Student Perceptions of Teamwork Support

Dr. Robin Fowler, University of Michigan

Robin Fowler is a lecturer in the Program in Technical Communication at the University of Michigan. She enjoys serving as a ”communication coach” to students throughout the curriculum, and she’s especially excited to work with first year and senior students, as well as engineering project teams, as they navigate the more open-ended communication decisions involved in describing the products of open-ended design scenarios.

Dr. Laura K. Alford, University of Michigan

Laura K. Alford is a Lecturer and Research Investigator at the University of Michigan. She researches ways to use data-informed analysis of students’ performance and perceptions of classroom environment to support DEI-based curricula improvements.

Mr. James A. Coller, University of Michigan

James Coller is an engineering PhD pre-candidate at the University of Michigan focusing on the use of Bayesian Networks for Early Stage Ship Design. James also completed his BSE and MSE in Naval Architecture and Marine Engineering in 2017 and 2018 respectively at Michigan. He spent three years during his undergraduate education as an Instructional Assistant for a first year design-build-test-communicate engineering course. His research interests include autonomous robotics for both land and marine environments and ship design for the U.S. Navy.

Dr. Stephanie Sheffield, University of Michigan

Dr. Sheffield is a Lecturer in Technical Communication in the College of Engineering at the University of Michigan.

Mr. Magel P. Su, California Institute of Technology

Magel P. Su is a PhD student in the Department of Applied Physics and Materials Science at the California Institute of Technology. He earned a B.S.E in materials science and engineering and a minor in chemistry from the University of Michigan. At Michigan, he was a member of the Ultrafast Laser - Material Interaction Laboratory and the Engineering Honors Program. He also served as an instructor for several courses including Introduction to Engineering, Introduction to Materials and Manufacturing, and Structural and Chemical Characterization of Materials.

Students' Perceptions of Team Supports

Abstract

In this evidence-based practice paper, we report on a variety of interventions we provide in an attempt to support first-year student teams in a project-based learning course. At the end of the semester, we surveyed students to ask their perception of the usefulness of each of the intervention strategies. While a majority of students rated each of the strategies as useful, the two strategies rated highest were peer mentoring and progress meetings with the instructors.

Introduction

Teams are common in engineering courses, for a variety of pedagogical and logistical reasons. Working in teams, especially without significant support from instructors or mentors, is stressful for some students and can lead to negative outcomes [1]. Many potential pitfalls have been identified in the literature and resonate with us from our combined >20 years of teaching a team-based first year engineering course, including inequitable task allocation [2-4] and inequitable group conversational dynamics [5,6].

To minimize students' negative experiences with teamwork, faculty should critically consider how they choose to support teams. Many factors necessarily impact that decision, including class size, team size, and student level. There are a plethora of strategies suggested in the literature for supporting teams, including having the teams make a team contract, using peer mentors to facilitate teams, surveying the students regarding team members to assess individual contributions and to identify social loafers, and checking in with the teams regularly. However, most discussion of supporting teams is in the "pedagogical strategies" literature [1, 7]. To our knowledge, there is little research on students' perspectives regarding these types of support or on outcomes from the implementation of these strategies; see [8-10] for some exceptions.

This study reports on a survey of a group of first-year engineering students at the conclusion of a teamwork-intensive course to address the question of students' preferences regarding faculty support of teams.

Context

This project is an *in situ* investigation of students' perspectives of faculty support in a team-based course. The course is a required first year course for engineering majors, and it includes technical and communication content (and is co-taught by faculty from Technical Communication and from Naval Architecture & Marine Engineering). In the course, students worked to design, build, test, and communicate about two vessels. The first project was only a few weeks long, and student teams developed unpowered bathyspheres. The second project ran the majority of the semester, and students developed remotely operated vehicles (ROVs) to complete a surveying task. Sixty students were enrolled in the class, and they were split into three groups of 20 students for labs and discussions. Teams were made up of five students, selected from within the lab sections. Teams were assigned by instructors based on logistical

considerations (such as dorm location) and on equity concerns (avoiding stranding women and minority students in particular).

