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Study Partners Matter: Impacts on Inclusion and Outcomes

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Abstract

Socio-cultural theory shows that significant learning takes place during social interactions and lack of opportunity to interact with others can have detrimental impact on learning outcomes. Moreover, not having others whom students deem to be "like me" can lead to feelings of not belonging in the field. Unfortunately, many students feel isolated and this isolation affects persistence and success in college-level Engineering courses.

Given these oftentimes detrimental conditions, this investigation represents an exploration to understand the ways in which women, a group notoriously underrepresented in Engineering, feel connected to others in their Engineering classes, how this is related to their feelings of belonging, and how feelings of belonging are related to their academic outcomes.

Specifically, we examined the ways in which students understand, find, and utilize study partners as supports for feelings of belonging and for learning engineering content. Survey results from students in three large undergraduate Engineering courses ($N = 157$) suggest that obstacles to finding study partners may adversely affect sense of belonging, participation, and learning outcomes.

This investigation provides insights into these equity challenges and the results suggest new strategies for equitable interventions to support all students—and particularly those from groups underrepresented in engineering.

Introduction

The experiences of women in STEM are exemplified in the following quotes from female students majoring in a department within the College of Engineering. These are a selection of comments that were collected as part of this study at a large public university in the Midwestern United States.

> "*My freshman year . . . I briefly took a class called [course name redacted]—an honors section—and by the time I dropped the class, I was one of four or five women in the lecture class. For contrast there was a* $50 - 50$ *split between men and women at the start. That was very demotivating for me because in high school I always academically excelled but to enter this environment, which was supposed to be a beginner-friendly class and had only four or five women, was difficult.*"
>
> "*After a month or two into the class, I could tell that the guys in my code review*

group—consisting of four other guys and one other girl—looked down on me a little bit. I did really badly in that class and I did not feel like I was supported in any way."

"*Having female friendships definitely helps because I'm constantly amazed by them, they're definitely my role models. I feel like they're like me, I'm like them. It definitely helps to have a couple female friends because being a woman in STEM definitely has its mental challenges so having other people to talk about it helps.*"

Women are underrepresented in Engineering compared to men. Although this is not new news, the fact that this has persisted for decades is disconcerting. In this paper, we explore some of the reasons that women are underrepresented in Engineering, especially focusing on reasons that we can work to change (i.e., malleable factors that could increase the representation of women in Engineering). In particular, we examine the ways in which finding and relying on study partners might play a protective role for women enrolled in Engineering in college.

The problem of underrepresentation of women in Engineering is not just a problem of women not choosing Engineering; it is also a problem of women leaving Engineering at higher rates than men (e.g., [1, 2, 3]). Some of the reasons that women are underrepresented in Engineering include a mismatch of values (especially being human-centered vs. machine-centered) or life goals (e.g., not being family friendly) and lacking female mentors and role models, as mentioned in the third quote above (see, e.g., [4, 5, 6, 7]). More generally, women do not enter Engineering at the same rate as men and also are likely to leave more readily because they feel like they don't belong. The first quote that we shared at the beginning of this paper from a woman majoring in Engineering at our institution conveys the sentiments of women who drop classes, at least in part, because they feel that they do not fit in, not even in a "beginner-friendly class."

Why would women feel this way? One explanation comes from the self-to-prototype matching theory (e.g., [8, 9, 10, 11]). This theory proposes that, when considering the typical person who might be in that field, individuals compare the features of the prototypical person in that field to the features that they believe that they also possess. If they perceive a mismatch between self and the prototypical person—as is expected for women in male-dominated fields—they may also result in feeling that they do not belong in that field. In this way, women do not choose to enter, and if they have entered may choose to leave, because they cannot see themselves represented in the field.

Socio-cultural theory provides an additional compelling explanation for why women would feel like they do not belong in Engineering. This theory makes clear that much learning takes place during social interactions (e.g., [12]). A lack of opportunity to interact with others can have detrimental impact on learning outcomes [13]. Unfortunately, many students feel isolated—especially among students from groups who are underrepresented in Engineering—and this isolation affects persistence and success in college Engineering courses. As the second quote that we shared at the beginning of this paper illustrates, women can feel unsupported when they are in the minority and these feelings of not being supported interferes with learning and, ultimately, with academic outcomes.

The antidote to this unfortunate situation could lie in understanding ways to decrease isolation and increase feelings of belonging. But how can the antidote be administered in a context where women are isolated and where they receive many signals that they do not belong? We focus our

lens to find answers to these pernicious and persistent questions by examining how women perceive the value in working with other women in their Engineering classes, in how they perceive the support they need to find and connect with other women, in how these perceptions are related to their sense of belonging in Engineering, and how their sense of belonging is related to their academic success.

