Introduction

Engineering education is currently undergoing transformative changes in an attempt to better align educational experience with real-world engineering practice. For example, Project Based Learning (PBL) is being widely implemented within the university setting, providing students with a more authentic experience (Beddoes, Jesiek, & Borrego, 2010). While the benefits of PBL are being widely touted, attention to gender within PBL has been scant, despite the fact that PBL is a site where significant gender biases can surface. Notable exceptions include Du and Kolmos (2009) and Mills et al., (2010). Still, no study has examined what and how engineering professors think about gender and PBL. It is unknown to what extent professors are practicing gender inclusive PBL. Do they take gender into consideration when forming teams? How do professors think about gender in PBL? To begin to address such questions, our research examines professors' practices and knowledge surrounding teamwork and gender. Understanding current practices and beliefs will facilitate the creation of faculty development materials that target the most pressing problems.

Literature Review

A lack of previous research was found that pertains to how instructors think about gender when assigning PBL activities. A preponderance of research does exist from the students' perspective and how they perceive and are affected by gender within a team setting (Opdecam, Everaert, Keer, & Buysschaert, 2014; Ro & Choi, 2011; Tonso, 2007; Vaz, Quinn, & Heinricher, 2013). While some work has been done specifically within engineering, a broader scope of disciplines will be analyzed to provide a more comprehensive picture. The literature discussed herein comes from the fields of accounting, business, engineering, information technology, management, medicine, and physics. The analysis at hand focuses primarily on the initial step that leads to teamwork; team formation. Within team formation, we will look at how teams are assigned, the effects of gender composition on team outcomes, and the roles that individuals play within a team. In our future work, we will discuss other parts of PBL, such as students' experiences and assessment across a breadth of disciplines, including business, accounting, and STEM fields.

One of the first considerations when implementing PBL into the classroom is how the instructor will assign teams. Instructors can allow for self-selection, random assignments, or take a more systematic approach. From the gender inclusive viewpoint, there is not one right answer, as each method has advantages (Mills, Ayre, & Gill, 2010). Research has shown that self-selection (e.g. working with friends) does not seem to increase the overall satisfaction of teamwork (Hamlyn-Harris, Hurst, Von Baggo, & Bayley, 2006). Instead, it might actually teach students who they do not want to work with in the future. The consensus among the research in this area though is to have instructors select teams (Curşeu & Pluut, 2013; Rosser, 1998). When instructors select teams, they are able to take into account the unique characteristics of each student, which assists in maximizing the team learning experience (Curşeu & Pluut, 2013). In particular, the characteristics that instructors should consider when assigning teams include race, abilities, experience, and gender (Rosser, 1998). This finding is echoed by the best practices constructed by the Center for Research on Learning and Teaching in Engineering at the University of Michigan who state that, "successful groups are heterogeneous in ability and background" (Bumbalough & Lu, 2014).

The question remains though about how the characteristic of gender should be factored into the equation in a way that produces the greatest outcomes for all students. The research thus far is divided on this topic; whether homogenous or heterogeneous teams are most advantageous. Some of the research supports the well-accepted stance that gender diversity benefits group work (Curşeu & Pluut, 2013; Hansen, Owan, & Pan, 2015; Joshi, 2014;

Kaufman, Felder, & Fuller, 2000; Lau, Beckman, & Agogino, 2012; Zeitun, Abdulqader, & Alshare, 2013), but that stance is rejected by others (Laeser, Moskal, Knecht, & Lasich, 2003; Okudan & Bilén, 2003; Okudan, Horner, Bogue, Devon, & Russell, 2002). Starting with a middle ground approach, a study by Hamlyn-Harris et al. (2006) asserted that the length of the project should dictate the level of gender diversity on a team. Specifically, it was found that long-term projects (5+ months) benefited from mixed gender teams but short-term tasks (5 weeks) were better suited for homogenous gender teams. The additional time spent together during the long-term projects is thought to allow students to become better acquainted and capitalize on females' communication skills. Further supporting the argument that there is not just one 'right' way to account for gender when assigning teams is research by Mills et al. (Mills et al., 2010) who, in response to how to divide up females among groups, state, "…this question must be worked out in the particular context that applies to those women in the course" (p. 144).

