and how they are managed to support students' development to work in diverse team. Thus, the overall research question of this study is what are the associations between the dimensions of personal cultural orientation of first-year engineering students and psychological safety in teams?

Methods

Study Contexts and Participants

The data came from the entire cohort of undergraduate engineering students enrolled in a mandatory introductory engineering course in the Fall 2022 semester. This course had 16 sections taught by 13 instructors at various times who shared an identical syllabus and common course materials (although instructors had latitude to customize those materials), and committed to provide equivalent learning experiences for all students. The learning objectives of this course were related to mathematical modeling, a systematic design process, evidence-based decision making, and professional skills, including teamwork. The typical course section enrolled 120 students. Further, this course was a team-based course, where students needed to work in teams to complete several projects as well as weekly individual assignments. The course finished with an eight-week term team-based project where students extensively collaborated with other teammates. Students in this course were randomly assigned into ad-hoc teams for about the first quarter of the semester and then reassigned into other "permanent" teams for the rest of course. Both teams consisted of three or four students. Teams were formed with the assistance of the Team-Maker tool (Layton et al., 2010) to prioritize student team's schedule compatibility and minimize isolation of minoritized students based on gender and race/ethnicity. The institution offering this course is a large land-granted predominantly White Midwestern university with very high research activity in the United States (The Carnegie Classification of Institutions of Higher Education, 2021 edition, n.d.). We chose to conduct research focused on first-semester undergraduate engineering students for two reasons: (1) for many students, it is often the first exposure to formal engineering education with extensive teaming experiences; (2) many students have the first opportunity to interact and work with many other students who had quite different and diverse lived experiences. Such educational contexts can greatly shape students' perceptions on team dynamics and interactions.

Data Collection and Questionnaires

Near the end of the Fall 2022 semester, we surveyed to the entire cohort of 1752 students with items about their personal cultural orientations and psychological safety using the online Peer Evaluation tool included in CATME (Ohland et al., 2012). We replicated the seven-point Likert scale PCO survey developed by Sharma (2010) to measure individual perceived cultural value orientations. Specifically, we measured sub-scales of independence, interdependence, power distance, social inequality, risk avoidance, ambiguity intolerance, masculinity, and gender inequality. All sub-scales have been defined in the literature review section and each of them was measured by four items. We also used an adapted form of the seven-point Likert seven-item scale psychological safety instrument developed by Edmondson (1999). All instruments are treated as continuous.

Variable Measurement and Data Processing

To remediate response bias related to lack of interest, we list-wise deleted data samples without responses or with identical responses across psychological safety items before reverse coding and across personal cultural orientations items. Then the sample size becomes 1607 and no item-level, construct-level, or sample-level missingness is detected. Table 1 below summarizes students' self-identified gender, queerness, race/ethnicity, international status, the language of previous instruction, and high school GPA. A total of 193 students (12.2%) are international students and a total of 67 students (4.2%) reported the language of instruction used in their previous institutions as a language other than English.

Table 1

Sample Demographic Summary

		n (Mean)	% of valid responses (Standard Deviation)
Gender	*985*		
	Male	685	69.5
	Female	293	29.7
	Cisgender	73	7.4
	Queer	10	1.0
	Transgender	1	0.1
	Nonbinary/X	1	0.1
Race/Ethnicity	*1588*		
	White	955	60.1
	Asian	347	21.9
	Hispanic	138	8.7
	Black	28	1.8
	Native	2	0.1
	Declined	40	2.5
	Other	78	4.9
International Status	*1588*		
	Domestic	1395	87.8
	International	193	12.2
Language of instruction in previous institutions	*1588*		
	English	1521	95.8
	Related	36	2.3
	Different	13	0.8
	Very Different	18	1.1
High School GPA	*1568*		
		3.91	0.23

In Table 1, the overall sample size is 1607, where 19 samples omit all responses. Because the response choices included more sensitive data, students could withhold consent regarding the gender identity question, and 622 responses either lacked consent or were never reported. Students could multi-select their gender identity, e.g. cisgender and female. In measuring the language of instruction in the previous institution, examples of languages “related to English” are Spanish and French, examples of languages “different from English” are Hindi and Russian, and examples of languages “very different from English” are Chinese and Arabic (U.S. Department of State, n.d.). Finally, reported High School GPA ranged from 2.94 to 5 (median = 3.92, skewness=0.16, kurtosis=5.8, and SE=0.01).