Research Questions

To deal with these issues, we asked three interrelated research questions:

1. Do women feel that they have support in connecting to others in their courses?
2. How are their feelings of needing support related to their sense of belonging?
3. How is women's sense of belonging related to their success in their engineering courses?

To address these research questions, we first developed a survey and included items on if—and if so, how—students studied with other students in their Engineering courses along with items on feelings of belonging (which we used based on the items reported in [14]). Next, we analyzed student responses and related these responses to students' GPAs. Our investigation represents an attempt first to understand and ultimately to improve the landscape of inclusion, belonging and persistence in multiple college Engineering courses and thereby to improve opportunities for success in these courses.

Methods

Participants

The data includes responses to a survey from 157 students and their demographic information. The students were enrolled in three separate sophomore and junior-level classes—two in computer science (CS) and one in electrical and computer engineering (ECE)—at a large public university in the midwestern United States. The courses were a CS systems programming class, a signal processing ECE class and an algorithms class that was cross-listed in both CS and ECE. Our reasoning for choosing these classes was because these are known to be difficult courses in the CS and ECE departments, normally seeing high drop out rates among students in the major, particularly among women. The participants were recruited by sending class emails to the students. Because the survey was administered during the semester and the grades were not available, we chose to look at academic success using their overall GPA, writ large. Students included 43 women and 114 men. Out of the 157 students, 99 (63.05%, 29 women and 70 men) declared they study with a partner. The students who responded were unique students and were not part of more than one course included in this study. Both the survey and the research process were approved by the university's IRB.

Measures

In the survey, all participants were asked four questions related to their feelings of belonging (taken from [14]) (e.g., In this course, I feel like I belong, 5-point Likert: 1-Not at all/5- Very

much so) and 3 other yes/no questions related to their prior experience working with a partner and their experiences working with a partner in the course: "1) Has studying with a group partner worked for you in the past?"; 2) "Does your course currently require or recommend that you work with a study group/partner?"; and 3) "Would it be useful for you if this course helped students find a study group/partner for this course?" In addition, the students who indicated they were studying with a partner for the course—99 students (63.06% overall; the affirmative response proportion ranged from $57 - 69\%$ across the three courses)—were asked if they had signed up for the course with a study group or a study partner in mind and they were directed to 10 questions related to studying with a partner (e.g., Working with a study group or study partner helps me feel that I got my work accomplished, 5-point Likert: 1-Strongly agree/5-Strongly disagree). The questions used in the survey are available in the Appendix.

After conducting an exploratory factor analysis (EFA) and inspecting the loadings, a composite was created for feelings of belonging (loadings: $0.63 - 0.92$) and for representing the experiences of studying with a partner (loadings: $0.58 - 0.90$).

The respondents' demographics (nationality, gender, major and GPA) were obtained from the university with anonymized identifiers.

Data analysis

Given the exploratory nature of this paper, and our relatively small sample size, we conducted correlation analyses first to evaluate the strength of the relationship between our variables of interest and then to examine how these relationships could potentially differ for women and men. These analyses were followed by Wilcoxon-Mann-Whitney tests using the R `stats` [15] package. The Wilcoxon-Mann-Whitney test is the non-parametric test version of the Student two-sample independent t-test, which does not require the assumption of a normal distribution. Given the binary nature of some of these variables, we conducted several follow-up analyses using Chi-Square tests and the Jaccard Similarity Coefficient (aka Jaccard Index), available on R packages `stats` and `clusteval` [16].

Results

A Wilcoxon-Mann-Whitney test indicated no significant differences in feelings of belonging for women ($median = 3.25$) and men ($median = 3.50$) in these courses, $U = 2777, p = .19, ns$. Also, no significant differences were found for course grades (Overall GPA) between women ($mean = 3.69, median = 3.77$) and men ($mean = 3.65, median = 3.79$), $U = 2376.5, p = .77, ns$.

Wilcoxon-Mann-Whitney tests indicated no significant differences between women and men for our composite questions about studying with a partner when considering the entire sample (women: $median = 1.60$; men: $median = 1.55$; $U = 2362.5, p = .72, ns$) or the subset of students already working with someone (women: $median = 2.10$; men: $median = 2.40$; $U = 1074.5, p = .65, ns$).

