Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025
Paper ID #46746

Social Network Analysis of Teams in Engineering and Computer Science Courses

Tracy Marie Wenzl, University of New Mexico

Tracy Wenzl is a doctoral student in the Organization, Information and Learning Sciences department at the University of New Mexico (UNM) and the Senior Program Manager for UNM's Grand Challenges program. She holds a Bachelor of Arts in Psychology from New Mexico State University and a Master of Education in Information Science and Learning Technologies with a focus on educational technology from the University of Missouri. She aims to facilitate effective and inclusive collaborative learning experiences via her own research and in her professional role supporting interdisciplinary research teams. She uses social network analysis and qualitative methods to understand relationships between team members and plans to develop interventions to build closeness and belonging in teams.

Dr. Ruben D. Lopez-Parra, Universidad del Norte

Ruben D. Lopez-Parra is an Assistant Professor in the Instituto de Estudios en Educación (Institute for Educational Studies) at the Universidad del Norte in Colombia. His Ph.D. is in Engineering Education from Purdue University, and he has worked as a K-16 STEM instructor and curriculum designer using various evidence-based learning strategies. In 2015, Ruben earned an M.S. in Chemical Engineering at Universidad de los Andes in Colombia, where he also received the title of Chemical Engineer in 2012. His research interests are grounded in the learning sciences and include how K-16 students develop engineering thinking and professional skills when addressing complex socio-technical problems. He aims to apply his research to the design of better educational experiences.

Dr. Vanessa Svihla, University of New Mexico

Dr. Vanessa Svihla is a Professor in Organization, Information & Learning Sciences and in Chemical & Biological Engineering at the University of New Mexico. Dr. Svihla received the National Academy of Education / Spencer Postdoctoral Scholarship and the NSF CAREER Award, which President Biden also recognized with a PECASE. Their scholarship has been recognized for its contributions to diversity, equity, and inclusion by the American Society for Engineering Education and the Professional and Organizational Development Network. Dr. Svihla, a disabled and chronically-ill scholar, studies how people learn as they frame problems in power-laden systems and how these activities relate to identity, agency, creativity, equity, and organizational change.

Dr. Tito Busani, University of New Mexico

Tito Busani is an assistant professor in Electrical and Computer Engineering at the University of New Mexico. He actively works on renewable energy and fabrication technologies toward quantum computing and heterogenous integration. His teaching research is directed toward group work and peer-to-peer teaching enabling K-16 and K-12 interaction.

George Matthew Fricke, University of New Mexico

Social Network Analysis of Team Safety and Closeness in Engineering and Computer Science Courses

Abstract

While there is research on team formation in engineering and computer science, less is known about diverse team members' experiences of safety and closeness, which are prerequisites to innovation; the positive impact diversity can have on innovation depends on members feeling safe enough to contribute. We surveyed students enrolled in upper division undergraduate engineering and computer science courses about their experiences of safety and closeness with their teammates and used social network analysis to investigate differences across teams and across courses. While the engineering course used stable teams for a semester-long project, the computer science course used a sequence of teams for multiple small projects. Shifting teams may provide greater opportunities for diverse team members to locate allies.

Introduction and research purpose

Research suggests diverse teams can produce more innovative ideas, but this hinges on teams being inclusive, which fosters deeper, unfettered sharing of ideas [1], [2], [3]. In preparing students for professional practice, programs are expected to engage students in team work, as reflected in the ABET student outcomes, which stipulate that engineering students should be able "to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives" and similarly, that computer science students should be able to "function effectively as a member or leader of a team engaged in activities appropriate to the program's discipline" [4].

However, forming and supporting team learning is far from straightforward. While there is significant research to guide team formation and evaluation in engineering and computer science [5], [6], fewer studies have conceptualized team safety and closeness in these domains. Further, recent studies suggest these constructs are central to meeting the aims of broadening participation. Innovative outcomes hinge on inclusivity [1], [2], [3] and forming, but not supporting inclusion can negatively impact learning [7]. In this study, we aimed to explore the utility of team safety and closeness in upper division engineering and computer science courses, considering how these ideas might help instructors support teams. Specifically, we posed research questions about the ways that social network analysis (SNA) might reveal useful information about team dynamics:

- Across the two courses, how do teams vary in their closeness and safety?
- How does connectedness vary across stable versus shifting-teams approaches?

