A Mixed Methods Analysis of Student Experiences in Diverse Teams

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Abstract—**This work-in-progress research paper describes the initial findings of research on students' attitudes about diversity in first-year engineering teams. We used quantitative pre- and post-survey data and qualitative interviews with student teams to understand students' initial attitudes about diversity and teaming and how those were affected by engineering teaming experiences over a semester. The qualitative and quantitative data analyses interact throughout the project's iterations, with each informing the other. Here, we review the progress made through in-depth qualitative analysis when compared to survey data about changes in variance of students' attitudes towards teaming. By using an iterative mixed methods approach, we are able to explore the subtle distinctions in students' attitudes and experiences affecting diverse teaming experiences. In this paper, we will detail this iterative process and how it has produced more nuanced findings than a particular research paradigm alone.**

Keywords—Diversity; mixed methods; teaming; first-year engineering

I. INTRODUCTION

Globalization and resulting culturally diverse workplaces have produced an environment in which the social skills associated with working with diverse of colleagues has become nearly, if not equally, as important as traditionally emphasized technical skills for engineers. However, teaming studies focusing on diversity in terms of race and gender have shown mixed results in student learning and outcomes, pointing to a breakdown of learning in certain contexts [1]–[5]. Studies examining other types of diversity, such as values, motivations, and attitudes have similarly mixed findings [6]–[8]. The positive results of teaming result in greater creativity and divergent thinking outcomes when compared to homogeneous group results, having clear benefits for the projects and employers [9]. These mixed findings point to an incomplete understanding of the factors involved in forming successful and diverse teams, leading to student inefficiencies in the classroom and, possibly, later in the workplace. This paper describes the emerging results of a study jointly conducted at two public U.S. institutions. The goals of this study are to understand the mechanisms for how engineering students develop teaming skills and diversity sensitivity in first-year engineering courses.

In this paper, we discuss the emergent findings from both quantitative and qualitative data streams to answer the research question, "What changes, if any, occur in students' attitudes about diversity and engineering practices as a result of working in diverse teams?"

II. THEORETICAL FRAMEWORK

We used the lens of cultural diversity to understand students' attitudes towards diversity and how those attitudes related to their teaming. Cultural diversity refers to the representation of people with distinctly different culturally significant group affiliations [10]. Prior research suggests that there is a seemingly universal human tendency to respond positively to others who are similar and negatively to those who are dissimilar [11]. Additionally, groups must work through a number of stages before they can be successful as a team [12]. Participants usually begin in a state of high member uncertainty and search for common goals, attempt to establish group norms, begin to exchange information, and if effective, stabilize into team roles. Teams may only achieve these steps if they develop a common identity within a group [13]. Members of diverse teams arrive with a variety of social identities based on their backgrounds, cultures, and prior experiences. To develop this group identity, members of diverse groups must develop diversity sensitivity and multicultural effectiveness, which aid in integrating individual cultural identities into a group identity. This integration occurs early on in team formation processes [14] and is necessary for team effectiveness.

III. METHODS

A. Research Context

The data streams for this paper are a part of a larger research study at two predominately white, public institutions. The engineering student populations of the two campuses differ greatly, which was one of the reasons these sites were chosen for this investigation. The first institution has a large

international student population [15], and the second institution has a larger proportion of Native Hawaiian/Pacific Islanders and Hispanic students when compared to national averages for undergraduate enrollment in engineering [16].

The importance of diversity in engineering and teaming skills are explicitly taught as core learning objectives in the first-year engineering courses that are included in his study. Throughout the semester, these learning objectives are revisited in class discussions, reflections, and assignments. Students are taught about the best practices of teaming including regularly rotating roles, communication, organization, and contributing as an effective team member.

B. Data Sources

The quantitative data come from two sources collected during the fall of 2015. As a part of the first-year engineering curriculum at both institutions, students were placed into diverse teams of four for an entire semester-long class using the Comprehensive Assessment of Team Member Effectiveness (CATME) team formation tool [17] and evaluated their teammates' effectiveness several times throughout the semester [18], [19]. The CATME team formation tool maximized diversity within teams given the demographic and attitudinal makeup of the class. Students also were surveyed twice during the semester (i.e., at the beginning and end) to assess their perceptions of diversity, teaming attitudes, and evaluation of teaming experiences. In total, we received 1,206 student responses on both the attitudinal survey and CATME surveys.

