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Advisor Perspectives on Diversity in Student Design Competition Teams

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Introduction

For the past 30 years the engineering community has placed a premium on recruiting and retaining a more diverse pool of future engineers. Research has demonstrated that student population diversity is linked to a number of important educational outcomes including problem-solving skills, complex thinking, occupational awareness, group work skills, and cultural competency.[1-5] These important educational outcomes resulting from diversity are scarce in engineering student design competition teams. Furthermore, because ECT are promoted as the image of engineering at institutions who have them, and because those images are predominately white and male, ECT images provide a clear contradiction to the recruiting messages of diversity and inclusion in engineering. Explaining and rectifying the lack of diversity in teams requires attention to the processes that produce and perpetuate it.

Student, design-build, engineering competition teams (ECT) include activities such as AIAA Design, Build, Fly, SAE International Formula series, and ASME Human-Powered Vehicle Challenges. Our previous work on ECT examined team cultures from the student team members' perspectives, specifically which aspects contributed to their generally exclusive and exclusionary compositions and cultures. For most teams an ethos of commitment prohibited inclusion of students who were not able to commit to the team the equivalent of full-time employment or more.[6] Thus students who were focused on or struggling with academics or who had out-of-school responsibilities, were self-supporting, etc. could not find a place on the teams. Established team members pushed out interested female students by enforcing gendered norms, schema and stereotypes that made it difficult for some female students to find acceptance, while they blamed the lack of female involvement on lack of interest.[7, 8] Team recruiting was strongly tied to friendship networks perpetuating the homogeneity of the teams.[9] No teams reported any kind of diversity training or core values related to diversity.[9, 10] Actually, teams reported a general lack of formal education, training, or mentoring for any important team skills, but especially in the areas of professional skill development such as leadership, management, communication, or interpersonal interactions.[9, 10]

Our previous work on ECT from the students' perspectives described faculty advisors as adopting a generally hands-off approach.[6-10] Over half of the students indicated that advisors' general interactions with teams comprise one hour or less per week. These studies proposed that closer or more active oversight and intervention from team faculty advisors could be utilized to mediate exclusive climates such as a 'night campus' environment,[11] to influence team structures and dynamics in positive directions, and to actualize some of the professional skill development opportunities that teams offer. On the other hand, one must also realize that faculty members may not have the expertise or even the requisite belief systems to mentor teams to toward inclusive cultures.

Therefore, this paper offers a different viewpoint of team cultures asking the research question, "What are ECT faculty advisors' beliefs and attitudes of diversity and inclusion as they relate to team cultures?" Seventeen team faculty advisors were interviewed for their beliefs and

observations of team demographics and cultures and any attempts to address those cultures or demographic homogeneity. In most cases advisors sit external to the day-to-day operations of the teams, nevertheless, they impact team cultures and processes with their attitudes, beliefs and roles as agents of their institutions and departments.

Why are faculty perspectives important?
Faculty play a critical role in the structure of any university. They develop and teach the curriculum, conduct research that advances the existing knowledge base, and serve on committees that determine many of the standards for their campuses. Staff come and go, trustees' terms expire, students phase in and out, but once tenured, faculty are entrenched. Because faculty play such a primary role in the life of the university, it is essential to better understand their attitudes and actions towards diversity.[12]

A review of the literature indicates that most faculty support the notion that a diverse student body is good for student learning even though many faculty believe that students of color are not as qualified as applicants from the majority group.[13-15] While many institutions, colleges, and departments have developed diversity plans, statements and initiatives, a disconnection often exists between institutional policy and faculty commitment to diversity.[16] Most troubling is that engineering faculty, who are predominately white and male, are the least likely departmental faculty to act as diversity mentors and advocates or to support campus wide diversity efforts.[14] Part of this inaction may be due to an ideology in which questions of inequality are viewed by faculty and administrators as largely irrelevant to real engineering work.[17]

Whether positive or negative, faculty attitudes and actions play a significant role in the overall quality of all diverse student experiences. If they choose, faculty can create or promote environments where all students are heard and respected. Implicit or unconscious bias affects interracial and other cross-cultural interactions. Even well-intentioned - "I treat students the same no matter their skin color" - faculty may be acting as agents of the social norms that privilege white students in engineering classrooms and organizations. In a study of African-American male experiences on multiracial student engineering teams, Cross and colleagues found that the social norms of the engineering community decreased African-American students' sense of belonging.[18] Contributing factors included but were not limited to indifferent faculty interactions. The authors recommended that multiracial team projects should be monitored carefully by faculty to ensure positive experiences of all team members.