The head faculty in this course have taught together for twelve semesters and have evolved the course to have a fairly heavy teamwork focus. Faculty, along with senior students who support the class (as lab instructors and as peer mentors), take a number of steps to try to coach students as they negotiate the team project:

- An ice breaker/communication activity
- An operating agreement
- Peer and self evaluations
- Feedback based on those evaluations
- A Gantt chart to plan project tasks and timelines
- Peer mentors
- Reflections on teamwork topics
- Mid-semester progress meetings

Ice Breaker and Communication Activity. Teams are revealed during lecture, at which point students are encouraged to take seats near their new teammates and quickly exchange names and contact information. After the teams have a few minutes to chat, we introduce a teaming activity: a logic grid puzzle with 30 written clues, divided as evenly as possible among the team members on slips of paper. Our puzzle was adapted from [11], and we have made our version available electronically [12]. Generally, our students seem familiar with this type of puzzle, but as they receive their clues, we inform them of two important caveats: teams are forbidden from writing anything down as they attempt to solve the puzzle, and they can only read the clues on their own slips of paper (in other words, all information about the clues must be communicated verbally). Students frequently express some frustration at not being able to use their existing strategies to solve the puzzle (we hear "This would be easy if I could just write things down!" quite a bit), but teams eventually settle into trying to solve the puzzle within the given restrictions, frequently trying one or more different approaches before finding one that works best for them. Given the moderate complexity of the puzzle and the added difficulties of divided clues and the inability to write things down, students are forced to talk through the puzzle and negotiate their approaches to solving it; in addition to giving teams a first experience at collaborating with each other on a low-stakes "project," this activity also gives us the chance to observe the teams at work, and to begin to see how successfully (or unsuccessfully) they communicate. We wrap up this activity with a conversation regarding fluid leadership and listening to all members.

Operating Agreement. An operating agreement is similar to a team contract, but it is a living document that can evolve as the team evolves its operating style. Operating agreements are also common internal documents in industry, making them a good fit for an internal document used by student teams. Students in first year courses, like this, may not have much experience with either team contracts or operating agreements; therefore, the operating agreement used for this class starts as a heavily scaffolded document that is housed in a Google Doc (also available in [12]). Student teams copy the to-be-completed Google Doc, and share it with each member of the team, the faculty, their lab instructor, and their peer mentor. During class time, teams collaboratively work to complete their operating agreements with supervision by the faculty -- an

easy thing to do since it is a Google Doc shared amongst all team members and team members can work on the document simultaneously. Teams then solicit feedback from their lab instructor and peer mentor, again easy to do because of the shared Google Doc. This feedback by fellow students (lab instructor and peer mentor) is particularly useful since they have direct experience being on a team in the course.

These Operating Agreements are referred to throughout the term when teams show indicators of struggling. Through our scaffolding, we guide the teams to address *a priori* what they would do in situations such as: teammate A has missed the last two meetings, teammate B won't reply to group messages, teammate C won't get their work done on time, teammate D keeps rewriting everyone else's work, etc. Since most team conflicts fall into one of the scenarios covered by the Operating Agreement, we can guide the team back to functionality using their own agreed-upon operating methods. We have found this to generally work better than trying to impose sanctions/solutions in the heat of the moment.

Peer and Self-Evaluations. Four times during the semester, students complete self-assessments and peer assessments to help the faculty understand individual contributions on the team. In the semester of data collection, the surveys were housed in Qualtrics. Our surveys are fairly thorough and ask questions about project-relevant behavior as well as team dynamics, including quality and quantity of contributions to the project, division of labor on team tasks, voice safety and equity in team discussions, and students' sense of belongingness on teams.

We believe these surveys serve multiple goals: Responses from students help us better understand what is happening on teams, so that we can intervene if we believe that intervention is appropriate. Students reflect on team behaviors as they complete the surveys, hopefully noticing ways in which their own behavior might deviate from what they would consider ideal and modifying their behaviors accordingly. Students who are not contributing well to the team are put "on notice" that instructors will be aware of social loafing and that it might impact their grade.