The qualitative data are from both observations of students working in teams in the engineering classes (Fall 2015) as well as interviews with five diverse teams (Spring 2016). The five teams were chosen based on a maximum variation sampling of both attitudes as well as demographic characteristics including gender, race/ethnicity, international status, and disability status. In other words, the teams chosen for in-depth analysis demonstrated the greatest in-group diversity, which allows for more personal and possibly impactful experiences with diversity. Individual interviews were conducted with the members of five teams twice during the Spring 2016 semester. We collected two approximately 60-minute interviews from each team member using a semi-structured interview protocol. The first interview focused on students' prior history including their upbringing, perceptions of diversity, and pathway into engineering. The second interview focused on students' teaming experiences and attitudes about teaming.

These interviews were analyzed using Interpretive Phenomenological Analysis (IPA) [20]. The process involves multiple rounds of memoing, coding, and three passes of analysis (e.g., descriptive, linguistic, and conceptual) to produce a more nuanced view of the individual and his or her experience in his/her team. IPA is necessarily iterative and produces multiple themes and subthemes for each person, illuminating subtle factors affecting group interaction, which may not have been revealed through standard qualitative coding methods. The interviews were used to generate documents explaining the themes and utilized quotes to provide support for those themes. The students were also videotaped during class on several occasions, providing a means to analyze physical interactions, gestures, and how the group members spoke to one another. Utilizing all of these data, a complete picture of group interaction from each individual's perspective as well as an analyst's perspective could be produced.

By using the qualitative data to explore and further understand findings in the quantitative, we drive our research forward seeking to answer more nuanced research questions. Below, we report one of our initial findings that has been triangulated from both the quantitative and qualitative data collected. We describe the results of the quantitative data, the results of the qualitative data, and how the mixing of these streams creates a broader understanding of how students experience working in diverse teams.

IV. VARIANCE IN THE TEAMING EXPERIENCE

We found significant variation in how students felt about teaming at the beginning of the semester as well as after their experiences within diverse teams using a Kolmogorov–Smirnov test to compare the distributions. The quantitative data showed a doubling of the variance in the attitudes towards teaming over the course of the term for the study population. The qualitative data provides additional detail to help understand these results. We discuss the quantitative results as well as the results from two of the five teams currently being analyzed.

A. Quantitative Results

To explore the question of how the diversity within a team influenced teaming attitudes, we developed a similarity index along multiple demographic characteristics. Simple counts of the number of women, underrepresented minority students, or international students in a particular team did not give information on how these diversity categories related to each individual's characteristics. The similarity index accounted for how many other teammates were like each student within the team. For example, if a team consisted of two women and two men, then each woman would receive a similarity score of one and each man would receive a similar score of one to indicate that there was one other person of the same sex on their team. This score was created across the dimensions of sex, underrepresented minority status, and international status. Then, these scores were summed and normed for an index ranging from zero to three with zero indicating no similarities across sex, underrepresented minority status, and international status and a three indicating perfect similarity across the three team members on all dimensions.

We used this index to predict changes in teaming attitudes. We saw a small negative shift in the average of students' teaming attitudes, but we also found increased variance where some students' attitudes positively increased and others decreased. We investigated the distribution tails of students' attitude changes to understand the factors that caused large positive shifts and negative shifts in students' attitudes about teaming. First, we created a binary outcome of being in the top quartile or bottom quartile of student changes in attitudes about teaming across the semester. The top quartile was a greater than a one-point increase on the scale, and the bottom quartile was a greater than a one-point decrease on the scale. Then, we built two logistic regression models to investigate how well the

similarity index predicted positive and negative shifts in teaming attitudes. We controlled for English as a first language; prior teaming experience as self-reported by students; and team effectiveness ratings of each individual normed to the team average. The odds ratio for the similarity index was 1.40 indicating that students' odds of being in the top quartile of teaming attitude shifts are 1.4 times greater when on a more dissimilar (diverse) team. In other words, every one-point decrease in the similarity index (i.e., one more team member that is different on race, gender, and international status) increased the probability of being in the top quartile by 8.48%. Therefore, placing students in diverse teams of four may increase the probability of strong positive teaming shifts. In our work these differences increased teaming shifts by 25.44% [21]. Similarly, the odds ratio for multicultural openness shifts was 0.74 indicating that the odds of students with positive shifts in openness being in the bottom quartile of teaming attitude shifts are less than one. The probability of students who increase by a point on the openness scale being in the bottom quartile of negative teaming attitudes decreased by 7.57%. These findings indicate that students who worked in more diverse teams were on average more likely to have positive shifts in their teaming attitudes and that students who had positive shifts in multicultural openness were less likely to have negative shifts in teaming attitudes. Thus, more diverse teams and large shifts in multicultural openness can have a significant compounding impact on students' attitudes about working in teams.

