Assessing the culture of engineering student project teams

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Abstract

Engineering student project teams are common across engineering schools world-wide. These teams provide leadership opportunities for students as well as hands on learning that can be missing from the classroom. The teams provide an opportunity for students to gain valuable experience during their engineering education.

These teams can have a large influence on student success post-graduation. Students who excel on project teams are able to network with industry professionals at competition events, during sponsorship activities, and while seeking mentorship and guidance. These contacts are often key for finding high impact careers after graduation.

The culture on student project teams can vary widely. While some teams intentionally focus on being welcoming and inclusive of all students, others can be highly selective, sexist, and exclusive. We have created a survey to better understand how cultures differ across teams and within multi-team makerspaces, as well as how those cultures are related to team-level and student-level outcomes.

In this paper, the authors discuss their development of a culture survey of student project teams at a large research institution. The goal of the survey is to examine the team culture of the approximately 25 student project teams at our institution and identify opportunities to increase equity and inclusion on teams.

Student members of project teams (N=7) provided feedback on the pilot via a focus group, resulting in modifications to pilot items as well as the suggestion of additional items. The paper will describe the focus group feedback as well as present our resulting survey.

Introduction

Extra-curricular student project teams are an important part of the undergraduate engineering student experience. Students participate in project teams to do hands-on work, to learn important skills, and to find community and belonging with their peers. However, as in any team project, if the team dynamics are not positive, a student's experience may be more detrimental than beneficial [1], [2]. Student project team situations may be at even higher risk for poor team dynamics since they are often student-run and student-led; thus, they may lack the scaffolding of a team project that generally exists in the classroom. Team experiences may be inequitable, not inclusive, not providing learning to all students, and dissatisfactory to some students.

There are a wide variety of tools focused on engineering student team dynamics generally, typically intended for in-class project team use [3]–[6]; there are also studies devoted to the

relationship between extracurricular engineering activities and learning or success [7]–[10]. However, there is a gap in assessment tools intended specifically for extra-curricular project team culture. The goal of the survey presented in this work is to be a general tool to be used to study student project teams in order to ascertain how the team dynamics are impacting the general culture or climate for the team members. The use of the survey will enable a deeper dive into examining the underlying implicit and explicit biases that student teams experience, explore how team dynamics and leadership can impact the team climate, and examine how individual motivations and team satisfaction may be related to the team culture. Further, the survey will increase understanding in how teams are interconnected through the shared makerspace and how the culture of the shared workspaces may impact student teams.

This paper presents a survey that was developed to assess student project team culture, intended to be distributed to individual project team participants starting in the Fall of 2020. This paper also outlines the process undertaken to develop and pilot the survey. First, the authors considered elements of team culture identified in higher education and business literature that relate to the student project team experience. After items were written individually pertaining to each topic, authors edited the items collaboratively for clarity and relevance. The survey was then piloted in a focus group of seven students who participate in five different project teams, and items were rewritten or added to be able to better assess the student project team experience. The final version of the survey, included in its entirety here, contains four sections of survey items that aim to assess different aspects of project team culture:

1. **Diversity, equity and inclusion**: Does the student project team represent and support students of different identities? Are all students engaged, provided equal opportunities, and included?
2. **Motivation**: Is the team more learning oriented, performance oriented, or performance-avoidance oriented? Does the individual survey respondent's goal orientation match that of the team? How does the team value external motivation or validation?
3. **Team satisfaction**: Is the survey respondent satisfied with the team? Do they describe the team positively?
4. **General**: What is the student's role and participation on the project team? What is the demographic information of the student?

Literature Review

Before developing the survey, several aspects of team dynamics, garnered from education and business literature, were discussed as being relevant to student project team culture. Brief descriptions of each of the included constructs follow.

Bullying

Various forms of bullying are common throughout not only primary and secondary education [11], but also in post-secondary education [12] and the workplace thereafter [13]. Bullying has been shown to have a negative impact on student climate and increases levels of student involvement in risky behaviors [14]. The survey queries whether team members perform acts that can be interpreted as bullying. These potential acts of bullying would impact not only the students involved, but the bystanders and entire team environment.