Framework

Closeness in teams improves collaboration

Social closeness in collaborative learning is defined as "an individual's perceived strength of relationships with group members" [8, p. 28]. Teams whose members share closeness may be more comfortable disagreeing with each other and more likely to engage in critical discussion, leading to more effective collaborative work [9], [10]. In an advanced computer science course, researchers found that stronger team closeness ties (using friendship as a proxy for closeness) correlated to better team performance [11]. Developing closeness can reduce bias and improve institutional belonging and commitment for minoritized students [12]. Social closeness also leads to more satisfying collaborative learning experiences [8].

Team psychological safety impacts performance

Team psychological safety is "a shared belief that the team is safe for interpersonal risk taking" [13, p. 354]. Safety within teams is necessary for team members to share their ideas and opinions [10]. One study found that psychological safety was an indicator of the inclusion of minoritized students in teams, and that psychological safety was correlated with team learning and active participation in the team by individual students [14]. They also found that international students, Black/African American, Asian, and Hispanic/Latino students experience lower psychological safety than their peers. Higher levels of psychological safety correlate to better quality ideas as rated by student engineering design team members [15].

Feeling safe within a team is influenced by many factors. Studies in first-year engineering courses found that psychological safety is positively influenced by good communication between members, and negatively influenced by unresolved conflict and absenteeism [16], [17]. Numerous studies have found a link between closeness among team members and higher levels of psychological safety [16], [18]. These findings point to the importance of positive communication and team closeness to the development of team psychological safety.

Methodology

Social network analysis (SNA) is a means to study the relationships between people within a system [19], which in a learning setting, could be defined as each team in a class, the entire class, or even the broader community that supports student learning (e.g., tutors, peers, etc.). In SNA, each system is represented by a network, also called a sociogram, comprising nodes and ties between them. Each node represents an individual, and the ties between them represent the relationship.

In this study, we use SNA to investigate group dynamics as they are influenced by different approaches to collaborative team learning. Past studies using SNA have found correlations between positive interpersonal relationships and successful team collaboration [20]. Researchers found correlations between social connections and learning networks among construction management students [21], suggesting social connections matter for learning. Further, having isolates—people who do not report giving or receiving advice within a network—is negatively correlated with publication productivity, indicating that teams with members who are isolated or absent can negatively impact team productivity [20].

Some SNA studies measure the mere presence or absence of a connection between people. In contrast, the current study uses *weighted directional* connections, meaning we asked students to report the strength (as a weight in the network) for each person they reported a relationship with (directional). Specifically, students evaluated connections to their peers in terms of how close they felt and how safe they felt. We explored students' closeness and safety in teams in two upper-level undergraduate/graduate courses in electrical and computer engineering (ECE) and computer science (CS). These two courses used collaborative teamwork in different ways.

Participants and setting

The study was conducted in two courses at a Hispanic-serving research university in the American Southwest. Following informed consent, we collected student demographics in a survey at the beginning of the semester (Appendix A). Due to the small sample size, we did not use demographic data in the analysis we report, as it would make certain students identifiable once linked to teams. We report these data collectively by course to allow instructors to consider how our context might be different from or similar to their own.

In the CS course, students learned how to configure and provision the components of a high-performance computing cluster. They deployed and ran different software packages, determined performance benchmarks, and wrote a paper describing their results. They completed this work as a series of mini projects in teams of three that were initially randomly assigned by the instructor; later in the semester, students were given the option to choose their teammates on two separate occasions. They did not receive any dedicated time to get to know one another in the class before choosing teammates, but as it was later in the course, they had opportunities to interact with one another.

The ECE course is an elective class open to students from different disciplines interested in photovoltaics—the conversion of light into electricity. The course followed a project-based approach in which students worked in teams on designing a solar farm capable of sustaining a small city (50,000 to 100,000 people). Students chose their own teams, following guidelines that required each team to have members with expertise in programming, leadership, technical writing, and oral presentations. Students got to know each other in the first two weeks of class, though they chose their teams in the first week. The instructor intervened to balance the teams in the second week to assure teams had all the necessary expertise. The instructor recommended teams with no more than five students to assure the needed expertise was present, though three groups had more than five members. Teams remained stable across the semester.

In both courses, students had previously gotten to know some of their peers in prior coursework.