Transitioning to the homogenous side of the argument, we see in physics education that when assigning lab partners, females paired together had higher lab quiz sores and an increased level of self-efficacy as compared to co-ed partners (Shi, He, Wang, & Huan, 2015). Interestingly, males in the same study were unaffected by coed or single-sex lab partner assignments (Shi et al., 2015). Additionally, it has been shown that first year students who participated in homogenous teams perform at a higher level as compared to mixed-gender teams (as measured by a revised design report scoring rubric, originally developed by Leydens and Thompson (Laeser et al., 2003; Leydens & Thompson, 1997). This is thought to relate to the maturity of the students and further supports the necessity to consider the characteristics of individuals when assigning teams (Curşeu & Pluut, 2013; Rosser, 1998). Gender diversity has also been seen to have a negative effect on design team performance; in one study as the number of females on a team increased, design performance decreased (Okudan & Bilén, 2003). Specific to engineering, it has also been found that the overall grade of homogenous teams are slightly higher than mixed gendered teams (Okudan et al., 2002).

The research that supports heterogeneous teams indicate that mixed gender teams in engineering have, on average, higher group ratings (based on average of peer ratings) compared to same sex teams (Kaufman et al., 2000). This finding was also supported in non-engineering courses, such as business, in which mixed gender teams performed better than homogenous groups (as measured by final group grade) (Zeitun et al., 2013). Though both of these studies were centered on classroom learning, this finding has been shown to hold in research groups at a university as well (Joshi, 2014). Gender balanced faculty positively influenced these groups, and as the number of women increased within the research group, females' expertise was more frequently capitalized on, further increasing the group's overall productivity (as indicated by number of publications, weighted according to the prestige of the publishing source). This finding is further supported by additional research which indicates that gender diversity contributed to higher complexity of groups' collective knowledge, which has direct benefits for emergent cognitive structures (Curşeu & Pluut, 2013).

Though the research appears to be divided on whether gender diversity hinders or enhances PBL, it has mainly focused on the performance of the team as a whole and not the role that each individual took within the team. Understanding the roles individuals take in conjunction with team performance could provide additional insight on what aspects of gender diversity that can enhance individual outcomes. For instance, it has been found that in engineering, females typically take a supportive role in group work and less often a technical role (Meadows & Sekaquaptewa, 2013). They are the organizers and writers of the group instead of contributing technical knowledge to the project. Not only do females take the less technical roles typically, they are also less likely to recognize this gender bias (Meadows & Sekaquaptewa, 2013). Taking on this gender stereotypical role can negatively affect female's learning, causing a greater gap in knowledge between them and their male peers. The problems are exacerbated when females are assigned singularly to an all-male team. The female takes on the role of 'mom,' and is often 'picked on' by other members of the team

(Meadows & Sekaquaptewa, 2013). To combat this problem, it has been suggested that roles should be assigned and rotated by the instructor (Rosser, 1998). Not only does this strategy allow students to learn a role they are often not comfortable with, it also puts them at an advantage later on as they are better equipped to fully participate in a team and break free from their expected gender role (Rosser, 1998).

Methods

In 2014 and 2015, semi-structured interviews were conducted with thirty-nine engineering professors from three different institutions in different parts of the United States. As summarized in Table 1, the interviewees represented a mix of Assistant (n=13), Associate (n=11), and Full (n=15) professors, and the full range of engineering disciplines that exist at each of the three institutions were included in the study. Several also held administrative positions. There were eighteen women interviewees and twenty-one men.

