Association between personality traits diversity in teams and their performance in a semi-virtual learning environment

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Abstract

Teamwork skills is an essential component of engineering professional skills. Engineering colleges rely on team projects to develop students' teamwork skills. Traditionally, this is done in an in-person setting where students hold meetings, discussion, and design activities related to their projects. In this context, data has suggested an association between some personality traits and team performance, and between specific learning styles and team performance. It is unclear how this is affected in a semi-virtual environment. This research leverages the restrictions due to COVID-19 to study, in the context of a semi-virtual team-based first-year engineering course, the association between team personality diversity and team project performance. Three aspects of personality traits are considered: biogenic, sociogenic and idiogenic.

Introduction

Engineering colleges rely on projects to develop students' teamwork skills. This ability to work effectively on a team is highly valued by employers, and collaboration among students can lead to intrinsic motivation, increased persistence, and greater academic performance [1]. Successful teamwork involves many intertwined factors [2]: Individual factors and group-level factors. Individual factors include students' personality traits. Team composition is commonly studied as an important group-level factor. It can vary by individual factors such as gender, race, education, and functional background, in addition to measures of ability and personality. Some studies [3]-[4] found that diversity personality in a team does not always increase a team's performance, and as a result, diversity has to be managed carefully when selecting team members for a project. A comprehensive compilation of group personality clusters on engineering design team performance in the literature is presented in [5]. The current knowledge has been gathered in the context of traditional in-person learning environment. It is unclear how this is affected in a semi-virtual environment. COVID-19 restrictions created an opportunity to research the extent to which diversity in team-members' personality type is associated with their team performance, in a semi-virtual learning environment. Following the framework of Little [6] for flourishing individual, we will consider three aspect of personality attributes: biogenic, sociogenic and idiogenic. Our research question is as follows: To what extent does diversity in personality traits associate with team performance in a semi-virtual learning setting?

Background

Biogenic traits
As defined by Little [6], "biogenic traits shape our first nature and are rooted in five dimensions of personality" (p. 20). The Big Five framework of personality traits has emerged as a robust and parsimonious model for understanding the relationship between personality and various academic behaviors [7]. The five dimensions are (a) Open vs. closed to experience – how open a person is to new ideas, adventures and experiences; (b) Conscientiousness vs. casual – how goal-directed, persistent, and organized a person is; (c) Extroverted vs. introverted: how much a person is energized by the outside world; (d) Agreeableness vs. disagreeableness – how much a person puts others' interests and needs ahead of their own; and (e) Neurotic vs. stable – how sensitive a person is to stress and negative emotional triggers. Personality traits have been shown

to influence academic achievement. For instance, conscientiousness and openness have consistently emerged as a stable predictor of team performance, and openness predicts overall academic performance and college performance [8]. In contrast, neuroticism is negatively associated with academic achievement. Schilpzand et al. [9] found that student teams diverse in openness exhibited more creativity on their innovative class project; Horwitz & Horwitz [10] in a study of personality diversity in team concluded that team performance is associated with team synergy.

Sociogenic traits
Sociogenic constitute one's "second nature," resultant from one's social environment. To quote Little [6], "how you are doing [in experiences] do not hinge on your first nature [biogenic], but on the recurring circumstances of your life [sociogenic]" (p. 20-21). These traits that involve the ability to process social information, social skills, and social awareness. Social intelligence will be measured using the Tromsø Social Intelligence Scale [11]. It has three dimensions: (a) Social Information Processing – the ability to understand verbal or nonverbal messages regarding human relations; (b) Social Skills – the basic communication skills, such as active listening, acting boldly, establishing, maintaining a relationship; and (c) Social Awareness – the ability of active behavior in accordance with the situations [12].