However, women indicated a stronger need than men for the course to help students find a study partner, as indicated by the correlation analysis (see Tables 1 and 2, variable *Useful to provide*

Variable	*M*	*SD*	1	2	3	4	5	6	7
1. Overall GPA	3.66	0.36							
2. Sense of Belonging	3.37	0.81	.31** [.16, .44]						
3. Studying with Group or Peers	1.58	1.46	.09 [-.07, .24]	-.05 [-.20, .11]					
4. Studying with group/peers worked in the past	0.78	0.42	-.02 [-.17, .14]	-.03 [-.18, .13]	.30** [.15, .44]				
5. Course requires study group/peers (1=Yes)	0.56	0.50	-.13 [-.28, .03]	-.18* [-.33, -.03]	.15 [-.00, .30]	.14 [-.01, .29]			
6. Useful to provide better ways of finding a study group/peers (1=Yes)	0.58	0.50	-.13 [-.28, .03]	-.21** [-.35, -.05]	.03 [-.12, .19]	.04 [-.12, .19]	.10 [-.06, .25]		
7. Gender (1=Female)	0.27	0.45	.06 [-.10, .21]	-.09 [-.24, .07]	.03 [-.13, .18]	-.01 [-.17, .14]	.08 [-.07, .24]	.18* [.03, .33]	
8. Citizenship Type (1=International Student)	0.22	0.42	.12 [-.04, .27]	-.06 [-.22, .10]	.03 [-.12, .19]	-.08 [-.23, .08]	.01 [-.15, .17]	.06 [-.10, .21]	.05 [-.11, .20]

Table 1: Correlation analysis on the entire sample ($N = 157$). M and SD are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation. * indicates $p < .05$. ** indicates $p < .01$.

Variable	*M*	*SD*	1	2	3	4	5	6	7	8
1. Overall GPA	3.70	0.33								
2. Sense of Belonging	3.34	0.86	.34** [.15, .50]							
3. Studying with Group or Peers	2.52	1.02	-.06 [-.26, .14]	.00 [-.20, .20]						
4. Already have a study partner in mind	0.71	0.46	.21* [.01, .39]	.19 [-.00, .38]	-.05 [-.24, .15]					
5. Studying with group/peers worked in the past	0.91	0.29	.10 [-.10, .29]	.12 [-.08, .31]	-.13 [-.32, .07]	.34** [.15, .50]				
6. Course requires study group/peers (1=Yes)	0.63	0.49	-.09 [-.28, .11]	-.09 [-.29, .11]	.04 [-.16, .24]	.01 [-.19, .20]	.05 [-.15, .24]			
7. Useful to provide better ways of finding a study group/peers (1=Yes)	0.58	0.50	-.03 [-.23, .17]	-.09 [-.28, .11]	.08 [-.12, .27]	-.15 [-.34, .05]	-.13 [-.32, .07]	.06 [-.14, .25]		
8. Gender (1=Female)	0.29	0.46	.02 [-.17, .22]	-.14 [-.32, .06]	-.04 [-.24, .15]	.17 [-.03, .36]	.05 [-.15, .24]	.04 [-.16, .23]	.24* [.04, .42]	
9. Citizenship Type (1=International Student)	0.22	0.42	.19 [-.01, .37]	.05 [-.15, .25]	.08 [-.12, .27]	-.19 [-.37, .01]	-.25* [-.43, -.06]	-.04 [-.23, .16]	.02 [-.18, .21]	.08 [-.12, .28]

Table 2: Correlation analysis on the subset of students that studied with a partner or group ($N = 99$). M and SD are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation. * indicates $p < .05$. ** indicates $p < .01$.

better ways of finding a study group/peers (1=Yes)). These variables were found to be positively correlated for the entire group of students, $r(155) = .18, p < .05$, as well as for the subset of the students who reported studying with a group or partners, $r(97) = .24, p < .05$. Given the importance of these findings to address our research questions, our small sample, and the binary nature of the variables analyzed above (i.e., *Gender* and *Useful to provide better ways of finding a study group/peers*), we also conducted Chi-Square tests and Jaccard Similarity Coefficients to ensure that these gender differences were significant. In all cases women indicated a stronger need for the course to help them find a study group or partner. For all students: $\chi^2(1, 157) = 4.48, p = 0.03$ / Jaccard Index = 0.38; and for the students studying with someone: $\chi^2(1, 99) = 4.60, p = 0.03$ / Jaccard Index = 0.38.

In addition, the results of our correlation analysis for the entire sample indicated that this need for the course to provide better ways of finding a study group or peer was negatively correlated with the sense of belonging in the course, $r(155) = -.21, p < .01$. However, these variables were not correlated for the subset of students already studying with someone, $r(97) = -.09, p = 0.39, ns$. Of the 157 students, 90 (57.3%) students indicated a preference that the course provide better ways of finding a study partner or group. Out of these 90 students, 31 were women, representing 72.1% of the women sampled in these courses.