Table 1. Overview of Participants and Response Rates

Group	N Participated	N Invited	Response Rate
Assistant professor	13	44	30
Associate professor	11	46	24
Full professor	15	66	23
Women	18	63	29
Men	21	93	23

Recruitment was done through a combination of maximum variation sampling and purposeful random sampling (Patton, 1990), and recruitment efforts are discussed in greater detail elsewhere (Beddoes, 2015). The goal was to recruit interviewees who were randomly selected in order to avoid a participant pool who all had involvement with women in engineering initiatives, such as would have been the case if recruitment was done through listservs for women in engineering organizations, for example. (That is not to say that the random sampling did not enroll some participants with involvement in women in engineering initiatives). Public, departmental websites were used to randomly generate names. Yet, within the parameters of random sampling, purposeful steps were taken to recruit a full range of engineering disciplines, career levels, and an approximately even number of men and women.

The interviews covered a wide range of topics that have been identified in prior scholarship as contributing to either the gendering of engineering and/or women's underrepresentation in engineering. The overarching aim of the interviews was to better understand what and how engineering faculty members think about gender in engineering. Because they were semi-structured interviews for which the majority of participants could not spare unlimited time, not every interview could cover every topic to the extent I would have liked. Two interviews did not cover the topic of team formation. Additionally, eight of the thirty-nine participants did not utilize teamwork, bringing the number of professors discussed in this analysis to twenty-nine.

Findings

Gender was largely not on participants' minds when they thought about team formation. In fact, one participant described how her department had recently been having a lot of formal discussions about facilitating teamwork, but that gender has never come up in these discussions. Participants' practices for forming teams spanned the full range of possibilities,

as summarized in Table 2. Eight participants mentioned that they had changed their practices at some point, or that they vary it from year to year, and those numbers are accounted for in Table 2, with several participants being counted in more than one category. By far the most common practice was to let students choose their own teams.

Table 2. Prevalence of team-formation practices

Practice	**# of Participants**
Students self-select teams	19
Teams assigned with consideration of gender	7
Teams assigned with no consideration of gender	6
Other	1

Those who allowed students to self-form had a variety of reasons for doing so. The two most common reasons were that they thought students should be able to work with people they felt most 'comfortable' with, and that the teams were working on projects with different topics and students should be able to pick the project that was most appealing to them topically. Likewise, participants who formed teams did so for a variety of reasons. Those who formed teams with no consideration of gender either had no specific rationale or engaged a discourse along the lines of "you don't get to pick your team in the real world so they need to get use to that now." Those who took students' gender into consideration when forming teams differed in both practice and reasoning. Some spread the women out across teams, others tried to ensure they had more than one woman on each team, and others said it depends. One participant utilized a combination of strategies: she first allows students to form their own groups of two, and then she combines them into teams of four. Of the thirteen participants who did assign teams, there was no pattern in terms of correlation between professors' gender, career level, or discipline and whether or not they took gender into consideration when assigning teams. However, they were all at two institutions, meaning that all participants at one institution let students self-select teams.

A common theme in the discussions was that participants did not know why they did what they did. The following quotation from a female full professor is representative of what many said:

> *I just do it randomly right now. I've experimented with other models like putting all the girls together or making sure there are two girls in a team. I do it randomly now and I'm not exactly sure why I do it that way [laughter]…I don't know. I don't know why I'm doing it that way [laughter]. It could just be laziness.*

Similarly, when asked why he changed his practices, a male associate professor chalked it up to laziness:

> Participant: *But actually, more recently in classes I've just allowed teams to form themselves and just allowed people to go with who they were closest to and not try to interfere too much.*
>
> Interviewer: *Was there a reason you changed?*
>
> Participant: *Laziness [laughter]. I think. Well, also, I mean…[women] tend to sit in groups that they're comfortable with. So I just let it happen naturally.*

Eight participants had changed the way they form teams over the years, but most of those could not identify a reason why they changed.