Idiogenic traits
These traits form a person's "third nature" [6]. These traits build on biogenic [who you are] and sociogenic [how you are doing] [6] to make us who we are. As described by Kolb & Kolb [13], "because of our hereditary equipment [biogenic, who you are], our particular life experiences [sociogenic, how you are doing], we develop a preferred process of learning" [13]. Individual learning style refers to style or learning methods used in the process of learning. Thinking, processing information and acquiring knowledge are processes that differ from student to student [14]. Fleming and Mills [15] suggested four modalities and the related questionnaire that seemed to reflect the experiences of the students in learning: Visual Learners (internalize and synthesize information when it is presented to them in a graphic depiction of meaningful); Aural learners (a preference for information that is heard or spoken.); Reading learners (emphasizes text-based input and output – reading and writing in all its forms but especially manuals, reports, essays and assignments); Kinesthetic learners (learn through physical movement aspect while studying, such as, touch, feel, hold, perform and move something). The VARK learning style does not involve intelligence or inherent skill, it relates to how we acquire or understand information or new knowledge.

Method

The study took place in the College of Engineering and Applied Sciences of a large, public, midwestern, R1 university. First-year students enrolled in the college are required to take a two-semester long course sequence in engineering design thinking. The current study is based in the second semester of this course, offered in Spring 2021. The course covers topic like fundamental statistics, statics, strength of materials, electricity, mass and energy balance, in addition to computational tools of MATLAB and Visual Basic for Applications. The course sequence is taught in a flipped-classroom setup and during the course of the pandemic was offered in a hybrid environment. The course was offered for two days every week. Unlike a regular semester, where the whole class attended every day, half of the class attended in-person and the other half virtually on Zoom, for one day a week. For the other day, the teams swapped attendance.

Students are formed into teams of four (with a minimum number of teams containing three or five students) through the course of the semester by the teaching team (1 instructor, 1 graduate teaching assistant, 3 undergraduate teaching assistants) which forms the primary mode of learning during class-time. Teams are formed using self-reported surveys on basic programming skills before joining the class, so that teams have similar skill levels across the classroom (uniform heterogeneity). Students' majors, gender and race are also taken into account to not isolate any student from an underrepresented minority group. Outside of team in-class activities (ungraded), individual and team quizzes, individual homework, and two individual exams, students also engage in three team projects based on engineering design. The projects are majorly evaluated as team assignments, however there were minimal individual components (reflection and peer-critique).

Data collection
Data for this study was collected both from a self-reported survey and student records. The learning styles, social skills and personality data came from a survey administered at the end of the semester. The preferred learning style was obtained by the VARK scale [15]. It is a 16 items questionnaire with four categories V-A-R-K. The preferred learning style is the category with the highest score. The reliability estimates for the scores of the VARK subscales are .85, .82, .84, and .77 for the visual, aural, read/write, and kinesthetic subscales [16]. The social skills were measured using the Tromsø Social Intelligence Scale; a 21 items Likert scale questionnaire with 3 dimensions (social information processing, social skills, social awareness) and reliability between 0.79 -0.86 [11]. The personality type was measured using the Big Five Inventory Short Form. It is a 15 items Likert scale with 5 dimensions (extraversion, agreeableness, openness, conscientiousness, and neuroticism) and reliability between 0.89- 0.95 [6]. The Team performance was measured using the three design project scores achieved in the course while demographics and student team numbers were linked using student records.

Participants
All participants in this study were students taking an engineering course at a state R1 institution in the Midwest during the year 2020/2021. A typical first-year engineering cohort consists of 1100 -1300 students. Students self-select their sections during registration and sections are assigned to instructors to match their teaching schedule. First-year engineering students are enrolled with two tracks: declared engineering major or undeclared engineering major who enrolled in the Freshman Engineering Program (FEP). The research survey was made accessible to 182 students, from three sections of the cohort, all taught by the same instructor. Students from various engineering disciplines were part of this sample including a few in the exploratory program. We received 150 valid responses for a response rate of 82.4%. 81.3% (122) of valid responses were received from white students. The remaining responses were received from students of other ethnicities. Given the relative low representations of these ethnicities, we referred to them as Non-white (18.7% of participants). Students were 85.3% males (128) and 14.7% females (22); 94.6% (142) decided major and 5.4% (8) undecided major.