Feedback Based on those Evaluations. When these assessments are conducted in Qualtrics, the output is not user-friendly. We download the data files, and we look at each team individually. We have skeleton messages that students might receive based on how the student self-rates, how the student is rated by the peers, and how the team seems to be doing overall. Each student receives an individual email from an instructor, "tailored" in this minimal way. An example email is included here in Appendix 1.

Gantt Chart to Plan Project Tasks and Timeline. In order to encourage teams to think about and plan for the entire project before they begin, teams are required to develop a Gantt chart at the early stages of the second project. A scaffolded approach to development of the Gantt chart is presented in class, during which time teams brainstorm project tasks, determine task dependencies, assign point people to tasks, and estimate task duration. Teams are encouraged to use the Gantt chart to add time buffers to alleviate crunch-time stress and to avoid over- or under-scheduling of individual members at any given point in the project. Teams present their Gantt charts at an in-person progress meeting with faculty (described later), along with their

proposed design—in this meeting, faculty review and make suggestions about both the design and the team's plan for it, as represented by the Gantt chart.

Peer Mentors. We have used peer mentors for about ten semesters now, partly because of the many positive effects that peer mentors have. Peer mentors have been shown to increase retention [13, 14] as well as increase learning gains in the classroom [15]. Peer mentoring also has a positive effect on mentors themselves, who report developing skills in areas including effective pedagogy, communication, and leadership [16], and report feeling increased self-confidence, interest in teaching, and appreciation for intellectual diversity after the experience [10, 17].

In this course, peer mentors are used to guide and supplement student learning throughout the entirety of both design-build-test-communicate projects in the course. Peer mentors are selected from previous semesters of the course. All peer mentor positions are voluntary and unpaid. While peer mentors are given the freedom to decide how they should help their team, most peer mentors assist in technical course content, facilitate team communication and homework, and help with non-course related problems. Specific resources that peer mentors provide to students include but are not limited to: annotating examples of previous project designs and technical communication deliverables, attending team meetings outside of class time, rehearsing presentations with students, and giving advice on a range of topics from technical content to adjusting to life on campus. A previous study conducted on the impact of peer mentors in this course demonstrates that peer mentors are positively received by students; students report that peer mentors helped most with development of communication skills, facilitation of better teamwork amongst team members, and advice on non-course related problems [10]. Furthermore, peer mentors facilitate and enhance student learning by providing weekly feedback to faculty and staff. Since students are usually more willing to share concerns with their peer mentors, the peer mentors are an invaluable resource for determining student needs, and the feedback allows the instructional team to adjust each semester accordingly to best serve students.

Reflections on Teamwork Topics. In the course management system, students complete weekly readings and reflections on teamwork topics. Reflection is a critical component of learning from experience [18], and we believe that directed reflection helps students to abstract lessons from their teamwork experiences. Most of the weekly lessons include a link to an outside reading; topics included collaborative writing tools, giving and receiving feedback, the value of diversity on teams, and group communication pitfalls. Most weeks, students also write a few paragraphs in response to a prompt asking them to apply ideas from the reading to their teamwork experiences in the course. Reflections are checked for completeness, but they are primarily for students' personal benefit. Responses are rarely responded to by the instructional team.

Mid-Semester Progress Meeting. The mid-semester progress meeting is a critical face-to-face meeting of the faculty and the student team. The timing of this meeting is particularly important – it needs to happen *after* teams have had sufficient time in their teams for potential problems to appear but *before* it is too late to do anything to address those problems. In a hands-on project course like this one, the mid-semester progress meeting is placed after the teams have begun building and testing their subsystems and before they begin final assembly.

During the approximately thirty minute meeting, the team first gives a semi-formal update of how their project has progressed so far and what questions they have or feedback they would like to receive on their design. Faculty answer the team's questions and give honest feedback (requested or not) about the team's design. Faculty then ask questions concerning team functionality. The peer and self-evaluations as well as the reflections allow faculty to know which teams are struggling, and which are not, and what those struggles are. Faculty can guide the conversation to potential solutions for team struggles. For example, if the team is behind schedule, faculty can ask to see the team's project planning document and help the team revise deadlines to get them back on track. If a team is struggling with submitting deliverables on time, faculty can have the team bring up their operating agreement and re-visit what the team agreed to do for task allocation and completion. The goal is to engage the team and help them problem solve any team functionality issues.