Our analysis also replicated findings in the literature that sense of belonging is positively correlated to course performance (i.e., Overall GPA; [17, 18]), for all students ($r(155) = .31, p < .01$), as well as for the students working with someone ($r(97) = .34, p < .01$).

Hence, whereas we found no significant direct differences that working with study partners or groups are predictive of doing well in the course, a sense of belonging was predictive of doing well in the course.

We found that the variable *studying with group or peers* was not correlated with course grades. However, our results suggest that past/previous positive experiences working with group and peers are correlated with the decision to study with group or peers again (all students: $r(155) = .30, p < .01$; students working with someone: $r(97) = .34, p < .01$). Moreover, for the students already working with someone, having a study partner in mind was shown to be correlated with doing well in the course, $r(97) = .21, p < .05$. These results could suggest that positive experiences working with groups and peers do have an effect (directly or indirectly via sense of belonging) on grades.

Discussion

We will first summarize and discuss the potential importance of the results we obtained from administering the survey. Next, we consider the limitations of this exploratory study, along with future directions to pursue in understanding how studying with a partner or group might mitigate the typical, negative result of women feeling like they don't belong in Engineering. Finally, we end with a few conclusions.

Summary of and interpretation of results

We found that the women who participated in our investigation wanted more support than they were receiving in finding others with whom to study. If women are not finding others with whom they can study, they could be missing out on the learning opportunities that come from studying with others [13].

The result that these women desire more support could be signaling that these women were feeling a lack of social support or connectivity to other students in their Engineering courses. If women are to find others "like them," then providing opportunities to see and to access other women in their courses could be valuable steps in overcoming the typical, negative result of women feeling like they don't belong in Engineering.

The finding that women wanted support in finding others with whom to study seems directly related to our second finding: Students' feelings of belonging were inversely related to their expressing a need to find ways to connect to others in the course. In other words, if they already felt a sense of belonging, they were less likely to express that they wanted to connect with others, but if they did not feel a sense of belonging, they were more likely to express that they wanted to connect with others. By providing support to students to find others, especially when they feel like they don't belong, we could potentially stave off the negative repercussions—like bad grades, dropping the course, or even leaving the field—experienced by those who feel like they don't belong.

The final result we wish to discuss is that students' sense of belonging was related to their GPA. Although this result is hardly surprising, given our other results, we suggest that one way to subvert the negative effects of feeling like you don't belong is to provide students with obvious ways to connect with other students. However, we note that it will likely be particularly important to provide this support clearly and unambiguously (perhaps even requiring them to study with other students) for students to find other students "like them" thereby enhancing the likelihood that they will feel a sense of belonging in their Engineering classes.

Limitations and future directions

Our first limitation relates to understanding one of our results: we did not find that studying in a group was seen as a good thing by everyone. We suspect that when students study in groups where they are in a minority (e.g., the only woman in a study group with 4 other, all male students, or the only international student in a group), that this could exacerbate rather than diminish the feeling of not belonging [19]. We recommend that future investigations pay attention to the composition of study groups, to provide greater context for understanding this result.

Our second limitation stems from some of the inherent limitations of survey methods. For example, we felt it was clear what we meant by each of the terms we used in the survey instrument, but the students who responded may have interpreted these terms in alternative ways. We recognize that "studying with a group or partner" may mean different things to different people. We acknowledge that we could have avoided some possibilities for multiple interpretations by providing clear definitions within the survey itself, but we chose not to do this to keep the survey shorter and optimize the likelihood that students would complete our survey.

We could have also decreased the chances of misinterpretation by including other methods (e.g., interviews) to triangulate our results. We suggest including multiple methods in future follow-up investigations.

Our third limitation also stems from a methodological concern. This exploratory investigation only used survey methods, which left us unable to make any causal inferences. Moving forward, we suggest conducting an experiment to test whether those students—especially women—who are put into groups with other students like them will lead to more positive outcomes (feelings of belonging and better grades) than students who are put into groups with other students who are not like them or not put into groups at all. We have initiated this experiment and look forward to reporting results in the near future.

Conclusions

In this study, we examined survey responses to how students in Engineering courses find study partners, how having study partners acts as a support for feelings of belonging, and how studying with another person impacts learning outcomes. Our findings highlight the need for those who are underrepresented in Engineering—especially women—to see and have access to others who are like them because finding and working with others has important positive relations to students' sense of belonging and learning outcomes. Engineering a welcoming space where women can find each other—to lean on and learn from each other—seems like a good place to start.

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Appendix

The survey used in this study is provided here.