A study of Asian and Asian-American students in engineering showed that many students faced stereotypes from peers and faculty that detrimentally impacted their education, including that of being the model minority.[19] Because of this stereotype, the students encountered assumed competence and exclusion from tutoring and other support, despite having attended poorly-performing urban high schools.

Faculty may choose to alleviate the male-dominated culture women of all races and ethnicities encounter in classrooms, study groups, and teams by proactively addressing inappropriate comments and behaviors. However, ignoring "frat house" behaviors is easily interpreted by all students as endorsement for bad or bullying behavior.[20-22] A large body of research demonstrates

the ubiquitous nature of unconscious bias that female students, faculty, and employees face in engineering and technology from both faculty members and students.[23-26]

Student involvement in campus activities has been demonstrated to be important to cognitive development and persistence, as well as the accumulation of important social and cultural capital.[27-29] However, the benefits of involvement may be differently distributed among students from dissimilar social-class backgrounds. Specific differences, such as low SES students' need to work, affects the amount of time they can commit to extracurricular activities such as ECT.[30] Faculty must recognize that subjective thresholds of time commitment may exclude some students from participation.

We acknowledge that many different dimensions of diversity impact students' experiences in engineering education and that these interlocking "inequality regimes" create different barriers for different students.[31] A gay Hispanic male student's experience is not the same as his heterosexual peers. Nor is a physically disabled Black female's experiences the same as her able bodied peers. Unfortunately, because of the data available for this paper, we primarily will consider the factors that impact inclusion of students in ECT who are members of gender and racial/ethnic minority populations in engineering.

As noted above, engaging with dissimilar others is important to educational outcomes for 21st century engineering students. To ensure that student engagement with diverse others is a positive learning experience for all students, faculty must: recognize the value of diversity; develop their own skills for creating and maintaining inclusive environments; and supervise and direct diverse student interactions for the benefit of all. This paper will describe the beliefs and attitudes toward diversity voiced by ECT faculty advisors as well as their perceptions of their teams' inclusiveness.

Methodology

We employed a phenomenographic framework to answer the research question, "How do ECT faculty advisors' perceive diversity and inclusion as it relates to team cultures?" Phenomenography is a qualitative research methodology with a long history in education research. More specifically, phenomenography is not a new or sparsely used framework in engineering education.[32-35]

The goal of this approach is to describe the different variations of peoples' conceptions of a given phenomenon.[36-38] This investigative approach is not directed at the phenomenon as such, but at the variation in peoples' ways of understanding the phenomenon. Research on ECT faculty advisors employing this approach is important because it illustrates the various ways in which faculty conceive issues of inclusivity and exclusivity for these teams, if they conceive of them at all.

The traditional phenomenographic method of data collection is open-ended interviews. Experiences from a large number of phenomenographic studies have shown that data from ~ 20 participants is generally sufficient to discover all the different ways of understanding the phenomenon under investigation.[38] The data for this paper derives from 17 open-ended

interviews of ECT faculty and staff advisors. The majority of interviews were conducted at competition sites for Formula SAE (Michigan 2013, 2014, and 2015) and Human Powered Vehicle Competition (2013). Many of the faculty served as advisors to multiple ECT. Two interviews were conducted via the telephone after the completion of the competition season. Interviews generally lasted one and one-half to two hours. The Faculty Advisor Interview Protocol is attached as Appendix A.

Interviews or extensive interview notes were transcribed by the research team member who conducted the interview. Two team members coded transcripts using NVIVO software and developed code books independently.[39] Code books were then compared for interrater reliability and consistency.

In the quotations below, italics font indicates questions from the interviewer. Quotation marks indicate a quotation from the advisor. Words in () indicate explanatory text; whereas, words in [] have been replaced for confidentiality. Bolded words indicate tonal emphasis from participants in their responses. Although we cannot specify the exact number, the research participants included at least one female advisor, who represent less than one percent of ECT advisors. To protect the confidentiality of the female participants, only masculine pronouns will be used. Likewise, we do not provide identities or clues to the institutions represented. Most schools participating have long histories doing so and the advisor networks are fairly tight. We do not want to compromise their privacy or confidentiality. This study was approved by our Institutional Review Board for the protection of human research participants.