Methods

As part of the surveys and reflections, students were asked at the end of the semester to rate their perception of the usefulness of each team intervention on a four-point, Likert-style scale, with "a waste of my time" on one end and "critical to my team's success" on the other. The scale forced a choice; students couldn't select a middle "neutral" option. Students were also asked to provide open-ended commentary regarding their ratings.

The survey was housed in the course management system and was assigned three points (for completion). Of the 60 students enrolled in the course, 53 completed the survey. We used data from the registrar to code gender. All of the students had indicated male (n=34) or female (n=19). All students assented to have their data included in this project, which is exempted by our institutional review board.

A statistical analysis, including a Kruskal-Wallis test by ranks, was performed on the data. This test allows us to compare whether men's and women's ratings come from the same population, even though the data is not normally distributed and our sample sizes are uneven [19].

Results

To determine how students felt about the effectiveness of these team intervention strategies, we examined student responses to understand their preferences. We looked at overall preferences as well as explored whether there were differences in preferences based on student gender.

First, to address what team intervention strategies students think are most effective, the average response for each method is examined. We assigned values of 1, 2, 4, or 5 to the student Likert-style responses; this choice is meant to reflect the intentional choice to omit the "neutral" (3) score from the scale. The descriptive statistics for each of these strategies are shown in Table 1.

Table 1: Descriptive statistics for each intervention strategy.

Intervention Strategy	Mean	Std. Deviation	95% C.I.	
			Lower Bound	Upper Bound
Peer Mentors	4.74	0.45	4.61	4.86
Progress Meetings	4.66	0.48	4.53	4.79
Survey Feedback	3.94	0.79	3.72	4.16
Reflections	3.55	1.08	3.25	3.85
Surveys	3.49	1.14	3.18	3.80
Icebreaker Puzzle	3.43	1.18	3.11	3.76
Gantt Charts	3.34	1.45	2.94	3.74
Operating Agreement	3.26	1.26	2.92	3.61

The data show that the use of peer mentors for student teams (mean = 4.74) is the most preferred. The team operating agreement (mean = 3.26) is rated the lowest. Figure 1 plots the mean rating for each strategy, also broken down by gender (collected via University registrar).