It was also common for participants to state that they knew the research says you should do one thing, but they ignore that and do another thing. A female full professor explained why she lets students self-select despite knowing it goes against recommended best practices:

> *I know that the research says it's better to have at least two girls in a group or something, and I think I just do it because I think well, work is like that, you're going to be by yourself…I don't know. I think it's just mostly because you're gonna have to deal with it, so you might be the only girl in a group and you have to just deal with it (laughter). I might do it differently now [after the interview]… (laughter)*

A male assistant professor echoed this:

> *[In graduate school], I took a class in course design. There was a piece of research that suggested if you assign teams, it is better to have underrepresented students with other underrepresented students or always in the majority on a team. Just statistically they found the underrepresented students have better outcomes if you do it that way. For my classes though, I've been trying to let people self-select so they are more comfortable.*

Others went against recommended best practices for other specific reasons. For example, a male full professor said that he had had a negative experience one time: he had put the small number of women in the class together on one team (as the literature would recommend), but they were offended by this and had complained, so he stopped doing that. As another example, a male associate professor worried about getting in trouble. He reasoned that it is illegal to treat women any differently than men at the university and so he could lose his job if anyone knew he was taking gender into account when assigning teams.

Gender and team roles were also almost wholly absent from teamwork discussions, with only two participants actively doing anything about team roles. A female full professor implements a rule that women cannot be the team note-takers, and a female assistant professor had a rule on team roles: all team members must take turns acting in each role to ensure that everyone has a chance to do everything. Otherwise, she said, the women get relegated to note taking and management roles and do not get experience with the hands-on technical work. Indeed, this was a common discourse that will be discussed further in future work: women often take on the 'leadership' roles in teams, and this was seen as a good thing. The issue, however, is that in engineering cultures, it is still the 'technical' work that tends to be more highly valued, despite increasing assertions that 'soft' skills should be valued.

Discussion and Conclusions

Professors' previous experiences often influenced their chosen method of team formation, with the predominate method being self-selection. Though research suggests that students gain an understanding of who not to work with in the future through self-selection (a valuable lesson to learn), it often does not align with the intended outcomes of teamwork. Several instructors even acknowledged that their methods go directly against recommended 'best practices.' Those decisions were sometimes attributed to 'laziness', but other times to student feedback.

Those professors who assigned teams were roughly evenly split when asked if they considered gender during the team assignment process. Though it is encouraging that at least a proportion of the instructors considered gender when assigning teams, previous research indicates this as a major component that should be taken into account when forming teams. As discussed in the literature review, not only has it been shown that gender composition of teams affects overall team performance, but also that students benefit on an individual level when gender is considered in combination with other student characteristics during team formation (e.g. maturity level of students or abilities). Our findings therefore suggest that there is a need for further integrating gender awareness into faculty development, especially around PBL.

Less than one-fifth of the professors considered gender in team formation and even fewer considered how gender affects the roles played by students within a team. Two instructors did, and the rules they enacted for division of team roles directly discouraged females from taking on stereotypical roles. As noted, research supports this strategy because taking the less technical roles is detrimental to women in engineering education, and roles should thus be assigned and rotated to give all team members experience. The low number of faculty who take into consideration team roles is alarming and presents an opportunity for future faculty development materials.

Being aware of the research appears to initially inform professors about 'best practices,' but their experiences and personal obstacles have prevented them from widely implementing those strategies in their classrooms. This lack of wide-spread use of 'best practices' in regards to teamwork is puzzling and suggests a possibility that recommended 'best practices' are too overarching and do not account for the intricacies found within an actual classroom and across varying levels of coursework. The conflicting evidence found in the literature review also raises questions about recommended 'best practices' and indicates that there is a need for further research on gender and PBL. Other research has found that transportation-engineering instructors focus most of their course planning and decision-making on lectures, as opposed to other course components (Peters et al., Forthcoming). Indeed, our interviews revealed that many professors had not put a great deal of time into reflecting upon their teamwork practices. It is promising however that three participants explicitly said that being asked about their practices in the interview made them realize that they needed to pay more attention to gender in teamwork or to change their practices.

Our current research has brought to light areas within the field of teamwork research that need further development. As part of our ongoing work, we are exploring the topic of gender and teamwork through a systematic literature review, as well as expanding the analysis at hand to account for other aspects of teamwork, namely student experiences and assessment. Informed by these research findings, and in collaboration with faculty development experts, we are creating faculty development materials to promote increased gender inclusivity in engineering education.

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