B. Qualitative Results

In this work-in-progress paper, we describe the qualitative results for two of the five teams in this study here named Apis and Canis, which are pseudonyms. The two teams discussed here utilized different teaming methods which became apparent especially in role assignment, methods discussions, and interactions throughout the course of the term. The primary difference between the two groups was in how much trust was placed in the individual to satisfactorily complete his or her specific tasks. This trust translated into differing levels of latitude for group members' responsibilities and actions as well as differences in attitudes toward teaming.

Members of both teams received high marks and reported that their respective team functioned well. However, the Apis team reported a slightly higher level of variability in their initial attitudes about diversity. The Apis team consisted of Icarus (white, male), Sarah (white, female, Jewish), Mari (mixed-race—Asian and white, female), and Milton (Asian, male, international student). The Canis team consisted of Ezekiel (male, mixed-race—Black and white), Peter (male, Asian), Stanley (male, Asian, international), and Xander (male, white). All names are pseudonyms chosen by the students (see Table I for a summary of the team composition).

TABLE I.   BRIDGER TEAMS AND MEMBERS

Bridger Teams	
Apis Team	*Canis Team*
Icarus (white, male)	Ezekiel (mixed-race—Black and white, male)
Mari (mixed-race—Asian and white, female)	Peter (Asian, male)

Bridger Teams	
Apis Team	*Canis Team*
Milton (Asian, male, international)	Stanley (Asian, male, international)
Sarah (white, female, Jewish)	Xander (white, male)

The Apis team exhibited more collegiality and higher levels of trust than the Canis team. During one session in which the group was videotaped, Mari playfully ruffled Milton's hair and the team members took turns playing with a soft pencil holder shaped like a cow. The discussion of how to approach the new project was marked by occasional jokes and some socializing. When asked about this mix of off-task interaction and task-driven work, the students in the team described how they were friends outside of class and had developed friendships as a part of being teammates. Sarah often led the initial project discussions to figure out what shape the project would take. Then, Mari and Icarus would often lead a discussion of the particular design issues that needed to be solved. This part of the process was the most conflict observed in the team when Mari and Icarus did not agree on a particular approach; however, the disagreement was not contentious and was often solved through compromise. Milton was more involved in the technical discussions than Sarah but less so than Mari and Icarus. Milton was not interviewed as a part of this study; we requested his participation, but he was not interested in follow-up interviews. In general, the Apis team approached projects as a mixture of socializing and work, with neither being mutually exclusive. All team members reported a very positive teaming experience and they continued to socialize on occasion after the course finished.

The Canis team had a task-driven understanding of teamwork, which shaped how participants viewed the role of diversity in teaming. They valued quality work over interactions in the team [22]. The team members had different approaches to completing tasks. These different approaches were used by other team members to evaluate the quality of work someone could produce and thus with what they can and cannot be trusted. This lack of trust in students' abilities led to the roles people were allowed to assume on the team. Stanley checked over the team's work repeatedly. Ezekiel said his team trusted him when they knew what he was doing. Xander trusted anything the team did because throughout the year he learned that everyone produced "pretty much high quality" work "no matter what." Stanley trusted Peter's work more than Xander's and especially more than Ezekiel's. The general trust in this team was based on the quality of work delivered by the "smarter" students (as described by the team) given higher levels of trust within the team.

For the Apis team, the differences in approaches to engineering problems manifested in Mari and Icarus' debates over the methods to complete certain aspects of each project. Mari preferred to make detailed plans whereas Icarus preferred to build a prototype and adjust as the project developed. Mari would usually agree to Icarus's general approach only when that approach was used in the tasks for which Icarus was responsible. Although she did not agree with his approach, she trusted him to finish his parts of the project with a high degree of quality. Icarus did mention that Mari would often check on his progress on the tasks, but he mentioned that Mari would only say something if

he had gotten off track. The aspect of checking and monitoring progress occurred in both teams but served very different functions. For the Apis team, the other team members knew that Icarus had a personal tendency to suffer from scope drift while working, so checking on him during time sensitive projects was necessary. On the Canis team, Stanley checked his teammates work repeatedly as a function of not trusting Xander or Ezekiel to turn in assignments and trusted Peter to audit the team's work. While both teams may have appeared to be working similarly in terms of checking and monitoring, these actions served very different purposes and were understood in the context of the team and contributed to variance in teaming attitudes.