Findings

The products of phenomenographic analysis are categories of description.[38] The categories of description are the researchers' abstractions of the different ways these advisors talked about team processes and structures from their point of view, in other words, their beliefs. Aspects of team culture identified in our earlier work with students that had the greatest impact on team inclusivity/exclusivity are: recruiting, integration, ethos of commitment, and beliefs about the lack of team diversity. From our coding of advisor interviews in which we asked questions related to team culture, we identify 11 belief categories. The belief categories are listed in Table 1 below. Following Table 1, we provide a rich narrative summary of the descriptions of team culture from which the advisor belief categories are synthesized.

One advantage of phenomenographical research is that by accounting for the different ways that people think about certain phenomenon we may uncover conditions (unconscious biases, avoidance, stereotypes, etc.) that constrain the transition from one-way of thinking to a qualitatively better way. Our hope is that by examining the ways some faculty talk about their roles in and the processes that contribute to the cultures of their teams other advisors may come to see their own impact on team diversity or the lack there of.

Table 1: Faculty advisor belief categories in terms of team cultural aspects

Team Cultural Aspect	Belief Category	Quote
Recruiting	Open and they will come	"Everybody knows about the competition teams, you don't really have to look for new members, they will come."
	Snowball recruiting	"Good members come from friends of members." "We have to have girls recruiting girls, and it helps when they are outspoken."
Integration	Come with skills	"If you have skills and can contribute, you are immediately in."
	Assert yourself	"You have to be assertive… that is how we see who is really interested and who is just hanging around."
	Insert yourself	"When different people come together there is a sorting. If you can't hang with the group, you don't stick around."
Ethos of Commitment	Give us your all	"40+ hours per week is fine; the experience launches careers."
	Restrains participation	"Working students can participate but will never be in leadership positions."
Lack of Diversity	Reflecting pool	"We don't have many URM in the college and the department has less than that."
	Environment	"The team space is called the 'closet.'"
	Student attributes	"They are just not interested" "If they don't like cars, we can't make them come participate."
	It's a white man's world	"I think there is a little bit of an intimidation factor, 12 guys and 1 girl. I **think** the guys are nice to her, but it would be like me going into a deal with 12 girls. I would feel like, mmm, I don't think so." "I have a spiel I give to new teams every year…, I tell them 'Get the race card out of the way and this is a PC (political correctness) free zone.'" "There are very few (URM) at [State University] and they did not seem interested in majoring in engineering anyway."

Team Culture Overview

Almost all advisors describe themselves "hands-off" when it comes to the teams. Some attend formal meetings and drop-in occasionally to team work areas to "see how things are going but not to interfere," whereas others view their role as facing up or out – a liaison with departmental, college, and university administration or external partners – and only interact with team leaders or members when called upon for some specific need. The amount of time spent with the team or on team activities ranges from less than 5% to more than 30% of professional time yet, ironically, was not proportional to the perceived intensity (hands-off vs highly) of their involvement. One advisor requires all design decisions be defended in front of him, while others

control design choices via purchase approval. One explains this approach, "If I see something questionable, they have to convince me that they have done their homework before I will approve the order." Many advisors leave all technical decisions to the teams and only get involved with non-technical issues, although only a few reported having dealt with divisive behaviors.

A small number of advisors recognize that their role includes monitoring or influencing team culture. One expresses this recognition saying that he drops in at odd times to "monitor the 'animal house.' I'm not saying there is that culture, but I do not want it ever to manifest." This advisor understands that if faculty do not actively confront bullying or degrading behavior, students can interpret that inaction as tacit support for bad behavior.[20-22] One advisor mentions a time when the team had some members with "grating personalities," during which he spent more time assisting with interpersonal relations than usual. He felt that he needed to intervene as those students were contributing to a hostile climate for new members. Finally, a young advisor believes that his wife exerts positive influences on team cultures. His wife, a highly successful engineer in industry, provides input during design critiques and reviews and aids in troubleshooting. They sometimes bring their young children to team activities. She becomes visible proof of a successful engineer who is also a wife and mother, an important role model for many female students.[40-42] He sees this role model as important for the male students as it is for female students because the male students do not often interact with accomplished, professional female engineers.

Recruiting
The belief categories *Open and they will come* and *Snowball recruiting* are observed in almost every advisor interview. Most advisors subscribe to the rhetoric that the teams are "open and welcoming to all." Operating under this assumption, all students are free to choose to participate on any team. Although this approach or assumption implies lack of restrictions on membership, it does not alter the structures that produce and reproduce exclusive team environments. No advisors report any guidelines for recruiting new members or any encouragement from the institution to diversify the team membership. Most indicate that the majority of active team participants join because of friends or friends of friends. The team homogeneity and closed friendship networks that result from this kind of recruitment create exclusive team environments perceived as unwelcoming and even hostile.[6, 8] Several advisors believe that some students choose their institution because of the reputation of their ECT or to join a specific ECT. This belief is supported by their data collected at open call, team interest meetings. The advisors report and most accept that generally less than 10-15% of students who attend a get-started meeting become integrated team members. As one FSAE advisor summarized his beliefs about recruiting, "The best members find us. Good members come from friends. Occasionally a student responds to formal recruiting and sticks around to contribute." These beliefs and attitudes contribute to elitist and exclusive cultures.