Hierarchy of Team Decision Making

Within teams both large and small, there can exist a formal or informal hierarchy. Formal hierarchies are well defined with official positions and an explicit organizational structure, while informal hierarchies may exist based on social relationships based on dominance and authority [15]. Even when a formal hierarchy has not been defined, a social hierarchy is still likely to exist.

The need for a formal hierarchy is case dependent; in large organizations, a formal hierarchy is beneficial [16] but in other situations, the social barrier of formal hierarchies can be detrimental. Conflicting norms for decision making may exist, and communication barriers may exacerbate the situation [17]. These norms may impact diverse student teams in ways that are not realized on other teams.

Voice Safety

Voice safety is the perception that one can approach others within the group to express unpopular ideas without fear of repercussions [18]. When groups lack voice safety, the benefits of incorporating diverse perspectives cannot be realized [19].

Voice safety is an important aspect of good group decision making, and it is related to the hierarchical decision making described above. An individual might perceive a lack of voice safety for a variety of reasons, including actual enforcement of power differences within a group but also including differences in expectations regarding conversational rituals [20]–[22]. Items in the survey were based on validated items from [18], though language was changed to reflect the project team context.

Sense of Belonging and Community

A sense of belonging is when a student feels as if they fit in and belong to a community [23]; similarly, a sense of community means that students feel that they matter to a group and have a shared connection to others in the group [24]. If a student feels that they belong and have

community with a group, they will be more likely to engage with others, actively participate, and persist in the group experience [25]. Students who do not feel that they belong, or do not find community, are likely to gain less benefit from the experience; this feeling can be even more prevalent among underrepresented groups who already question their place within the community (in engineering project teams, this is likely to be women or underrepresented minorities) [26], [27].

Co-Awareness

As part of another study from two of this work's authors [28], surveys were conducted with students on curricular engineering teams. In those interviews, multiple women discussed their realization that particular experiences were gendered when they saw a female teammate experiencing that same treatment, a recognition we have termed "co-awareness." Survey items were added to our initial set to determine whether students felt they had close relationships with teammates and the ability to confide in one or more teammates.

Goal Orientation

Rooted in goal-orientation literature, survey items were developed to assess individuals' trait orientation (their own proclivities for engaging in activities) as well as their task-specific motivation (why they engage in the project team specifically, also called "state orientation"). We also try to capture participants' perceptions of the team's overall goal orientation.

For each of these pieces, individuals and teams can be learning oriented, performance oriented, and performance-avoidance oriented; these aspects are not necessarily related, and one could be high in all, high in one and low in others, or low in all [29]–[32]. Based on [33], we split performance-avoidance into both individual-oriented (e.g., I don't want to look ignorant) versus team-oriented (I don't want to do something that could hurt my team). Items were modified from [33] and [34].

Extrinsic Motivation

Relatedly, this survey also considers extrinsic and intrinsic motivation. Extrinsic motivation is when an individual (or, in this case, a team) is driven by an external reward system, such as praise, awards, or prestige [35]. Although extrinsic motivation can be an effective motivator, intrinsic motivation is generally considered more beneficial. In fact, the use of or reliance on extrinsic motivation can actually decrease an individual's intrinsic motivation [36]. Several other items already in the survey assess intrinsic motivation (particularly those related to goal orientation, discussed above), so survey items were developed to assess if a team relies on

extrinsic motivation, and thus encourages a culture of aiming for success or prestige over personal satisfaction.

Team Satisfaction

Many curricular engineering teams use self- and peer-assessment tools, such as CATME [6], for faculty to assess individual contributions. While that particular tool doesn't explicitly ask about team culture, it does query team satisfaction. Additionally, a previous study of curricular teams [37] found that team satisfaction can depend on the gender makeup of the team, and is different for women and international students. We included items about team satisfaction to relate this study to that previous work.

Methods

A first draft of the survey was developed, and then that draft was piloted with a focus group.