One factor that affected how the teams interacted from the initial meeting was the conception of professionalism, which was more apparent in the Canis team. For members of the Canis team, the definition of professionalism varied, but at the core of the idea was a sense of detachment from personal relationships and contextual role fulfillment. "Professionalism" as conceived by the team members played an especially important part in role assignment and task completion. Both teams talked about assigning tasks based on ability and inclination; however, the execution of this strategy varied. On the Canis team, Peter stated that the team norms dictated that a team member would pick a task in which he was first competent academically and second interest. Then, that person would remain as the person that accomplished those tasks, so that the team was successful. Stanley echoed a similar version of this when he expressed the opinion that there no point in doing something if you know a teammate can do it better. This approach to role assignment led to members of the Canis team failing to learn from one another's skills. Stanley reported that after the work was divided, each team member would complete his respective parts individually and team discussion was rare. In contrast, members of the Apis team often worked in pairs and helped one another with project tasks. Sarah, who admittedly was the least technically savvy of the group, reported holding back asking a team member to explain or teach her something because of tight deadlines. When there was no deadline, she assumed that any one of her teammates would assist her whereas members of the Canis team assumed a prior, and complete, knowledge necessary for task completion or if the knowledge was not present, it could be acquired by the individual later on outside of class.

V. Discussion

Our quantitative findings demonstrated an increase in the variability of students teaming attitudes after their first semester in engineering. We found no significant difference in the initial teaming attitudes and final teaming attitudes through comparisons of the averages (e.g., Welch's t-test) but did find differences in distributions (e.g., Kolmogorov-Smirnov test). Additionally, we found that students who worked in the most diverse teams, as defined by others different from one another by gender, race/ethnicity, and international status, were more likely to have positive teaming shifts. While these results provide some information about how students' attitudes about teaming are changing, it does not provide enough detail to understand *why* we observed these results.

The emerging qualitative findings of this study provide some insight into why the increase in variability may be occurring. Teaming strategies, such as how both Apis and Canis assigned project roles, were enacted very differently across the two teams. Overall, the participants described the process as assigning tasks to the person best able to complete them, but the process of how this goal was carried out affected the interactions in teams. The Canis team's more contractual approach to group work versus the Apis team's community-oriented approach resulted from the different attitudes that students had about the purpose and goals of teaming. While we do not have enough evidence to claim that a wider diversity of attitudes towards teaming and approaches to interacting within a team produces more positive teaming experiences, the two cases described in this paper point to that possibility.

Our overall goal of this research was to understand how placing students in diverse teams affected their attitudes about both diversity and teaming in first-year engineering. Our results indicate that the simple placement of students in demographically diverse teams is not sufficient to develop positive attitudes about diversity or about teaming. This finding is consistent with what the current literature shows about diverse teams [23], [9]. Additionally, explicit instruction about diversity and teaming and best practices of teaming formation and management [24] are not sufficient to shift significantly all students' attitudes about teaming. Our emerging results indicate that understanding the teaming process and providing tangible ways for engineering students to connect the tasks of engineering with diversity may provide better ways to encourage positive attitudes towards both teaming and diversity.

VI. Future Work

This paper is a first step in combining multiple sources of data about students' experiences in diverse teams to understand particular ways to improve both students' attitudes about diversity in engineering as well as their teaming experiences. We acknowledge that the results are limited to our initial analysis and results from only two U.S. institutions. Our future work includes finishing the analysis of all data streams to provide a rich description of teaming experiences in first-year engineering as well as implications for forming and teaching students in diverse teams. We also plan to expand our research sites to include other types of institutions with different demographic representation to understand how the context of the institution and courses influence students' experiences in diverse teams.

Acknowledgment

References

[1]   T. Carte and L. Chidambaram., *"A capabilities-based theory of technology deployment in diverse teams: leapfrogging the pitfalls of*

diversity and leveraging its potential with collaborative technology," J. of the Assoc. for Inform. Systems, vol. 5, no. 11-12, pp. 448-71, 2004.

[2] D. Cordes, D. Evans, K. Frair and J. Froyd., *"The NSF foundation coalition: The first five years,"* J. of Eng. Educ., vol. 88, no. 1, pp. 73-77, 1999.

[3] E. Fromm, *"The changing eng. educ. paradigm,"* J. of Eng. Educ., vol. 92, no. 2, pp. 113-122, 2003.