Integration
Expressing variations of the belief categories *Assert yourself* or *Insert yourself*, the majority of advisors indicate that new members have to take significant responsibility for finding a place in the team, or "sticking with it" when their early assignment is to stand by and watch experienced members design or build. Even teams where existing members are delegated to supervise small

introductory projects for new members tend to maintain the value that if a student deserves to be on the team, then he will persevere through "grunt" work and some degree of marginalization. A small number of advisors report active educational processes or documents for knowledge transfer available to new members. Several say that students with prior knowledge or skill are the most likely to be accepted, expressed in Table 1 as *Come with skills*. Although in contradiction to that belief, one advisor indicates that having too much prior knowledge might be detrimental as a student with extensive background in the artifact under development was ignored and pushed out of the team because more senior members did not appreciate his advice and commentary. In another example, expert carpentry and welding skills did not prevent male team members from freezing out a female who could have provided much needed help. While a few advisors express a belief that the team's integration strategies are unsuccessful, the vast majority show a general lack of concern for these processes, including several who do not know how new members are integrated into their teams. This finding is alarming when teams are allegedly open educational experiences yet suffer 85-90% attrition of interested students. None of the advisors, in spite of their roles as faculty and in some cases with course affiliation for the teams, report taking an active role in educating new team members for the skills and knowledge necessary to contribute to the team goals.

Commitment
All of the advisors describe an extreme ethos of commitment required for students to become fully accepted members of the teams, although few could elaborate specific time expectations and only one expresses discomfort with the value. They all state that neither their institutions nor their teams set maximum limits on student participation. The general time commitment expected exceeds part-time, and sometimes full-time, employment and manifests as the belief category *Give us your all*. Only two mention that they will enforce individual restrictions on students who are placed on academic probation by the department or college. Several advisors observe that the ethos of commitment divides the teams along social-class lines, describing their belief that the ethos *Restricts participation*. Students who are working to pay for school or to support themselves or their families will have difficulty demonstrating an appropriate level of commitment. The inability to participate at the subjective minimum required has been demonstrated to have negative short term and long terms consequences for those students.[6]

One team at a school with a high proportion of low socio-economic status students requires a probation period with a minimum time commitment of 24 hours over three weeks. Students who do not meet that requirement have to start their three-week window over; eventually they either meet it or drop out. As the advisor states, "If they aren't willing to come observe and learn about the team for 24 hours over 3 weeks, then we don't want them." Over half of that team works at least half-time jobs to support themselves and to pay for their own school expenses. Thus, the team expectation of less than 20-25 hours per week during peak times is less than most other teams. However, this team established the probation period as a way of initiating new members to the expectation because no one on the team can invest the time to pick up other members' responsibilities. The advisor fully supports the team's policy.

Lack of Diversity
All advisors report that their teams lack racial and ethnic (R/E) diversity, except for some teams from minority serving institutions. Without specific prompts about R/E or gender diversity, most

advisors respond by describing their team's diversity with an accounting of the variety of academic majors of team members. When asked directly about R/E or gender, the advisors observe that most teams exhibit homogeneity as white and male, acknowledging that ECT are *A white man's world*. They attribute the homogeneity to being a *Reflection* of their college of engineering demographics or those of the discipline from which most of their team members come. No advisor connected the lack of diversity to recruiting outcomes or failures to successfully integrate any but the most aggressive and assertive students. A few advisors note that students with less financial means are less likely to join teams because of the time commitment. Also, a few advisors state that they believe the lack of diversity on their teams is a problem, yet none described conscious interventions to change the demographics.