Data Analytical Model

Since personal cultural orientation (Sharma, 2010) is derived from national cultural dimensions (Hofstede, 1980), we believe that some dimensions of personal cultural orientations of first-year engineering students, if not all, should influence their perceptions of psychological safety based on their theoretical connections. Thus, we choose to use SEM as the analytic tool to test the hypothesized relationships among observed measures and latent constructs of the three components. Specifically, we want to investigate the associations between eight (latent) dimensions of personal cultural orientation and one latent variable, psychological safety. Latent variables or dimensions are presented as ellipses, which are measured by items answered by students on peer evaluations. The connections of measured items and latent variables are tested in the measurement models using Confirmatory Factor Analysis (CFA) to evaluate whether the items used to measure the latent variable serve their purpose. Further, the double-headed arrows indicate the covariances between latent variables are predefined based on theoretical reasons and empirical evidence. The single-headed arrows show the regression paths between latent variables in the model. The combination of all components forms the SEM structural model.

The benefit of using SEM is in threefold. Firstly, this method is appropriate for analyzing the complex relationships between multiple latent variables with even more measure items. Secondly, it allows specifying correlated variables and analyzing the relationships between them simultaneously. Thirdly, this technique provides a variety of fit indices to robustly test hypothesized theories by comparing multiple models (Byrne, 1994).

Confirmatory Factor Analysis for the measurement model

First part of analyses were conducted in R, version 0.6-13 (R Core Team, 2023), using the combination of “stats” (R Core Team, 2023) and “lavaan” packages (Rosseel, 2012). Previous studies of PCO in both marketing and engineering showed psychometric evidence of validity (e.g. face, content, convergent, discriminant, nomological, and predictive validity), composite reliability (all scales ranging from 0.75 to 0.84 in the marketing study and from 0.71 to 0.91 in the engineering study), and cross-cultural measurement equivalence of this instrument (Murzi & Cruz, 2019; Sharma, 2010). In this work, we applied the limited information and asymptotically distribution-free estimator, diagonally weighted test squares (DWLS), as the estimator for CFA due to its popularity and consideration of ordinal nature of the data (Savalei, 2021; YangWallentin et al., 2010). The reliability was evaluated with Cronbach’s alpha, for which 0.7 is usually considered a threshold for use as a sub-scale (Hair et al., 2010; Sarmento & Costa, 2017). The reliability of the eight dimensions ranges from 0.61 to 0.83, with three sub-scales failing to meet the 0.7 cutoff criterion: Independence (0.61), Interdependence (0.62), and Social Inequality (0.61). Regarding psychological safety, the original paper showed that the construct reliability measured by Cronbach’s alpha was .82 (Edmondson, 1999) and another study reported the value as .84 (Ramalho & Porto, 2021). In our sample, the reliability (.63) was below the 0.7 cutoff. We acknowledge the relatively low reliability for those instruments, but we choose to maintain the fidelity of the original instruments. Due to the page limitation, the descriptive summary of the PCO dimensions and psychological safety as well as the psychometrical information for the result of those instruments were omitted in this paper. Interested readers are welcome to contact authors for more information.

Full SEM model

We then examined the relationships for the exogenous personal cultural orientation variables and endogenous variable, psychological safety using the full SEM model. SEM tests a priori theoretical model to see if the structure is supported by the sample data. Different from the conceptual path model shown in Figure 1, we set the covariation of each pair of latent variables that shared the same theoretical antecedents (e.g. Independence and Interdependence). Several fit indices and path significance tests were used to evaluate the model we tested based on Byrne's suggestions. For this part of analysis, we performed the analysis in Stata, version 17.0 Standard Edition. All results are standardized.

Results

The model fit for this model is not good according to the chi-square model fit test χ^2 (690) = 3682.51 ($p < 0.001$), CFI (0.974), TLI (0.801), but is good according to the RMSEA (0.052, 90% CI = [0.50, 0.54]). Standardized factor loadings for all nine latent variables were statistically significant at $p < 0.001$ but did not have substantial and comparable size where most loadings were < 0.80 indicating that a standard deviation increase in the latent constructs associated with an increase in each item that was less than 0.80. R-square estimates of item reliability were also low for most items, generally below 0.7. One possible explanation goes to student survey fatique.