Data collection and analysis

The primary data source for this study is responses to the *Closeness and Safety Survey* that students completed at the end of the semester (refer to Appendix B for full survey). The survey included items measuring team safety and closeness drawn from previously developed surveys [8], [22], [23], [24]. 17 of 20 students (85%) enrolled in the CS course and 17 of 32 students (53%) enrolled in the ECE course completed the survey. As with most any research method, missing data is a documented and understood issue in SNA. As a result, several approaches and norms have been developed to handle missing responses. A first assessment of missingness in SNA evaluates whether the full network is represented or not. Despite the missing responses, we received enough responses in both courses that all students in each course are represented in our networks because their teammates did complete the survey. Students who did not complete the survey can be identified in Fig. 1 as nodes with no arrows pointing away from them. Although we would prefer to have complete data, when data are missing in one direction (i.e., from student A to student B, but not from student B to student A), social network analysts can choose to treat the relationship as mutual, and based on studies, the impact of these missing ties between students can be expected to be small [25]. Non-response results in lower clustering, meaning that our calculated modularity scores (discussed in more detail below) are likely underestimating the true modularity of the full classroom. However, we can notice in the sociograms (Fig. 1) that the modularity is correctly represented in the ECE course with fixed teams and can confirm the relative accuracy of the representation of modularity in the CS course by examining the teams that turned in work together across the semester. Finally, the impact of missing responses on average path length may be tolerated for response rates of 50% and better [25].

There are two primary methods of collecting information about the ties (relationships) between nodes in a network. The first is to provide respondents with a roster of names and ask them to choose from the list. The second is to ask respondents to recall the names of relevant relations. As not all students consented to participation, providing a roster would have been inappropriate and therefore name recall was the appropriate method. Both methods should produce similar results as long as the respondent is being asked to recall a reasonable number of contacts [26].

Students were asked to "Assign each of your team members a number, starting with 1. List the numbers with their first names below. You will answer the questions below based on your list." Some CS students rated everyone they'd worked with across the semester, while others listed only members of their most recent team. While this might appear to be inconsistent data, social network analysts have argued that such differences are not artifacts of different interpretations, but rather, that this accurately reflects the differing strength (whether positive or negative) and durability of relationships. For instance, some students may have continued to interact with former teammates when completing homework sets outside of the team project.

After naming the peers with whom they worked, students evaluated their relationships by answering two questions about each peer:

- Closeness: "How close or distant did you feel to each group/team member?"
- Safety: "How safe or unsafe did you feel expressing a different idea or disagreeing with this person?"

Each question used a 7-point Likert scale (1= Very distant to 7 = Very close; 1 = Very unsafe to 7 = Very safe). Closeness and safety scores all refer to pairs of students (e.g., student A was very close (7) to student B). As students were asked to respond to these questions about each team member, we were able to combine all the pairs to analyze the data at the team level. Data were de-identified, separated by course, and then further separated into matrices for closeness and safety. We used Gephi 0.10.1 [27]—an open-source program that enables the analysis of network data and the production of sociograms (graphical representations of those networks)—for analysis.

In SNA, the unit of analysis can be the relationships between nodes, the network as a whole, subnetworks within a larger network, or a collection of networks in a larger community. We first focused on whole network analysis, using means and standard deviations. We calculated mean scores as the average of the total of every individual closeness and safety rating in each course. Next, we explored subnetworks within each class, using modularity [28] to detect groups within the courses. In this approach, an algorithm separates nodes into groups with which they are densely connected, which is represented by node color in Fig. 1. This allowed us to identify clusters even when students evaluated members from multiple team experiences and compare that with the known team associations. Finally, we used another whole-network metric, average path length, as an indicator of the strength of connections among members. Average path length measures the average distance between any two nodes in the sociogram. The distance between two linked nodes is 1. In weighted sociograms such as these, the average also takes into account the value of the tie (line) between two nodes. The strength of the ties between students is reflected in the weight or thickness of the ties (lines) between nodes in Fig. 1, with thicker lines representing higher ratings.

Results

Overall, we found differences between the course networks in the CS and ECE courses (Fig. 1). The ECE course had five clearly separate groups, while the CS course had five groups of varying sizes with numerous connections between groups. Within the larger groups in the CS course, several triads can be seen, demonstrating that students worked in small groups that changed throughout the semester.