Survey Development

The first phase of survey development involved identifying areas in team literature that were relevant to student engineering project team experiences. After discussing different constructs, theories, and research studies, four areas were identified: diversity, equity, and inclusion; motivation; team satisfaction; and general (including demographics and student self-reported participation on the team). A subset of questions were modified from previously-validated surveys, as indicated in the previous section; in one case, questions were selected from a previous study conducted by one of the authors [33].

In the first phase of survey development, the authors worked independently and developed 121 items from a mixture of prior work and personal experiences. From this initial set, the authors then worked together to ensure that the survey was properly designed using best practices for survey development: that the survey item would properly gauge the information we needed; that the wording was clear, concise, and precise; and that the item was important and relevant [38]. When multiple questions were intended to address the same construct, the authors discussed characteristics of the wording as well as consulted statistical information, such as factor loading in a previous study, in order to select the best item to include. During this process, the initial set of items was pared down to 47, with the goal of having the survey take minimal time while still collecting enough information to adequately assess project team culture.

Most of the items were written to be Likert-scale items, in which students will rate their agreement with the statement on a scale from 1 (strongly disagree) to 5 (strongly agree) with a

neutral option. Only four open-ended survey items were developed to allow students to express additional feedback and share specific examples of team interactions.

At this point, the survey draft was submitted to and approved by the University's Institutional Review Board (IRB) for human subject research approval. The IRB also granted approval to pilot the survey in a focus group setting.

Focus Group Pilot

Following the creation of the survey and approval of the IRB application, the authors recruited students for a focus group. The purpose of the focus group was to discuss each of the survey items, to determine if they were clear and relevant, and to identify if there were any elements of the project team culture that were not assessed with the existing items.

The targeted demographic of the focus group was women and underrepresented minority students, in order to discuss the survey with students who may be most likely to be a target of a negative culture. The authors wanted to create an environment where these students would feel comfortable speaking openly. These students were individually recruited by the authors who knew that they were on various student project teams.

The focus group was held in the same building as the project team makerspace after business hours when students may normally be working in the team center to maximize student convenience. Food was offered as an incentive.

Seven students participated from five student team projects. The students represented a wide cross-section of potential student survey respondents, with a mixture of electrical and mechanical sub-teams as well as teams that work heavily in the student project center and teams that may only spend a few weeks per year in the project center. There was representation of teams that participate in traditional student team competitions as well as student teams with no formal project, but rather build projects for various community groups globally.

The focus group was run by two of the paper authors, one man and one woman. During the focus group, survey questions were shown one-at-a-time on a screen to the group, which was seated around a conference table. The participants were asked to share how they interpreted the question and to express their thought process. Audio was recorded on a phone and transcribed using the transcription service Otter.ai, and an additional backup recording was made with a digital audio recording device. The focus group lasted approximately one hour, ending after all survey items were discussed. At the end, the participants provided overall feedback on survey length, incentive, and topics they felt were missing from the study.

Results & Discussion

Results from Focus Group Pilot

After the focus group, the survey was refined by adding items to address the concerns raised, changing the language of items to improve clarity and focus, and adding an "N/A" option to the Likert scale to better accommodate responses from the variety of student teams.

Addition of Items Related to Overall Project Team Culture

The most common suggestion from students for new items was to include survey items pertaining to the culture of the larger makerspace that project teams use. During initial survey development, the authors focused on the culture of individual teams, but in the focus group, it was revealed that while there are definite disparities between the cultures of individual teams, a larger portion of student dissatisfaction with their student team experiences may come from the culture of the large makerspace used by many of the project teams.

Within this institution, many engineering student teams share space in a large high bay building. The teams are assigned individual work areas for their specific team, which vary in size. The site also has common areas where all teams must work together and share resources, including in machinery spaces (mills, lathes, saws, welding tools, paint booths, etc.), chemical wet labs, and meeting spaces. In these makerspaces, student staff, who are often members of individual student teams, monitor and regulate the spaces.