Many advisors provide comments that indicate how their beliefs in heteronormative gender schemas and stereotypes influence their views of team diversity. These beliefs in the impacts of *Student attributes* show up several ways. Faculty ascribe lack of interest in vehicles or racing as a major factor for lack of involvement of female and R/E diverse students. If their team ever had a female or non-white student in any kind of leadership role, they would quickly highlight that student. One could focus on the positive aspect of leadership positions open to female students, but those positive views should be moderated by recognizing that the advisor's ability to recall that example is grounded in its uniqueness and, in many cases, the leadership role is founded on gendered norms and schema. For example, teams often have captains who serve an administrative role rather than a technical engineering role. As one advisor observes, "in general across all the teams (at his institution), female students are much better at leadership than male students. They are happy doing organizing and management and not worried about whether they are designing." Another advisor muses, "I've always had one or two (female students) on the team - sometimes in a couple with a male team member, sometimes not. ... I don't know how much responsibility they have. I hope the team has matured enough to accept female students in leadership positions."

Conclusion

Opportunities for collaborating with diverse individuals in a team environment are considered essential to prepare undergraduate engineering students to meet 21st century global challenges. However, prior research on ECT from student members' perspective has found that most teams are predominantly white and male and do not provide an experiential learning space where students collaborate with dissimilar others. The aspects of team culture identified in our earlier work with students that had the greatest impact on team inclusivity/exclusivity are: recruiting, integration, ethos of commitment and beliefs about lack of team diversity. This work seeks to answer the research question "What are ECT faculty advisors' beliefs and attitudes of diversity and inclusion as they relate to team cultures?"

It is important to understand faculty beliefs and attitudes toward diversity because faculty play a critical role in supporting and advancing institutional initiatives that would encourage diversity. More importantly, faculty attitudes and beliefs directly impact student experiences in and out of the classroom, particularly those of students identifying as members of minority groups.

While all advisors ascribe to the belief that teams are open and welcoming to all, they struggle to explain why teams are overwhelmingly white and male. The most common path to team membership is by direct recruiting, that is, friends invite friends. No one recognizes the negative consequences of this method. For most students, their friends are so similar in race, gender, socio-economic status, and beliefs that the teams become homogenous groups that are difficult for diverse students to access.

Advisors acknowledge that in general teams do a very poor job of retaining and integrating new members, but they offer little to address the situation. "Assertive students get integrated" places the responsibility on newcomers to shoulder their way into these closed and homogenous environments. Students describe the teams as fraternities, which aligns with the advisor perspectives. In most instances, a student with pre-existing skills more easily finds a place in a team, which seems to be contradictory to the touted benefit of hands-on learning.

Advisors recognize the punitive implications of excessive time commitment requirements. Most observe that working students would find it difficult to participate. Again, these advisors do not suggest or implement policies to moderate team expectations.
As evident in the preceding aspects of team culture and their associated belief categories, the participating advisors admit that the teams they advise lack diversity. They attribute this homogeneity to a reflection of the demographics of their departments or institutions. We find, by comparing the institutional demographics to those of the team, that their teams are actually less diverse in terms of both racial and ethnic identity and gender. The advisors also express beliefs in racial stereotypes and socialized gender norms as explanations for the lack of diversity.

Advising an ECT avails faculty the opportunity to impact team cultures and processes through their attitudes, beliefs, and roles as agents of their institutions. Since the beliefs expressed by the participant advisors in this study demonstrate that few have the skills and knowledge to promote inclusive cultures, much less to teach others those skills, cultural sensitivity and intercultural communication education should be on-going for ECT advisors. Until the belief structures that surround ECT change to be more inclusive, team diversity is unlikely to improve. As in the corporate world that many engineering competitions are designed to emulate, diversity policies originate from the top, but inclusive actions must take place from the bottom all the way to the top.

Acknowledgement

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Appendix A

Experienced interviewers used this semi-structured interview protocol on site at event competitions (or in telephone calls). The interviewers asked for expansions of responses with additional probe questions and requests for examples when appropriate. They also recorded the institution name with each interview.

1. How do you define a successful team? Who or what drives that definition?

2. How are students recruited? Does the College of Engineering have requirements that address team recruitment and composition? Is your team associated with any specific courses?

3. What is the budget for this team? Where does the funding derive? Who is responsible for securing funding?

4. In what ways do you interact with the team? Formally vs. informally? Scheduled vs unscheduled?

5. Where do team activities take place? Are there time commitment expectations or restrictions? Are team members able to work without staff or faculty supervision?

6. How is the team structured? How is team leadership determined? How do new members learn the rules and expectations and needed skills? What input do you have in those processes?

7. On average, how many students participate on this team? Do you consider the team to be diverse? Are there efforts being made to address diversity? Do you think your team is open and welcoming to all students?

8. How much of your professional time is spent on team activities? Do you feel you are adequately supported by your administration?

9. Does the university, college of engineering and department value this team? How is that demonstrated?