Data analysis
Data from the survey responses was combined with student team numbers, their scores on the three team projects, and demographics. The variables analyzed were most and least preferred learning styles (V, A, R, K); five dimensions of personality traits – Openness(B1), Conscientiousness(B2), Extroversion(B3), Agreeableness (B4), and Neuroticism(B5); Social

intelligence scale – Social information (T1), Social skills (T2), and Social awareness(T3); and Team performance calculated using project scores. Data analysis began with investigating if there were any differences based on gender, race, and major using t-test. Then the relationship between team performance and variation in learning styles, personality traits, and social intelligence scale respectively were investigated using correlation. For the correlation tests, respondents were grouped by their team numbers. Then the standard deviation of each variable was calculated to find the variability between the students in each team. Additionally, each student's average score on three projects were calculated (maximum score 100). The average score of each team was calculated to represent Team performance. Since the response rate was not 100%, there were teams with only 1-2 respondents (total 9 responses). These were removed from the analysis. Consequently, there were 41 teams which had 3-5 respondents. Results from the analysis follow in the next section.

Results

Independent Samples t-test was used to determine whether there is a statistically significant difference between the means in various unrelated groups. Testing for the difference in the three dimensions of the sociogenic (T1, T2, T3) by race (White students and non-White students), the difference was not statistically significant ($p>0.05$). Repeating the analysis with focus on gender (male and female), the difference in gender was significant ($p=0.027<0.05$) when considering T2. When regrouping students by major (decided majors and undecided majors) results were not significant ($p>0.05$). Repeating the analysis for the sociogenic, results were statistically significant for difference in gender for B3 ($p=0.043<0.05$) and B5 ($p=0.027<0$). All other dimensions of the biogenic were not statistically significant for gender, race and major.

The correlation tests between team performance and the diversity in team personality revealed only one significant relationship – between team performance and Social skills ($r = 0.417$; $p = 0.007<0.05$). Pearson's coefficient and corresponding p-values are listed in tables 1, 2, and 3.

Table 1: Correlation between team performance and idiogenic traits

Variable	Statistic	Value
V	Pearson's r	-0.069
	p-value	0.668
A	Pearson's r	-0.253
	p-value	0.111
R	Pearson's r	0.091
	p-value	0.570
K	Pearson's r	-0.093
	p-value	0.564

Table 2: Correlation between team performance and sociogenic traits

Variable	Statistics	Value
T1(Social Information Processing)	Pearson's r	0.020
	p-value	0.901
T2(Social Skills)	Pearson's r	0.417
	p-value	0.007
T3(Social Awareness)	Pearson's r	-0.068
	p-value	0.671

Table 3: Correlation between team performance and biogenic traits

Variable	Statistic	Value
B1(Openness)	Pearson's r	0.040
	p-value	0.804
B2(Conscientiousness)	Pearson's r	0.249
	p-value	0.116
B3(Extroversion)	Pearson's r	0.269
	p-value	0.089
B4(Ableness)	Pearson's r	-0.176
	p-value	0.272
B5(Neuroticism)	Pearson's r	0.231
	p-value	0.146

Discussion and future work

Personality traits of first-year engineering students was studied to investigate diversity of personality traits in teams and their relationship with team performance. Data from about 150 students did not reveal significant relationship between diversity in personality and team performance for most dimensions. This can potentially be attributed to the small sample size and that there were only 41 teams in the correlation study. A larger sample size may show different results. Furthermore, a more robust approach may be required to measure team diversity in personality traits instead of standard deviation. It is, however, worth noting that diversity in social awareness and agreeableness were negatively correlated with team performance. This suggests that diversity in certain personality traits can lead to team dysfunction. Further investigation is required to justify this claim. The findings of this study were exclusively obtained in a semi-virtual learning environment as a result of the course being offered during the COVID-19 pandemic. It must be noted that a fully in-person classroom environment may show different results. Comparative studies may be needed to validate findings in a traditional classroom environment (pre- or -post-COVID).