[4] J. E. Froyd and M. W. Ohland., *"Integrated eng. curricula,"* J. of Eng. Educ., vol. 94, no. 1, pp. 147-164, 2005.

[5] D. S. Staples and L. Zhao., *"The effects of cultural diversity in virtual teams versus face-to-face teams,"* Group Decision and Negotiation, vol. 15, no. 4, pp. 389-406, 2006.

[6] L. R. Hoffman, *"Homogeneity of member personality and its effect on group problem-solving,"* The J. of Abnormal and Social Psychology, vol. 58, no. 1, pp. 27-32, 1959.

[7] H. Lian, D. L. Ferris and D. J. Brown, *"Does power distance exacerbate or mitigate the effects of abusive supervision? It depends on the outcome,"* J. of Appl. Psychology, vol. 97, no. 1, pp. 107-123, 2012.

[8] B. M. Meglino, E. C. Ravlin and C. L. Adkins, *"A work values approach to corporate culture: A field test of the value congruence process and its relationship to individual outcomes,"* J. of Applied Psychology, vol. 74, no. 3, pp. 424-432, 1989.

[9] T. R. Kurtzberg, *"Feeling creative, being creative: An empirical study of diversity and creativity in teams,"* Creativity Research J., vol. 17, no. 1, pp. 51-65, 2005.

[10] T. Cox, *Cultural diversity in organizations: Theory, research and practice,* San Francisco: Berrett-Koehler Publishers, 1993.

[11] D. S. Byrne, *Social Exclusion*, Buckingham, UK: Open University Press, 1999.

[12] B. W. Tuckman, *"Developmental sequences in small groups,"* Psychological Bulletin, vol. 63, no. 6, pp. 384-399, 1965.

[13] K. Van Der Zee, N. Atsma and a. F. Brodbeck., *"The influence of social identity and personality on outcomes of cultural diversity in teams,"* J. of Cross-Cultural Psychology, vol. 35, no. 3, pp. 283-303., 2004.

[14] F. J. Milliken, C. A. Bartel and a. T. R. Kurtzberg., "Diversity and creativity in work groups: A dynamic perspective on the affective and cognitive processes that link diversity and performance," in *Group creativity: Innovation through collaboration,* New York, Oxford University Press, 2003, pp. 36-62.

[15] Inst. of Int. of Educ., "Open Doors 2014 Rep.," Inst. of Int. of Educ., NY, 2014.

[16] B. L. Yoder, "Eng. by the numbers," in *Amer. Soc. for Eng. Educ.*, 2015.

[17] R. A. Layton, M. L. Loughry, M. W. Ohland and a. G. D. Ricco., *"Design and validation of a web-based system for assigning members to teams using instructor-specified criteria,"* Advances in Eng. Educ., vol. 2, no. 1, pp. 1-28., 2010.

[18] M. L. Loughry, M. W. Ohland and a. D. J. Woehr., *"Assessing teamwork skills for assurance of learning using CATME team tools."* 36, no. 1 (2014): 5-19.," J. of Marketing Educ., vol. 36, no. 1, p. 2014, 5-19.

[19] M. W. Ohland, M. L. Loughry, D. J. Woehr, L. G. Bullard, R. M. Felder, C. J. Finelli, R. A. Layton, H. R. Pomeranz and a. D. G. Schmucker., *"The comprehensive assessment of team member effectiveness: Development of a behaviorally anchored rating scale for self and peer evaluation,"* Academy of Manage. and Learning Educ., vol. 11, no. 4, pp. 609-630, 2012.

[20] P. F. a. M. L. J.A. Smith, *Interpretative Phenomenological Analysis: Theory, Method and Research,* London: Sage, 2009.

[21] A. M. Liberman, *"How much more likely? The implications of odds ratios for probabilities,"* Amer. J. of Evaluation, vol. 26, no. 2, pp. 253-266, 2005.

[22] H. E. Rodríguez-Simmons, N. S. Pearson, J. A. Rohde, K. P. Vealey, A. Kirn and A. and Godwin, *"Forget diversity, our project is due,"* in ASEE Annu. Conf. & Expo., Columbus, OH, 2017.

[23] D. A. Harrison, K. H. Price and a. M. P. Bell., *"Beyond relational demography: Time and the effects of surface-and deep-level diversity on work group cohesion,"* Academy of Manage. J., vol. 41, no. 1, pp. 96-107, 1998.

[24] K. L. Tonso, *"Teams that work: campus culture, engineer identity, and social interactions,"* J. of Eng. Educ., vol. 95, no. 1, pp. 25-37, 2006.