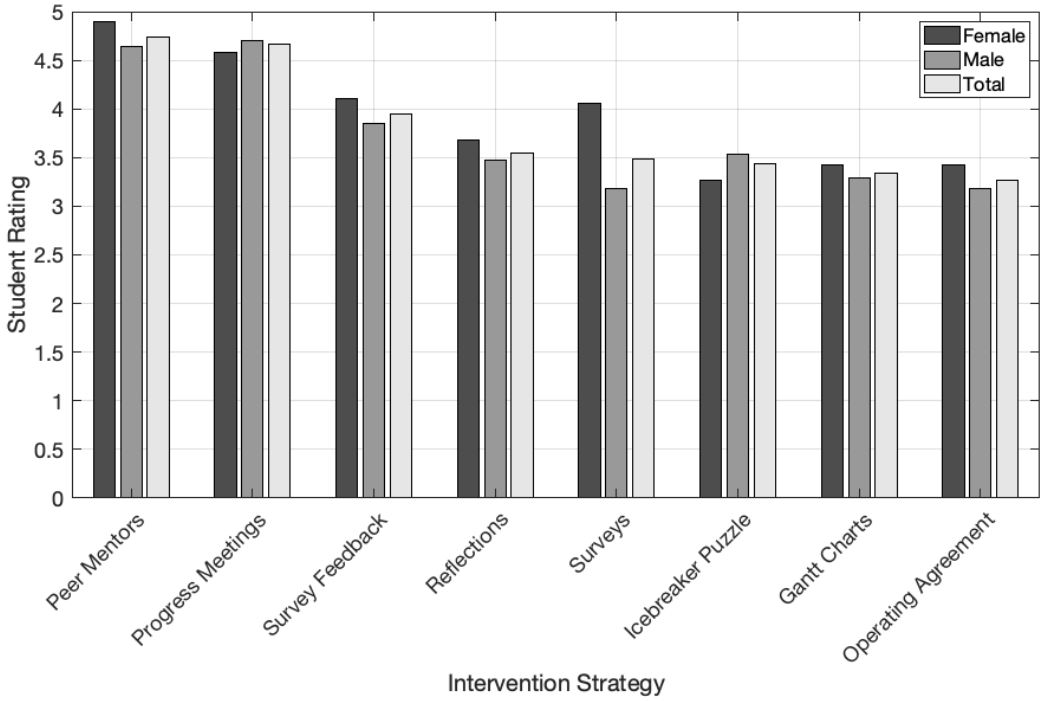

Figure 1: Mean student ratings for each strategy, broken down by gender and for the total population.

For Figure 1, each students' response bin was scored (1, 2, 4, 5), and the mean is plotted. However, because computing a mean score from Likert bins loses information, we also provide the responses to each strategy by the individual ratings assigned, in Figure 2.

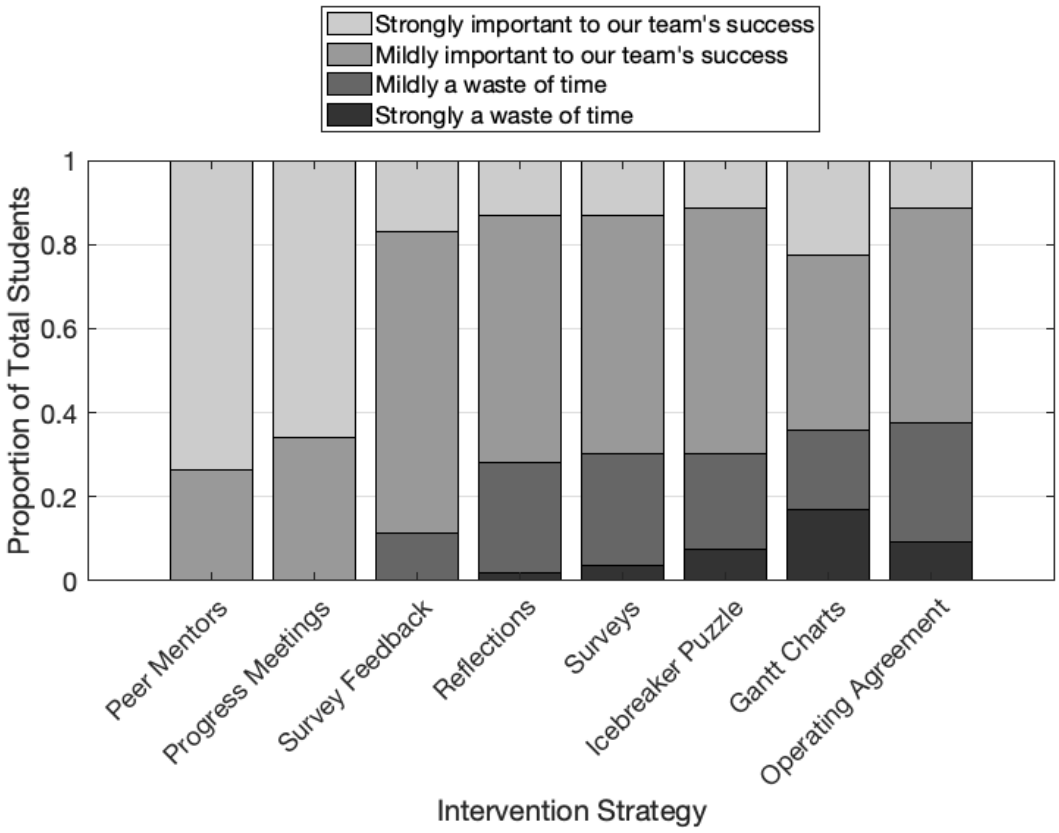

Figure 2: The ratings that each strategy was given, broken down by the proportion of students that gave each rating.

Peer Mentors. Students' qualitative feedback reflected their high ratings for peer mentors. One student reported that, "Peer mentors were a great resource since they were present in lab so whenever we had any questions, we could ask them directly. In addition, they gave us advice/tips based on their own experiences so we wouldn't make the same mistakes they did. Peer mentors also served as a good 'in-between' resource. If we had minor questions/clarification/confirmation issues, we could directly ask our peer mentors instead of asking our instructors who may not be able to respond as quickly due to their busy schedules."