Study Patterns Form

Your voice matters! Help us understand the way you study at Illinois!

We'd like to ask you some general questions about your feelings towards this course & your study methods.

Please take a few minutes to answer the following questions:

*** 1. Is this course in your**

- ◯ Major
- ◯ Minor
- ◯ Other - if so, please give us a description of why you are taking this course

Rank the following choices from 1 through 5, with 1 representing 'Not at all' & 5 representing 'Very much so'.

In this course, I feel like ...

***** 2. I belong

- ◯ Not at all
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ Very much so

***** 3. I always have to prove myself

- ◯ Not at all
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ Very much so

***** 4. As far as I can tell, this major sounds ideal for me

- ◯ Not at all
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ Very much so

***** 5. As far as I can tell, this major sounds like it's not for me

- ◯ Not at all
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ Very much so

Please select one of the options below:

*** 6. How frequently do you study with others for this course?**

- ◯ Almost never, I almost always study on my own
- ◯ Typically before a test, but not otherwise
- ◯ On a regular, weekly basis
- ◯ More than once a week

Please rate the following options on a scale of 1 through 5 where 1 represents 'Strongly agree' & 5 represents 'Strongly disagree'.

Please think about the group or person you work with most frequently in case you have more than one single group/person.

Working with a study group or study partner ...

* 7. Gives me a sense of purpose and accomplishment & is a highlight of my day

- ◯ Strongly agree
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ Strongly disagree

* 8. Helps me feel that I got my work accomplished

- ◯ Strongly agree
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ Strongly disagree

* 9. Helps me prepare for my exams and other assignments

- ◯ Strongly agree
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ Strongly disagree

* 10. Makes me feel more likely that I will get a good grade

- ◯ Strongly agree
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ Strongly disagree

* 11. Helps me stay organized and on top of deadlines

- ◯ Strongly agree
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ Strongly disagree

* 12. Provides me with social connections

- ◯ Strongly agree
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ Strongly disagree

***** 13. Motivates me to attend the synchronous class sessions more often than in courses without a study group/partner

- ◯ Strongly agree
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ Strongly disagree

***** 14. Didn't work well for me because I didn't get on with the others in my group (they were not a good match for me)

- ◯ Strongly agree
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ Strongly disagree

***** 15. Didn't work well for me because I rarely got the help I needed

- ◯ Strongly agree
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ Strongly disagree

*** 16. Did you sign up for this course with a study group/study partner in mind?**

- ◯ Yes, I had a study group/partner when I signed up for this course
- ◯ No, I met my study group/partner through resources offered by the course.
- ◯ No, I met my study group/partner through resources other than those offered by the course(e.g., Reddit; informal meeting places; etc.).

17. For the above question, if you chose the option 'No, I met my study group/partner through resources offered by the course', please select the sources that were helpful in finding your study group/partner

- [ ] Lab sections
- [ ] Lectures
- [ ] Office hours
- [ ] Discussion sections
- [ ] Piazza posts for study groups/study partners

18. For the above question, if you chose the option 'No, I met my study group/partner through resources other than those offered by the course', please list those sources that were helpful in finding your study group/partner (e.g., Reddit, informal sources)

*** 19. In general, when studying with others, do you ...**

- ◯ Mostly study in a group
- ◯ Mostly study with an individual

Study Patterns Form

What does studying with your group look like?

*** 20. When I study with a group of people,**

- ◯ They are a set group of people where studying together is a regular activity
- ◯ The members tends to vary (e.g., office hours, dorms)

In my study group, at least one person generally:

*** 21. Identifies with the same gender as me**

- ◯ Yes
- ◯ No

*** 22. Identifies with the same racial/ethnic group as me**

- ◯ Yes
- ◯ No

*** 23. In general, when you study in a group for this course, how large is the size of the group?**

- ◯ A relatively smaller group (e.g., two or three people other than you)
- ◯ A relatively larger group (e.g., more than four people other than you)

*** 24. Please describe how you met this study group :**

*** 25. When you joined the group, did you know anyone else?**

- ◯ Yes, I knew someone in the group whom I know well
- ◯ Yes, I knew someone in the group but not too well
- ◯ No, I did not know anyone in the group

Study Patterns Form

What does studying with your study partner look like?

*** 26. When I study with a single person :**

- ◯ This person generally varies because I study with different people but mostly with one person at a time
- ◯ This person is constant and I don't generally study with anyone else

Generally speaking, my study partner :

*** 27. Identifies with the same gender as me**

- ◯ Yes
- ◯ No

*** 28. Identifies with the same racial/ethnic group as me**

- ◯ Yes
- ◯ No

*** 29. Please describe how you met this study partner :**