Mean scores

Mean scores were calculated for each class by averaging all scores submitted on the student survey on the questions “How close or distant did you feel to each group/team member?” (closeness) and “How safe or unsafe did you feel expressing a different idea or disagreeing with this person?” (safety). The mean safety scores in both courses were relatively high (ECE: *M* = 6.18, *SD* = 1.28; CS: *M* = 6.33, *SD* = 0.76), suggesting that overall, students felt a high level of safety in their courses. The ECE students gave higher closeness ratings to their teammates (*M* = 5.47, *SD* = 1.87) than the CS class did (*M* = 4.02, *SD* = 1.51). This is likely due to the teams in the ECE course remaining stable across the semester, which provided more time to develop close relationships with teammates.

Modularity

Modularity is visible in the sociograms of each course network (Fig. 1). The ECE course had more modularity (Closeness = 0.77; Safety = 0.78), indicating more strongly connected teams, than the CS course (Closeness = 0.60; Safety = 0.59). This is apparent in the sociograms representing the course networks; the ECE sociograms show five distinct teams with no outside ties, while the CS sociograms show five clusters containing one or more teams in which every cluster has at least one tie to another cluster in the class.

Average path length

Both the distance between nodes and the strength of rating between nodes is reflected in average path length calculations [19].

ECE students are much more strongly connected to one another within their teams than the students in the CS course. The ECE average path lengths in closeness and safety are 1.11, meaning that most students within the teams reported links to all the other team members. However, in the CS course the average path lengths are 3.09, which indicates less connection within the teams but more connection across them.