At the structural level, three exogenous variables were found statistically significantly predicting endogenous variable, psychological safety: Interdependence ($\beta = 0.468$, $p < 0.001$), Social Inequality ($\beta = -0.161$, $p < 0.001$), and Ambiguity Intolerance ($\beta = -0.131$, $p = 0.002$) after controlling for other types of personal cultural orientation. Although Risk Aversion was not statistically significantly correlated with psychological safety ($\beta = 0.082$, $p = 0.064$), the correlations between ambiguity intolerance and risk aversion is high ($r = 0.56$, $p < 0.001$). Overall, all personal cultural orientation dimensions explain 27% (r-square value) of the variance of psychological safety with the 0.52 score of correlation between dependent variable and its prediction. Thus, only three out of eight hypotheses stand based on this empirical study that Interdependence, Social Inequality, and Ambiguity Intolerance were significantly associated with psychological safety. The SEM model with parameters is presented in Figure 1 below.

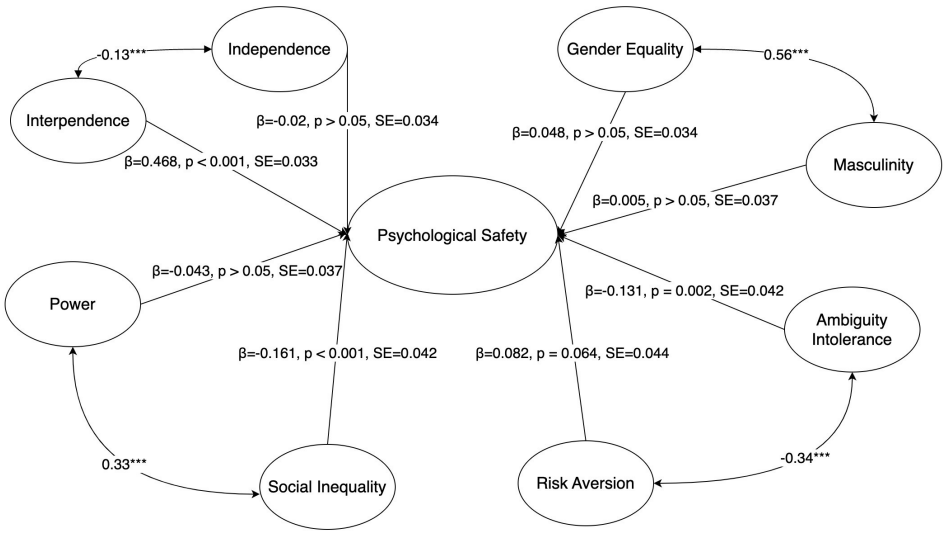

Figure 1: SEM model with parameters for associations between PCO and psychological safety

Conclusions

This empirical study confirms there are cultural antecedents of psychological safety. Specifically, we found that Interdependence, Social Inequality, and Ambiguity intolerance were significantly associated with psychological safety in first-year engineering students when working in teams. Findings of this work suggest instructors adopting team-based learning environment for students should strive to cultivating an equitable space for students to learn with and in the teams. It also suggests that instructors could provide scaffolding instructions for students to reduce ambiguity

and emphasize the importance and benefits of cooperative learning to alleviate the negative effects on students embedded with disconfirming cultural traits compared to the dominant engineering cultures.

This work inspires future research to further investigate the cultural norms and traits activated behaviors in engineering classrooms and teams so that specific and targeted training session could be built to help disadvantaged students to successfully and inclusively navigate through engineering curriculums. In addition, researchers are also encouraged to explore the mediation factors between personal cultural orientations and psychological safety, such as intercultural competency.

This work has limitations. Firstly, the model could be further improved beyond the theoretical suggestions. The empirical approach to improve the model might further suggest more relationships among the personal cultural orientations. Secondly, the participants were required to take the survey as part of their homework so that there was a risk of survey fatigue and measurement error associated with the data collected. A higher response rate is expected with a new formulation of the questions measuring gender identity and race/ethnicity that is currently being evaluated (Ohland et al., 2023). Lastly, student responses to the survey accompanied with scores in their final grades for completion so that students might answer the survey items one way or another.

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