Students reported peer mentors giving not only project advice, but also assisting with presentation preparation, lending advice on writing reports, and meeting with teams outside of course instruction hours. Additionally, some peer mentors also offered guidance beyond the classroom, providing advice on life and other courses. Students repeatedly stated that their peer mentors were the single most useful resource, which is backed up by the numerical data.

Progress Meetings. Students also felt generally positive about the progress meetings. Students reported that they offered additional time for clarification and keeping their design on track. One student reported that "Having progress meetings with the instructors was strongly helpful because these meetings helped lead us in the right direction with our projects. In these meetings, we would get instant feedback on what we were doing well and not so well and where we should continue to invest our time in certain parts of the project. Overall these meetings allowed us to know exactly what we should be doing moving forward and what we should prioritize."

Reflections and Surveys. The overall response on written responses such as reflections and surveys was more positive than negative. While some students appreciated the required time to reflect on what they had done and where the project was, others felt it was a waste of time.

Some students found activities that included written feedback and reflection to be useful. One student reported that, "The writing reflections I found to be useful because it was a time dedicated to really thinking about how our work had gone so far and what if anything would I want to change to make it better or easier to do something in the next week." Another student reported that "Writing reflections was very helpful for me personally, as the prompts allowed me to think about and identify how I could be a better teammate. I do not think I would have thought about my effectiveness as a teammate without these reflections."

Other students found the written feedback and reflection to be a waste of time. One student reported that, "The reflections were also slightly wasteful because I was already thinking what I wrote down. I generally just used the knowledge in my head to write down which was just not very constructive for my time I personally believe."

Regarding the personal and peer evaluation surveys, students sometimes were unsure how to rate themselves and their peers, resulting in inaccurate feedback. "I wasn't always sure how to rate the team on the questions asked, and often the numbers for everyone were the same. It was just very repetitive," reported one student.

Another student wrote, "[The surveys] were so long that I really was focused more on getting through them as opposed to giving accurate or useful information. I also started to give the same numbers for each category per teammate, leading me to think I had biases for and against individual members." An additional student agreed that the survey design needed improvement, but liked the idea behind them. "Completing surveys also were [sic] useful for my team because if someone's particular performance needs to be highlighted or addressed, I think this is the best way to let the instructors know."

The surveys did provide an outlet for students to report feedback to the instructional staff. One student commented that, "I think that completing surveys were [sic] strongly useful for my team because I liked that there was way we could tell our instructors if our team was having issues without having to make a meeting outside of class."

Other Activities. The activities such as the logic puzzle icebreaker and Gantt charts received very mixed reviews. Some students saw value in them, and others found them to be a waste of time. Specifically, with the Gantt charts, some students reported that they found the activity

forced them to examine how to delegate tasks and maintain a schedule. Others reported that once it was created, the group never referenced it or looked at it again. They also reported having difficulty predicting how much time to allocate to a given task. While the tasks required for the project involved many dependencies, and therefore a Gantt chart was an appropriate project planning tool, students' inability to predict time required on various tasks decreased their effectiveness.

The team operating agreement was reported the least effective strategy, but even this had many students who felt it was important to their team's functioning. Many students reported largely ignoring their operating agreement after it was created, and some felt creating it was a waste of time. However, other students reported that they believe they ignored it because in the act of creating it, the team had already addressed many potential issues by setting clear expectations in advance of the project. One student wrote that, "Though we did not experience much conflict throughout the course of the project, I think a lot of that can be credited to the operating agreement, as writing one together at the start of the project helps us establish the team's standards right off the bat. Had we not written the operating agreement, there may have been certain behaviors that members of the team engaged in that other members were not particularly happy with, and there would be no backbone reference to say that the behavior is not encouraged. Rather than having to deal with that and face conflict in regards to it, it was completely avoided because it was already clear from the start of the project the expectations that we were all setting for one another." Another indicated that "What I saw to be mildly useless at the time we were filling it out turned out to be very helpful and it set some guidelines on how certain work would be done."