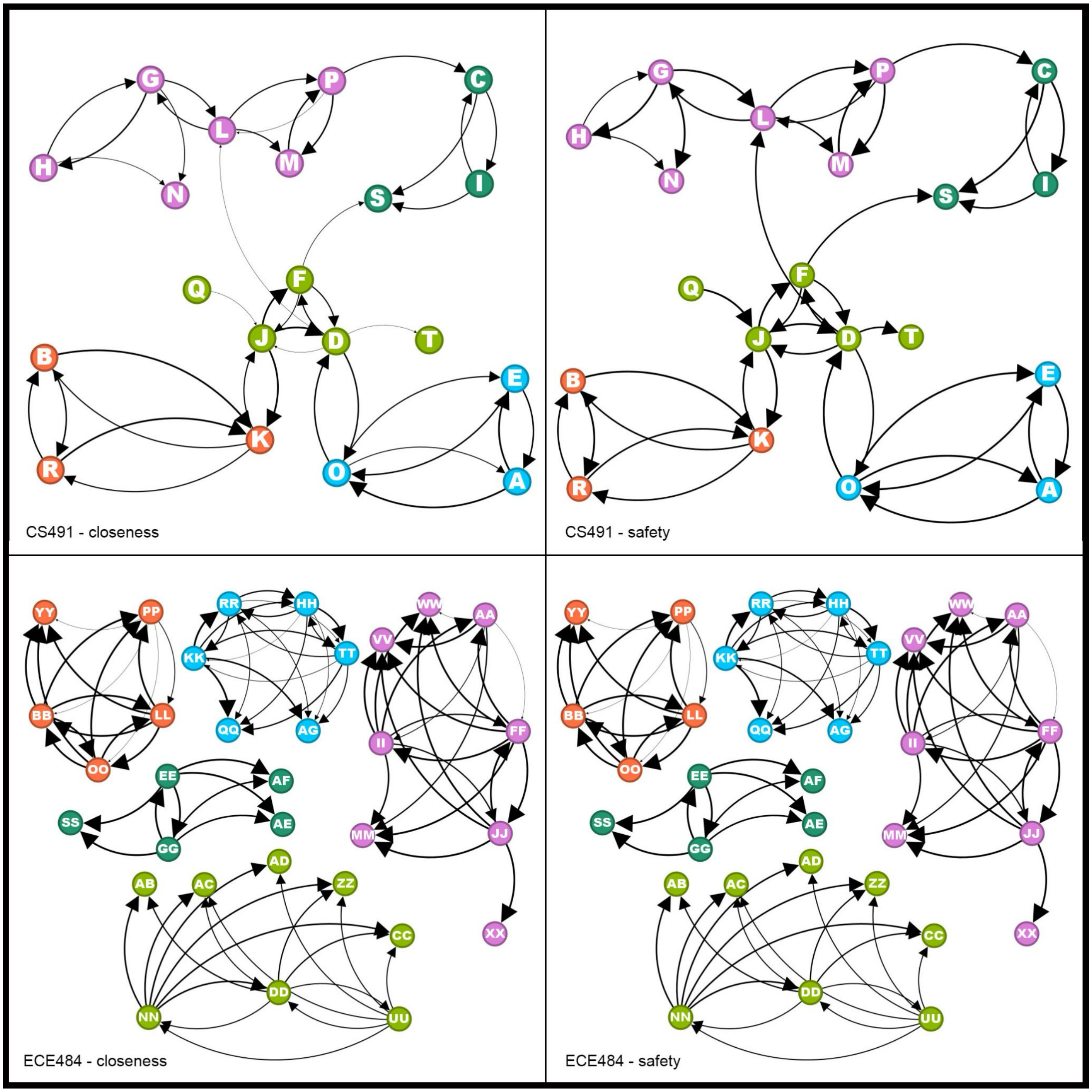

Figure 1. Sociograms of closeness (left) and safety (right) in CS491 (top) and ECE484 (bottom). The nodes represent individual students and the node colors are representative of modularity, or clusters within the classes. The full-semester teams are apparent in their clear clusters in the ECE sociograms, while the CS course with shifting teams demonstrate a number of dyads and triads (2- and 3-person teams). Line weight indicates strength of relationship; the thickest lines represent the highest rating (7) and thinner lines represent lower ratings. In these sociograms, node location and distance from others is arbitrary. Nodes with no outgoing arrows represent students who did not complete the survey.

Discussion

Overall, students reported high psychological safety within their teams and with other classmates with whom they affiliated. This suggests that the teams had good communication, as studies have linked students' psychological safety with communication [16], [17]. Team psychological safety relates positively to team learning and student participation [14], so we can expect that students were, in general, able to actively participate in team activities and learned through their team projects.

Research also suggests that psychological safety and closeness are positively correlated [16], [18]. For the ECE course, our findings clearly align with this result, as scores for closeness and safety were both high. However, there was a less clear relationship for the CS class, where students reported somewhat lower closeness scores. This likely reflects the shifting team structure in the CS class, and may reflect that it takes time for closeness to develop, a pattern reflected in studies that collected data over time [16].

We found that the ECE course network contained strong ties, based on the high modularity scores (Closeness = 0.77; Safety = 0.78) indicating distinct teams, and low average path length (1.11), indicating that team members are connected nearly perfectly within their teams to every other team member. Networks with strong ties, where all members of a team are linked to each other but not to others outside of their team allow members to build trust, commitment, and belonging [10], [29]. Strong ties enable the transfer of knowledge and information [11]. Networks with strong ties may be more effective when a goal of the learning activity is discussion and negotiation among learners. Thus, in the ECE course, we might expect that students had greater opportunities to learn by negotiating with their peers.

In contrast, in networks with multiple small teams, members that have connections outside of their team are best positioned to benefit from dissimilar thinking across teams [30]. The CS course network contains weak ties based on a larger average path length (3.09), which indicates less clearly defined teams but more connections across teams. Weak ties in a network, or those with links across teams, help information travel more effectively through the network [31]. Engineering design teams who had more contact with people outside of their teams reported higher levels of creativity within their teams in both originality of ideas and number of ideas developed and considered by the team [32]. Therefore, if a learning activity aims to produce creativity or innovation, a network with links across groups may be more effective.

Diverse teams are more effective with good communication leading to knowledge exchange [1] and deep-level diversity based on personality, values, and abilities instead of demographics [1], [3]. Researchers found that functional diversity, or diversity in background or discipline, "is a driver of creative, innovative team performance, regardless of interpersonal processes" [33]. The ECE instructor encouraged diverse teams by guiding students as they chose teammates, intervening when the team was missing a particular skill set or background necessary for the project. Spending time analyzing the deep-level diversity present among learners can help with team formation, while attention to communication processes can support teams to work more effectively.

After teams are created, it is critical to continue monitoring and supporting teams, particularly in the areas of psychological safety and closeness. Instructors should be sensitive to interpersonal dynamics, especially those related to demographic diversity factors that could create barriers to closeness and psychological safety.