Future work will involve investigating diversity in personality traits in a team using other approaches like the Euclidean D-score [17]. Other measures of teaming like measuring team dynamics using team effectiveness and peer-evaluations can be used to explore effects of diversity on teams. The study will also be repeated for a larger cohort to get more generalizable

results with a more diverse representation of gender, race, and majors. Furthermore, qualitative and mixed-method studies may help further in getting a deeper understanding of how personality traits affect team functioning.

References

[1]- National Academies of Sciences, Engineering, and Medicine, The Science of Effective Mentorship in STEMM. Washington, DC: The National Academies Press, 2019.

[2]- J. Rhee, D. Parent, and A. Basu, "The influence of personality and ability on undergraduate teamwork and team performance", *SpringerPlus*, *2*(1), 16, 2013.

[3]- E. Kearney, D. Gebert, and S.C. Voelpel, "When and how diversity benefits teams: the importance of team members' need for cognition", *Acad Manage J,* 52:581–598, 2009.

[4]- M.E. Roberge, and R. van Dick, "Recognizing the benefits of diversity: When and how does diversity increase group performance?", *Hum Resour Manag Rev* 20:295–308, 2010.

[5]- M. Ogot, and G. Okudan, "Integrating Systematic creativity into a first-year engineering design curriculum", *Int. J. Eng. Educ*, 22(1), 109-115, 2006.

[6]- B. Little, "*Who Are You, Really?: The Surprising Puzzle of Personality*", Simon & Schuster, Inc., 2007.

[7]- A. E. Poropat, A Meta-Analysis of the Five-Factor Model of Personality and Academic Performance, *Psychological Bulletin,* 135(2):322-38, 2009.

[8]- M. Komarraju, S. J. Karau, R. R. Schmeck, and A. Avdic, "The Big Five personality traits, learning styles, and academic achievement", *Personality and Individual Differences* 51(4):472-477, 2011.

[9]- M. Schilpzand, D. M. Herold, and C. E. Shalley, "Members' Openness to Experience and Teams' Creative Performance", *Small Group Research* 41(2), 2010.

[10]- S. Horwitz, and I. Horwitz, "The Effects of Team Diversity on Team Outcomes: A Meta-Analytic Review of Team Demography", *Journal of Management* 33(6), 2007.

[11]- D. H. Silvera, M. Martinussen, and T. I. Dahl, "The Tromsø Social Intelligence Scale, a self-report measure of social intelligence", *Scandinavian Journal of Psychology*, 42(4), 313–319, 2011.

[12]- O. Iatsevich, T. Semenovskikh and Z. Bruk, "The Study of Social Intelligence of Students Majoring in Industrial and civil construction", International Science Conference SPbWOSCE-2016.

[13]- A. Kolb and D. Kolb, "Learning styles and learning spaces: Enhancing experiential learningin higher education", *Academy of Management and Learning Education*, *4*(2), 193-212, 2005.

[14]- L. Zhang, "Does the big five predict learning approaches?", *Personality and Individual Differences*, 34, 1431–1446, 2005.

[15]- N. D. Fleming, and C. Mills, "Not Another Inventory, Rather a Catalyst for Reflection*", To Improve the Academy*, 11, 137-155, 1992.

[16]- W. L. Leite, M. Svinicki, and Y. Shi, "Attempted Validation of the Scores of the VARK: Learning Styles Inventory With Multitrait-Multimethod Confirmatory Factor Analysis Models. *Educational and Psychological Measurement*. 70, 323-339, 2010.

[17]- C. M. Riordan, and J. H. Wayne, A review and examination of demographic similarity measures used to assess relational demography within groups. *Organizational Research Methods, 11*(3), 562–592, 2008.