Student comments revealed that there is a perceived hierarchy among the teams that use the makerspace that can drive the culture in the shared environment. One student in the focus group suggested that the environment has an impact on the willingness of students to participate in project teams:

> *One other thing that [student name] said a couple questions ago about team dynamics, it could be an aspect of the environment as a whole that could be making it difficult for someone to not participate ... not just the specific team that they are on, since the [makerspace] is a small space where people see each other from other teams.*

Another student added:

> *There are some unwritten rules in the [makerspace] about like machine usage, and how to fairly distribute them between the teams, and most teams follow them but some teams, sort of, rewrite the rules as they go along depending on how important they perceive their own work is but it's no more or less important than any of these teams*.

One student noted that this perception of power amongst some teams also transfers to individual members: “teams think they're powerful and it transfers down to each individual member thinking they're powerful because they're on that team.”

This dynamic was not originally considered, but the authors realized the importance of investigating how the environment within the makerspace is shaping the culture of the teams. The focus group participants implied that there is behavior not only within teams, but between teams that could be perceived as bullying, and that student staff may cause problems as well. As a result of this discussion, several items were added to the survey focusing on student perceptions of diversity, inclusion, and safety within the makerspace, rather than focusing solely within their team (Table 1).

Table 1. Survey items added related to the environment in the makerspace.

Section	**Sub- Section**	**New Item**
Diversity, Equity & Inclusion	Diversity	The makerspace is diverse in terms of race/ethnicity.
		The makerspace is diverse in terms of gender.
	Bullying	Some people in the makerspace interact with others in ways that could be interpreted as bullying.
	Sense of community & belonging	I feel like I am part of the makerspace community.
		I feel like my team is part of the makerspace community.
		I feel that my team deserves to have space in the makerspace.
		Other teams in the makerspace believe that my team does not deserve to have space in the makerspace.
		I feel that there are some teams in the makerspace that do not deserve to have space in the makerspace.
	Safety	I believe that the makerspace *student staff* work to improve the culture of the makerspace.
		I believe that the makerspace *student staff* respect my time and effort.
		I am comfortable going to the makerspace alone.
		I feel comfortable working in the machining spaces of the makerspace.
		I feel comfortable working in my team's space in the makerspace.
		I am comfortable going to the makerspace with other members of my team.

Extrinsic Motivation		Other teams in the makerspace believe our team is successful.
		University officials, professors, and the public at large believe our team is successful.
		I believe that my team is important and powerful within the makerspace space.
		I believe that I am important and powerful within the makerspace space.

Students also discussed that there are varying levels of comfort in the shared spaces. While students may be comfortable in their team spaces, they may be uncomfortable in common areas of the shop due to pressure from other teams. Some students also reported that there are students who just are not comfortable entering the project center without other teammates present. Resulting from this discussion, several items were added pertaining to students' perceived sense of safety when working in the makerspace (Table 2).

Table 2. Survey items added related to students' sense of safety in the makerspace.

Section	**Sub-Section**	**New Item**
Diversity, Equity & Inclusion	Safety	I believe that the makerspace *student staff* work to improve the culture of the makerspace.
		I believe that the makerspace *student staff* respect my time and effort.
		I am comfortable going to the makerspace alone.
		I feel comfortable working in the machining spaces of the makerspace.
		I feel comfortable working in my team's space in the makerspace.
		I am comfortable going to the makerspace with other members of my team.

Rewording Items to Improve Clarity

Some of the items presented to the students were considered to be relevant, but the wording needed to be reworked to improve clarity and ensure that the survey was assessing what was intended. Table 3 summarizes the items that were unclear to students, and the revised item wording based on student feedback. One item of note was the original item "I feel like the members of my team are supportive of me," which was deemed too vague by students; thus, it was split into several items, assessing support both personally and technically, by both others on their team and others in the makerspace.

Table 3. Survey items that were revised to improve wording clarity.