Study limitations can be addressed in future research. Some students did not complete the survey, leading to missing links in the sociograms. The survey only allowed students to score six teammates, but the ECE course had two groups with eight members, meaning that some connections between team members were not captured. Future studies should aim to get full participation from learners to fully evaluate team dynamics; the survey was updated to allow for up to eight teammates to be scored in future studies. This survey asked students to score relationships with their teammates only; allowing students to indicate ties outside of their teams might reveal networks not detected here. In light of this, the survey was updated to add a section for students to score non-teammates in the class to better represent the full class network. Demographic analysis by team may have been identifiable based on small sample size; future studies with larger sample sizes should analyze team demographic diversity. Future survey designs should incorporate analysis of communication processes, which could lead to a deeper understanding of the mechanisms impacting psychological safety and the design of interventions to improve collaboration for all learners. Also, the current study lacks the ability to address questions about the impact of prior relationships that might have shaped how students felt closeness and safety with their peers; future studies could investigate these phenomena longitudinally, studying such factors across the program of studies.

Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant No. 2412193. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

[1] T. Chamorro-Premuzic, “Does diversity actually increase creativity?,” *Harvard Business Review*, Jun. 28, 2017. Accessed: Jul. 17, 2024. [Online]. Available: https://hbr.org/2017/06/does-diversity-actually-increase-creativity

[2] S. Harvey, “A different perspective: The multiple effects of deep level diversity on group creativity,” *J. Exp. Soc. Psychol.*, vol. 49, no. 5, pp. 822–832, Sep. 2013, doi: 10.1016/j.jesp.2013.04.004.

[3] J. Wang, G. H.-L. Cheng, T. Chen, and K. Leung, “Team creativity/innovation in culturally diverse teams: A meta-analysis,” *J. Organ. Behav.*, vol. 40, no. 6, pp. 693–708, Jul. 2019, doi: 10.1002/job.2362.

[4] “Criteria for Accrediting Engineering Programs, 2024 - 2025,” ABET. Accessed: Dec. 19, 2024. [Online]. Available: https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2024-2025/

[5] R. A. Layton, M. L. Loughry, M. W. Ohland, and G. D. Ricco, “Design and validation of a web-based system for assigning members to teams using instructor-specified criteria,” *Adv. Eng. Educ.*, vol. 2, no. 1, 2010, Accessed: Jul. 19, 2024. [Online]. Available: https://advances.asee.org/publication/design-and-validation-of-a-web-based-system-for-assigning-members-to-teams-using-instructor-specified-criteria/

[6] M. L. Loughry, M. W. Ohland, and D. J. Woehr, “Assessing teamwork skills for assurance of learning using CATME team tools,” *J. Mark. Educ.*, vol. 36, no. 1, pp. 5–19, Apr. 2014, doi: 10.1177/0273475313499023.

[7] S. Calder-Wang, P. A. Gompers, and K. Huang, “Diversity and performance in entrepreneurial teams,” Apr. 2021, *National Bureau of Economic Research*: 28684. doi: 10.3386/w28684.

[8] S. Feng, S. Qiu, D. Gibson, and D. Ifenthaler, “The effect of social closeness on perceived satisfaction of collaborative learning,” in *Open and inclusive educational practice in the digital world*, D. Ifenthaler, D. G. Sampson, and P. Isaías, Eds., Springer, 2022, pp. 101–113. [Online]. Available: https://doi.org/10.1007/978-3-031-18512-0_7

[9] J. Janssen, G. Erkens, P. A. Kirschner, and G. Kanselaar, “Influence of group member familiarity on online collaborative learning,” *Comput. Hum. Behav.*, vol. 25, no. 1, pp. 161–170, Jan. 2009, doi: 10.1016/j.chb.2008.08.010.

[10] D. Levi, *Group Dynamics for Teams*. SAGE Publications, 2020.

[11] Y.-A. de Montjoye, A. Stopczynski, E. Shmueli, A. Pentland, and S. Lehmann, “The strength of the strongest ties in collaborative problem solving,” *Sci. Rep.*, vol. 4, no. 1, p. 5277, Jun. 2014, doi: 10.1038/srep05277.

[12] E. Page-Gould, R. Mendoza-Denton, and L. R. Tropp, “With a little help from my cross-group friend: Reducing anxiety in intergroup contexts through cross-group friendship,” *J. Pers. Soc. Psychol.*, vol. 95, no. 5, pp. 1080–1094, 2008, doi: 10.1037/0022-3514.95.5.1080.

[13] A. Edmondson, “Psychological safety and learning behavior in work teams,” *Adm. Sci. Q.*, vol. 44, no. 2, pp. 350–383, Jun. 1999, doi: 10.2307/2666999.

[14] B. Beigpourian and M. W. Ohland, “Psychological safety and team member effectiveness of minoritized students in engineering education,” *J. Women Minor. Sci. Eng.*, vol. 30, no. 6, 2024, doi: 10.1615/JWomenMinorScienEng.2023043341.

