It takes one to know one: Co-awareness as mechanism of identifying gendered marginalization

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CONTEXT

One common practice for team formation is to not isolate students from underrepresented groups; in other words, female students should not be isolated on a team. However, it has been found that women on teams with only one female student had significantly higher team satisfaction than women on teams with two or more female students. This finding also extended to the male team members, who were also more satisfied with their teams when the teams included one isolated woman rather than two or more women. This finding suggests that the common team formation strategy of pairing women on teams may lead to a more dissatisfying experience for the female students that we are attempting to support.

PURPOSE OR GOAL

The research question driving this work was: "what is contributing to dissatisfaction of female students who are paired on teams?"

APPROACH OR METHODOLOGY/METHODS

We conducted a qualitative research study to answer this question, holding fifteen semi-structured interviews with female engineering students, in which they were prompted to reflect on their team experience during a project-based first-year engineering course. Interview transcripts were axially coded for themes related to satisfaction as well as to perceived effects of gender on experiences. Both domain experts and female student researchers contributed to coding.

ACTUAL OR ANTICIPATED OUTCOMES

In this research paper, we focus specifically on one phenomenon that arose from the data: *co-awareness*. Female students discussed how the presence of another woman on their team led them to attribute characteristics of their team experience to their gender, rather than assuming it was more individual or personal. That is, a solo woman on a team may find herself relegated to particular project tasks and may believe something unique about her preparation or skills makes that situation appropriate. In contrast, two or more women see similarities across their experiences and realize that gender is affecting their possibilities in the engineering team context.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

This work illuminates how co-awareness can contribute to female student dissatisfaction on teams, but also to female student development as they work through gender dynamics that occur on student teams. We conclude that the satisfaction evidenced on engineering teams containing an isolated woman is not a reason to advocate for isolating women on first year engineering teams. In fact, we believe that pairing women allowed them to better recognize common forms of gender-based marginalization on teams, and to push back against unfair treatment.

KEYWORDS

Gender, teamwork, women in engineering

Introduction

Team-based learning is a common pedagogical tool used in engineering education, both as a method for delivering content (e.g., students study physics in study groups; students design and build something in response to a PBL scenario) as well as a way to address teamwork as a learning goal in itself (Lamm et al., 2014). However, the benefits of team-based learning are not equally distributed; researchers have highlighted multiple ways that teamwork can lead to negative experiences for some students (Cooper et al., 2018; Eddy et al., 2015) often based on a student's identity. Thus, team formation, scaffolding, and support is important to ensure that students all have equitable experiences.

Consistent with a widely cited paper on supporting undergraduate engineering teams (Oakley et al., 2004), many engineering instructors have avoided "stranding" historically marginalized engineering students on teams (e.g., avoiding having only one woman on a team, or only one student of racial/ethnic minority). An analysis of students' team satisfaction (Fowler, 2016) found, however, that women who were isolated on teams (i.e., who were the only woman on a team) had higher team satisfaction than women who were grouped with other women. The same analysis found that this sense of team satisfaction extended to all the team members, though the women's responses were more extreme (that is, men on teams with a solo woman were happier than men on teams with two or more women, but these differences were smaller than the differences between solo and grouped women).

In an attempt to understand these puzzling results and also to evaluate popular team formation choices, we embarked on a qualitative study to ask students about team satisfaction and gender following a first-year engineering team project.

Methods

The study presented here is a qualitative study, focused on collecting and analyzing female engineering students' perspectives on their experiences in a team-based, first-year design project course.

Participants and Setting

All of the participants in this study were enrolled in a large, public, Midwestern university in the United States of America. The participants were all sophomore students at the time of the interview but were reflecting on their experiences as a first-year student in the prior academic year. The participants all took a mandatory introductory engineering course, centered around a team-based, open-ended design project. The course content is equally divided between technical communication content (both written and verbal) and technical content. There are several sections of this course offered, so the specific project or technical content of the course was not consistent for each student. Examples of technical content are an electrical engineering-based section with a project focused on building and coding for a solar-powered device that tracks the sun in the sky; a computer science-based section that tasks students with creating a computer game for children with disabilities; or a biomedical engineering section that involves students researching and proposing a novel medical device. Teams were typically assigned by the instructor, and not self-selected by students.