Section	**Sub-Section**	**Original Item**	**Revised Item**
Diversity, Equity & Inclusion	Support	I feel like the members of my team are supportive of me.	I feel like the members of my team support me in technical tasks.
			I feel like others in the makerspace (not on my team) support me in technical tasks.
			I feel like the members of my team support me in my personal endeavors and problems.
			I feel like others in the makerspace (not on my team) support me in my personal endeavors and problems.
			I feel supported by my team if I fall behind academically.
Learning Orientation	Individual State	On this team, I work to learn a lot by selecting challenging work assignments	On this team, I seek out challenging tasks to learn new skills.
Performance-Avoid Orientation	Individual State	On this team, I'm motivated to avoid certain tasks so I don't look bad to others.	On this team, I avoid certain tasks to not appear incompetent to others on my team or on other teams.
	Team State	In my work on this team, I am motivated to avoid roles where my errors might negatively impact the team.	I avoid taking responsibility for tasks that may have a negative impact on my team if I do not perform well.
Performance-Prove Orientation	Individual Trait	I enjoy it when others are aware of how well I am doing.	I enjoy it when others (regardless of team membership) are aware and appreciate how well I am doing.
Team Satisfaction		Are there any aspects of your team dynamics that might make it difficult for someone to participate? If so, what?	What are the aspects of your team dynamics or the makerspace environment that might make it difficult for someone to participate?

Addition of "N/A" Option to Likert Scale Items

While we approached survey development aware that project team experiences differ across teams and project types, focus group feedback suggested that our language addressing project

type differences was more successful than our attempts to ensure questions were relevant for project teams who did less physical building. For example, some students reported that they would struggle to answer questions about their use of the makerspace; low utilization of such space might indicate particular roles on the team or particular project types rather than barriers. Students also reported that they would be less likely to respond to the survey if they came across questions that forced them to answer questions that they did not feel were applicable to their situation or their team. Based on this feedback, we have decided to offer a "not applicable" choice to most items on the survey.

Final Survey Items

This section presents the final survey, finalized after focus group feedback was taken into account to add and revise items.

The first section of the survey relates to the team culture related to diversity, equity and inclusion. This includes items that correspond to topics that relate to students of all identities feeling supported and engaged in their project team: diversity (in terms of demographics), bullying, hierarchy of team decision making, voice safety, inclusion, ritual opposition, sense of community and belonging, co-awareness, and safety.

Table 4. Survey items related to diversity, equity and inclusion.

Sub-Section	**Item**
Diversity	This team is diverse in terms of gender.
	This team is diverse in terms of race/ethnicity.
	The makerspace is diverse in terms of race/ethnicity.
	The makerspace is diverse in terms of gender.
Bullying	Some of my teammates interact with others in ways that could be interpreted as bullying.
	Some people in the makerspace interact with others in ways that could be interpreted as bullying.
Hierarchy of team decision making	A new member can approach leadership to disagree with team decisions
	A new team member's ideas are taken into consideration.
Hierarchy of team decision making; voice safety	Our team leadership is approachable.
Voice safety	I feel that my voice is heard in team discussion.
	Meetings are dominated by a few voices.
Inclusion	This team has a culture that is supportive of racial/ethnic minorities.
	This team has a culture that is supportive of women.
Ritual opposition	On our team, it is common to challenge ideas and debate as a way of reaching the best idea.

	On our team, it is common to fight amongst one another as a way of reaching the best idea.
Sense of community & belonging	I feel like I belong on this team.
	I feel like I am a part of this team's community.
	My closest confidants in the makerspace are on my project team.
	I feel like I am part of the makerspace community.
	I feel like my team is part of the makerspace community.
	My team works to create a social and friendly atmosphere (i.e. through social events, living together, etc.)
	I feel that my team deserves to have space in the makerspace.
	Other teams in the makerspace believe that my team does not deserve to have space in the makerspace.
	I feel that there are some teams in the makerspace that do not deserve to have space in the makerspace.
Support	Team members are supportive of each other in difficult times.
	I feel like the members of my team support me in technical tasks.
	I feel like others in the makerspace (not on my team) support me in technical tasks.
	I feel like the members of my team support me in my personal endeavors and problems.
	I feel like others in the makerspace (not on my team) support me in my personal endeavors and problems.
	I feel supported by my team if I fall behind academically.
Co-awareness	I have one or more people on the team I can confide in.
Safety	I believe that the makerspace *student staff* work to improve the culture of the makerspace.
	I believe that the makerspace *student staff* respect my time and effort.
	I am comfortable going to the makerspace alone.
	I feel comfortable working in the machining spaces of the makerspace.
	I feel comfortable working in my team's space in the makerspace.
	I am comfortable going to the makerspace with other members of my team.