[15] C. Cole, J. Marhefka, K. Jablokow, S. Mohammed, S. Ritter, and S. Miller, “What is the relationship between psychological safety and team productivity and effectiveness during concept development? An exploration in engineering design education,” *J. Mech. Des.*, vol. 144, no. 11, p. 112301, Nov. 2022, doi: 10.1115/1.4054874.

[16] C. Cole *et al.*, “What factors impact psychological safety in engineering student teams? A mixed-method longitudinal investigation,” *J. Mech. Des.*, vol. 144, no. 12, p. 122302, Dec. 2022, doi: 10.1115/1.4055434.

[17] M. V. Huerta, S. Sajadi, L. Schibelius, O. J. Ryan, and M. Fisher, “An exploration of psychological safety and conflict in first-year engineering student teams,” *J. Eng. Educ.*, p. jee.20608, Jun. 2024, doi: 10.1002/jee.20608.

[18] A. Newman, R. Donohue, and N. Eva, “Psychological safety: A systematic review of the literature,” *Hum. Resour. Manag. Rev.*, vol. 27, no. 3, pp. 521–535, Sep. 2017, doi: 10.1016/j.hrmr.2017.01.001.

[19] S. Wasserman and K. Faust, *Social Network Analysis: Methods and Applications*, Cambridge Univ. Press, 2009.

[20] H. B. Love *et al.*, “Towards understanding the characteristics of successful and unsuccessful collaborations: a case-based team science study,” *Humanit. Soc. Sci. Commun.*, vol. 9, no. 1, pp. 1–11, Oct. 2022, doi: 10.1057/s41599-022-01388-x.

[21] H. B. Love, M. E. Ozbek, and J. E. Cross, “Assessment of the development of social and learning networks in construction management courses using social network analysis,” *Int. J. Constr. Educ. Res.*, vol. 16, no. 4, pp. 290–310, Oct. 2020, doi: 10.1080/15578771.2019.1657208.

[22] S. Wei and M. W. Ohland, “The relative importance of team dynamics in predicting effective teamwork behaviors,” in *2021 IEEE Frontiers in Education Conference (FIE)*, Lincoln, NE, USA: IEEE, Oct. 2021, pp. 1–5. doi: 10.1109/FIE49875.2021.9637128.

[23] Popovic, Milne, and Barrett, “The scale of perceived interpersonal closeness (PICS),” *Clin. Psychol. Psychother.*, vol. 10, no. 5, p. 286, Oct. 2003, doi: 10.1002/cpp.375.

[24] A. C. Costa and N. Anderson, “Measuring trust in teams: Development and validation of a multifaceted measure of formative and reflective indicators of team trust,” *Eur. J. Work Organ. Psychol.*, vol. 20, no. 1, pp. 119–154, Feb. 2011, doi: 10.1080/13594320903272083.

[25] G. Kossinets, “Effects of missing data in social networks,” *Soc. Netw.*, vol. 28, no. 3, pp. 247–268, Jul. 2006, doi: 10.1016/j.socnet.2005.07.002.

[26] C. T. Butts, “Social network analysis: A methodological introduction,” *Asian J. Soc. Psychol.*, vol. 11, no. 1, pp. 13–41, Mar. 2008, doi: 10.1111/j.1467-839X.2007.00241.x.

[27] M. Bastian, S. Heymann, and M. Jacomy, “Gephi: An open source software for exploring and manipulating networks,” *Proc. Int. AAAI Conf. Web Soc. Media*, vol. 3, no. 1, Art. no. 1, Mar. 2009, doi: 10.1609/icwsm.v3i1.13937.

[28] V. D. Blondel, J.-L. Guillaume, R. Lambiotte, and E. Lefebvre, “Fast unfolding of communities in large networks,” *J. Stat. Mech. Theory Exp.*, vol. 2008, no. 10, p. P10008, Oct. 2008, doi: 10.1088/1742-5468/2008/10/P10008.

[29] G. A. Fine and T. Hallett, *Group life: an Invitation to Local Sociology*. Cambridge, UK ; Hoboken, NJ: Polity Press, 2023.

[30] K. Giuffre, *Communities and Networks: Using Social Network Analysis to Rethink Urban and Community Studies*. Cambridge: Polity, 2013.