Participants of this study included fourteen female engineering students who self-selected into the study, after receiving a broad recruitment email to all female students within the sophomore cohort across the entire college. In this paper, we refer to all participants with randomly-assigned pseudonyms (S1, S2, S3, through S14). In Table 1, we summarize the participants, noting the technical focus of the project and gender makeup of their team within their first-year design course experience.

Table 1. Summary of study participants.

Student	Technical Content of Course	Gender Makeup of Team	
		Number of Women	*Number of Men*
S1	Researching orthopedic implants & medical devices	3	2
S2	Building a renewable wind energy system	2	2
S3	Making recommendations to businesses to improve efficiency & customer experience	3	2
S4	Designing a diagnostic test or biomedical device	3	2
S5	Building a solar tracking device	1	2
S6	Researching orthopedic implants & medical devices	3	2
S7	Designing atmospheric sensing instruments on a weather balloon	1	3
S8	Developing a computer game for children with Autism Spectrum Disorder	2	2
S9	Researching orthopedic implants & medical devices	3	1
S10	Researching orthopedic implants & medical devices	3	2
S11	Designing a diagnostic test or biomedical device	3	2
S12	Design a device using transistors	2	2
S13	Researching orthopedic implants & medical devices	2	2
S14	Design an object to solve a problem on campus	3	2

Data Collection

Data was collected via semi-structured interviews, so there was a set interview protocol, but interviewers also allowed the participants to drive the conversation in different directions as needed. The interview protocol involved three phases, with increasing pointed discussion about gender dynamics within teams:

1. *General discussion about team project*: Students were first asked to generally discuss their experience in their first-year design course. They were asked to describe their course project, team members, and the tasks that each team member did as part of the project. They were also asked if there were any elements of the experience that they wish they had done differently: if there were tasks that they did but did not want to, or tasks that they wish they took on but did not.
2. *Gender dynamics within their team*: Next, students were asked questions about how gender might have impacted their experience. They were asked if they thought their experience in the project or with their team may have been different if they were a man. They were also asked generally how they thought the gender makeup of their team might have influenced their time in the project. If they were on a team where they were not the only woman, they were asked to reflect on other group experiences

where they were the only woman and consider how that differed from their experience in this class.

3. *Hypothesizing why solo women are more satisfied in teams:* In the final phase of the interview, the interviewee was shown the results of the team satisfaction study (Fowler, 2016), which demonstrated that women who were alone on a team were more satisfied with their team compared to women on teams with at least one other woman. The interviewees were first asked to speculate why this might occur and encouraged to reflect on their own team experiences with this new lens. Finally, they were presented with some findings from a focus group where students postulated why women were more satisfied alone on the team, and interviewees were asked to agree or disagree with the scenarios and explain why.

Data Analysis

After the interviews, the audio was transcribed by an external company and names of interview participants were removed. The interviews were then analyzed using thematic analysis (Braun & Clarke, 2006, 2012) to identify general themes without a specific framework.

The interviews were coded by two high school student researchers and two engineering education researchers (the authors of this paper). After individual coding, the four would discuss their identified themes and put together an initial codebook. After several rounds of iterating on the codebook, through individual coding and then group discussion, the resultant codebook was assembled (Hirshfield & Fowler, 2019).

Results and Discussion

The final codebook (Hirshfield & Fowler, 2019) includes themes that broadly describe female students' experiences in first-year engineering design project team course, organized into three categories: Treatment, or external factors impacting women in team projects; Feelings, or internal emotions that women have while in team projects; and Behaviors, or the actions that women take in response to these Treatments or Feelings (Table 2).

Table 2. Themes describing a female engineering student's experience in a team project.

Category	Theme	Definition
Treatment	Male-coded institutional culture	Overarching engineering culture that traditionally caters towards males
	Male-coded course structure	Course pedagogy or structure that is catered towards stereotypically male topics or qualities
	Ignorance	Others are oblivious to difficulties that women face in engineering disciplines
	Exclusion	Others prevent women from participating or engaging fully, either knowingly or unknowingly
	Patronization	Others make women feel inferior
Feelings	Representing their gender	Feeling pressure to prove themselves or speak on behalf of all women
	Competitive with other women	Women feel that they need to establish superiority over the other woman/women on their team
	Friendly with other women	Feeling a kinship specifically with other women on the team
	Co-awareness	**Realizing gendered behavior that is occurring in a team after confiding in and discussing with female teammate(s)**
	Regret	Feeling disappointed for doing or (more often) not doing something in the project
	Self-doubt	Lacking confidence