The second section of the survey relates to items on motivation and goal orientation, to assess what the team values as they work together: learning vs. performance orientation, related to both the individual student and team (Table 5).

Table 5. Survey items related to goal orientation and motivation.

Sub-Section		**Item**
Learning Orientation		On this team, I seek out challenging tasks to learn new skills.
		This team is motivated to develop members' new skills and knowledge.
		On this team, I look for opportunities to develop new skills and knowledge.
Performance-Avoidance Orientation	Individual State	On this team, I avoid certain tasks to not appear incompetent to others on my team or on other teams.
	Team State	I avoid taking responsibility for tasks that may have a negative impact on my team if I do not perform well.
	Team Trait	This team is motivated to avoid looking bad in front of other teams.
Performance-Prove Orientation	Individual State	On this team, I am individually motivated to achieve external goals (e.g., win a competition, earn accolades).
	Individual Trait	What are the aspects of your team dynamics or the makerspace environment that might make it difficult for someone to participate?
	Team	I enjoy it when others (regardless of team membership) are aware and appreciate how well I am doing.
Extrinsic Motivation		This team brings prestige to the University.
		This team includes the best students at the University.
		Other teams in the makerspace believe our team is successful.
		University officials, professors, and the public at large believe our team is successful.
		I believe that my team is important and powerful within the makerspace space.
		I believe that I am important and powerful within the makerspace space.
Individual Motivation		Why do you participate in this project team?

The next section includes items pertaining to team satisfaction, including how their team glorifies busy-ness (Table 6).

Table 6. Survey items related to their team environment.

Sub-Section	**Item**
Glorification of busy-ness	I feel pressured to sacrifice healthy sleep, academic work, or personal time for the team.
Satisfaction with team	I believe our team is successful.
	I enjoy being a member of this project team.
	What is your favorite thing about your team dynamics (how your team works together)?
	What is your least favorite thing about your team dynamics?
	Are there any aspects of your team dynamics that might make it difficult for someone to participate? If so, what? (open-ended)

The final section consists of general questions related to the students team participation and their demographics (Table 7).

Table 8. General survey items.

Sub-Section	**Item**	
Team Participation	What project team are you on?	
	Do you have a leadership position on your team?	
	What is the least amount of time you have spent on the project in a given week?	
	What is the most amount of time you have spent on the project in a given week?	
Demographics	Please select your gender identity.	
	Please select your race/ethnicity (check all that apply).	
	Please select your sexual orientation.	
	Are you an in-state student?	
	Do you identify as an international student?	
	What is your mother's highest level of education?	
	What is your father's highest level of education?	
	What is the zip code of your parents'/caregivers' current residence?	
	What is your major?	
	What is your year in school?	

Conclusion

Extra-curricular student project teams have the potential to be enriching and impactful experiences for students, but, as in any student team project, students may experience them differently based on the team culture. If a student team is not diverse, equitable, or inclusive; if a student's individual goal orientation does not match that of the group; or if a student is for some other reason unsatisfied with the team dynamics, then that student's experience on the project

team may not be satisfying or beneficial. One goal of this survey is to better understand the characteristics of project teams and students' experiences on them, so that we can begin to address issues that may make students feel they do not belong, cannot contribute, or do not gain skills or experiences that other students do.

Future work will involve disseminating this survey at the authors' home institution, to gather data about the wide variety of project teams at the university. The findings from the first dissemination of the survey will likely influence future research directions. One planned direction is to use the findings of the survey to determine how to develop ways to better engage with and encourage the teams that do appear to have poor team culture. By connecting teams that are more welcoming with teams that are still developing ways to be more inclusive, we may be able to push project teams to adopt more inclusive recruitment and retention strategies.

Another planned direction is to make the survey available for use at other institutions, and to word it more broadly so that it can be adapted for other extra-curricular student project team contexts. It is possible that some project-types and team characteristics will be related to some aspects of team culture, and we will only be able to see these patterns cross-institutionally.

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