[31] M. S. Granovetter, “The strength of weak ties,” *Am. J. Sociol.*, vol. 78, no. 6, pp. 1360–1380, 1973.

[32] J. Kratzer, R. Th. A. J. Leenders, and J. M. L. Van Engelen, “The social network among engineering design teams and their creativity: A case study among teams in two product development programs,” *Int. J. Proj. Manag.*, vol. 28, no. 5, pp. 428–436, Jul. 2010, doi: 10.1016/j.ijproman.2009.09.007.

[33] A. Wax, R. Asencio, J. Bentley, and C. Warren, “Safety first! Psychological safety as a driver of learning in functionally diverse, self-assembled teams | Emerald Insight,” *Team Perform. Manag. Int. J.*, vol. 30, no. 7/8, pp. 173–194, 2024.

Appendix A. Demographic survey responses from CS and ECE students

	CS (n = 20)		ECE (n = 32)	
	Count	Percent	Count	Percent
Gender				
Man	16	80%	21	66%
Non-binary	0	0%	1	3%
Woman	4	20%	10	31%
Race/Ethnicity				
American Indian or Alaska Native, Native American, Indigenous to Turtle Island, or First Nations	1	5%	0	0%
Arab or Middle Eastern	2	10%	1	3%
Asian or Asian American	2	10%	20	62%
Hispanic, Latino/a/x/é, Mexican, Mexican American, Chicano/a/x, Cuban, or Puerto Rican	4	20%	5	15%
White	11	55%	5	16%
Age				
18-24	11	55%	17	53%
25-30	5	25%	8	25%
31-40	4	20%	7	22%
Home language				
Another language or languages AND English	2	10%	15	47%
Only/mostly a language or languages other than English	4	20%	6	19%
Only/mostly English	14	70%	11	34%
Community context				
Rural	0	0%	2	6%
Small town or suburban	6	30%	11	34%
Urban/suburban	14	70%	18	56%
Family income				
High	1	5%		0%

Low	1	5%	3	9%
Lower middle	4	20%	8	25%
Middle	9	45%	19	59%
Upper middle	5	25%	2	6%
Academic standing				
Graduate student	3	15%	25	78%
Senior	16	80%	3	9%
Junior	1	5%	4	13%
Hours worked (employment)				
0 hours per week	2	10%	3	9%
up to 9 hours per week	4	20%	3	9%
10-19 hours per week	6	30%	14	44%
20-29 hours per week	4	20%	8	25%
30-40 hours per week	1	5%	1	3%
41 or more hours per week	2	10%	3	9%
Hours caregiving				
0 hours per week	16	80%	11	34%
up to 9 hours per week	0	0%	7	22%
10-19 hours per week	3	15%	7	22%
20-29 hours per week	0	0%	2	6%
41 or more hours per week	1	5%	4	13%
Other				
Active duty or veteran	2	10%	1	3%
First generation college student	6	30%	15	47%

Appendix B: Full Survey

Construct & Stem	Response Options
How true or untrue are the statements below about your team/group? In this team… ● Members actively exchanged ideas with each other. ● It was easy to achieve consensus. ● By discussing, I developed new skills and knowledge. ● We can rely on each other ● We have complete confidence in each other's ability to perform tasks. ● We follow through on commitments.	1. Very untrue 2. Untrue 3. Somewhat untrue 4. Neither 5. Somewhat true 6. True 7. Very true
The questions below ask about how much team members share openly or act closed off to one another. How open or closed are members of your team in terms of: ● Dealing with problems. ● Discussing issues that arise. ● Sharing ideas about important decisions. ● Offering help.	1. Very open 2. Open 3. Somewhat open 4. Neither 5. Somewhat closed 6. Closed 7. Very closed
How much conflict of ideas was there in your team/group?	1. None 2. Little 3. Some 4. Much 5. Very much
How often… ● Did you have disagreements within your team/group about the task you are working on? ● Did people in your team/group have conflicting opinions about the project you are working on?	1. Never 2. Very rarely 3. Rarely 4. Occasionally 5. Often 6. Very often
How close or distant did you feel to each group/team member?	1. Very distant 2. Distant 3. Somewhat distant 4. Neither 5. Somewhat close 6. Close 7. Very close

How safe or unsafe did you feel expressing a different idea or disagreeing with this person?	1. Very unsafe 2. Unsafe 3. Somewhat unsafe 4. Neither 5. Somewhat safe 6. Safe 7. Very safe