Behavior	Making excuses		Defending the behavior of a team member (typically male), often due to a friendship with that person
	Asserting herself		Standing up for herself
	Taking on tasks	Stereotypical tasks	Taking on a role that is traditionally and stereotypically assigned to women (i.e. notetaker, secretary, scheduler, writer, etc.)
		Unfavorable tasks	A team member assigns a woman to do a specific task, despite her not wanting to take on that role
		To pick up slack	Taking on a task due to lack of effort or action from other team members
	Not taking on tasks	To improve team performance	Refraining from taking on certain project tasks for fear of negatively impacting the team
		Due to lack of experience	Not doing a project work because she perceives that she has less experience than the other group members

Examples of each of these themes, and further discussion on the development of this codebook, is discussed in prior work (Hirshfield & Fowler, 2020; Hirshfield & Fowler, 2019). In this paper, we focus specifically on one theme: a Feeling that we are calling "co-awareness," which we define as a female team member *realizing gendered behavior that is occurring in a team after confiding in and discussing with female teammate(s)*.

Initially, the main research question driving this work was, "why are women who are alone on teams more satisfied with their teams than women on teams of two or more women?" However, the codebook we developed ended up describing female students' experiences most generally, identifying any type of external factor (Treatments), emotion (Feelings), and Behavior that women experience during their team-based engineering project courses, regardless of the gender makeup of their team. Yet, one theme that does address our initial research question, specifically, is co-awareness, which is a concept that may explain why women may be less satisfied in their team when they have at least one other woman with them. It is important to note that several limitations (a small dataset, with only two women who were isolated on their team, in one institutional context) keep us from making the claim that co-awareness, specifically, is the sole reason for why women are happier alone on teams; rather, in this work, we are presenting it as one potential rationale, with supporting examples from the interviews conducted in this work.

Experiences of Isolated Women on Teams

Only two of the female students interviewed (students S5 and S7) were the sole woman on their team in the first-year engineering design course (further illuminating that avoiding isolation is a common team formation strategy, at least at our university). Both students described similar experiences with their teams: they reported high satisfaction with their team and the project experience, consistent with the statistical findings that motivated this study (Fowler, 2016) in which female students who are isolated on a team report statistically higher team satisfaction. Both interviewees discussed how they spent very little time on technical tasks because the male students were more experienced (coded as "not taking on tasks due to lack of experience"), although it was unclear if that was due to a lack of confidence compared to the male students due to a perception that they were less prepared or an actual inequity in experience. Both women also discussed that they were friendly and close with their male groupmates, while simultaneously describing problematic gendered team behaviors (the inequity in task distribution for both of them, and experiences with male teammates being patronizing for student S7) that these team members exhibited. They did not seem to blame their male team members for these behaviors or even view them as

problematic. For example, student S7 outright described how her male teammates were patronizing to her at the beginning of the project, but she didn't necessarily seem affected by that in a negative way:

> *I think at the beginning, maybe there was a little bit of patronizing tones every once in a while, but I don't think it was super conscious of them, I don't know, that I guess it normally would be. But I don't think that they were ever saying things with the mindset that I was somehow holding them back or like less good or the weak link of the team or anything like that. I don't think they ever did anything on purpose to upset me.*

Experiences of Paired Women on Teams

Contrastingly, female interviewees who were one of two or more women on their teams almost all reported several more negative aspects of their experience. (Of course, twelve out of fourteen interviewees were part of this group; so simply because of numbers, we were bound to see a wider range of experiences.) Several of the interviewees identified experiences with co-awareness during phase 1 of the interview, before even being prompted to discuss gender dynamics of their team during phases 2 or 3 of the interview. One student, S2, discussed how the male members of her team would consistently take control of the project and "wouldn't let us [the female team members] touch any of the equipment" but then would "expect us to write up the report for them." S2 described how she and her other female teammate experienced the concept we are calling co-awareness:

> *We were both noticing it separately and we could tell that we were both getting annoyed by it, so I don't know who brought it up first, but we brought it up aside from the group and we talked about it, and realized the extent to which it was happening. Then we confronted the guys with it.*

When first describing team dynamics during phase 1 of the interview, Student S6 identified experiencing co-awareness with one of her female teammates, noting that they were "closest on the team" and they would discuss "concerns about what was the team dynamic… throughout the whole experience" but she did not necessarily mention that the "concerns" might be related to gendered During phase 3 of the interview, when the interviewees were asked about what specifically might contribute to less team satisfaction when women are paired on a team, S6 attributed it to this type of close relationship with another woman on a team:

> *So, I feel like whereas maybe in a team with one woman, she's not necessarily gonna have that other person to go through it, she's going through it on her own. It's just gonna happen how it happens. Whereas, if there's two women, if someone's not performing there's more of a like gang up and then you don't feel so bad marking them down in a survey or something like that. And it's talked about more, I feel like it's more of a voiced opinion between the team.*

While student S8's team in her first-year engineering project class had two women and two men, she also reflected on other team experiences in which she was the only woman on the team. Comparatively, she said she preferred having another women on her team to experience co-awareness, saying "it's definitely nice to have somebody who you could just be like, 'oh, did you hear how he just mansplained me?'"

When student S10 described her experience, she mentioned specifically that she did not necessarily realize how gender impacted her team dynamics while she was on her team. However, she realized it later, while in a seminar class where other women discussed experiences similar to her own. S10's experience perfectly describes co-awareness, in that several women had experienced gender-based discriminatory behavior (being "assigned" tasks that are stereotypically feminine like taking notes, writing, or organizing) but they did not realize it might be gender-based while they were on the team. But later, when they reflected together as a group of women, they did:

Freshman year, we had to take a seminar class where a lot of the times we would come and just talk about different experiences that we had in our entering classes and stuff. And I would definitely say that a lot of the people would recount their experiences where they were given the secretarial role. And then maybe they didn't realize it, but then maybe on reflection they're like, "Oh yeah. It was." But then when they're a couple of them, they did realize kind of ... not necessarily off the bat, but you go away from them being like "Wait. What role did we just get?" I think you have more people to reflect with then if there were more people on the team.

One final example of co-awareness was presented by student S13, who noted that it can be easier to not only notice gender-based discrimination on teams when there is another female team member (co-awareness), but also to confront others to fight against it. She describes how it can be more approachable to advocate for others rather than ourselves:

I'm definitely, in general, more defensive of my views if I see them happening outside of myself. Whereas ... I don't know, this could be a very individual, personal thing. But if someone says something sexist about one of my female friends, I'm like, "No. Shut it down, stop." But I might not be ... I guess that's a bad example 'cause I'm pretty good at catching sexist things in general. But if it was something towards me more specifically, I might not catch it or be as defensive. That might just be like how I view myself and how I'm more critical of myself, so I'm expecting more negative feedback… it would be nice if there was someone to advocate for me and be like, "Hey", and verify and validate what I'm feeling. "That's not cool." So I would want to be that person for someone else.

Conclusion

In this work, we present the concept we are calling "co-awareness," or realizing gendered behavior that is occurring in a team after confiding in and discussing with female teammate(s). In the interviews we conducted, we see evidence of female students being more aware of gender-based patterns when they were not isolated on a team. That is, while a female student might not observe or name gender-based discrimination when she is the only woman on a team (as we saw with students S5 and S7), they may more readily notice and recognize gendered patterns more when there is another female student on the team, as described by the other interviewees. Some interviewees described pushing back or confronting teammates with the unfairness of gendered expectations. Others did not, but they certainly developed some critical consciousness regarding their work as female engineering students and as prospective female engineers. While this study is limited in its small number of participants and singular context, we argue that this concept of "co-awareness" may be a contributor to female students' team dissatisfaction when they are on teams with other female students.

However, this does not mean that we suggest women be isolated on teams. While the women who are isolated on teams may be more satisfied with their teams, we do not maintain that this means they had a better experience overall. Women still may be having inequitable experiences on teams when they are isolated – for example, as we saw with students S5 and S7, they may be having inequitable access to project tasks or being patronized by their male team members – and simply not realizing that they are being mistreated because they do not have a fellow female team member with whom to experience co-awareness. In fact, we maintain that co-awareness is an important mechanism to how female engineering students can explore and establish their identity in a male-dominated field, which is likely a more important outcome than having a high team satisfaction score. By pairing women on teams to encourage co-awareness and using other means to embolden all of our students to recognize and confront gender-based discrimination, we can develop culturally-proficient, critically-conscious engineers.

With regards to future work in this space, we would like to explore this concept further with a wider set of participants across a broader set of contexts, to determine if this is, in fact, a primary reason why women may experience less satisfaction with their teams when they are not isolated.

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