What Works for Whom. While this survey focused on what strategies were most beneficial, the research team was also interested in whether the team-support strategies differentially affected students. Because this is evidence-based teaching, we did not pre-specify hypotheses or even set out to collect particular data. Instead, in her course-instructor hat, a researcher felt that she noticed a pattern in open-ended responses to the surveys: it seemed that women appreciated the surveys much more than men did. Based on this perceived difference, we tested whether there was a difference in response to any of the team-support strategies by gender. (Note that this is exactly the sort of choice that illustrates why some statisticians argue that p-values are not an appropriate metric: We saw what looked like a difference in the data and tested it statistically. See [18] for a discussion of "the garden of forking paths" and why this approach to hypothesis testing is problematic.)

A Kruskal-Wallis test revealed that there was a significant difference in the perceived usefulness of the peer and self-assessments by gender ($H(1) = 4.01111$, $p < 0.05$). Female students (mean = 4.05) found the evaluations to be more helpful than male students did (mean = 3.18). The breakdown of the respondent scores by gender for the survey activity is shown in Figure 3.

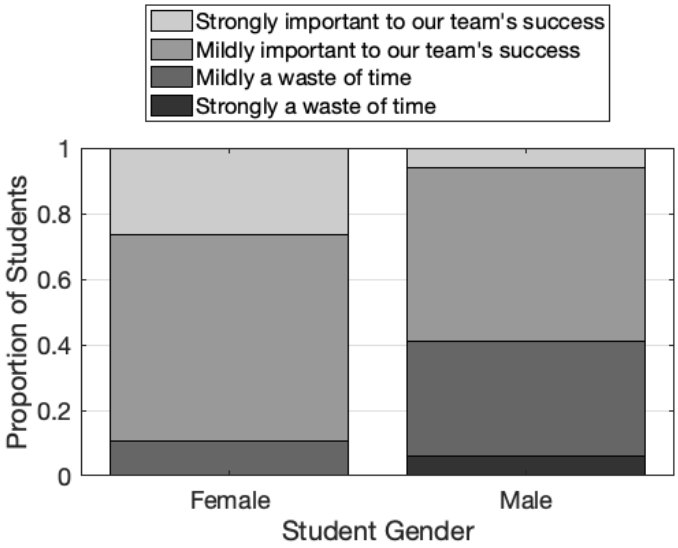

Figure 3: Women find the surveys on team functioning more useful than men do.

Figure 3 shows that almost all of the women thought that the surveys were mildly or strongly useful for the team functioning (>90%), whereas less than 60% of the men did. This difference is striking, and it is worth noting that some women called out the surveys as an important, indirect channel to instructors. “The [project] surveys are also very useful because there are issues in teams with some people not doing work, and the survey serves as a more indirect way of letting the teachers know that some people aren't contributing. If I weren't asked I wouldn't tell the instructor.”

Discussion

In this class, we spend a lot of time teaching students about teamwork and facilitating student project teams. We were pleased to see that every one of the support strategies we used was rated as “useful” by more students than it was rated “a waste of time.”

We notice a general pattern that students appreciated most the “hands on” team supports, such as peer mentors and progress meetings with instructors. While this isn’t a surprise, it does suggest that there isn’t an “easy” way to address teamwork issues. The supports that scale to large classes better, like surveys and reflections, were still rated as helpful – but not as helpful as the more time-intensive options.

We tested a gender difference in the result section, and we found that women appreciated the surveys more than men did. We actually suspect that it is students who are less comfortable/ feel they belong less on their team who appreciate indirect methods of communication (surveys, reflections). We believe women are over-represented in that group. Future studies should investigate that hypothesis, perhaps with a direct measure of belongingness, and/or considering other historically marginalized groups, such as underrepresented minority students, LGBTQ+ students, International students, or students with disabilities.

We note that this study includes only student perceptions of the effectiveness of team supports; we have no separate measure of how effective the support strategies actually are. We recommend that as a further route for study.

And finally, we want to add an appropriate note of caution to this section. Our results are specific to our context, to our students, and most importantly, to our implementation of these strategies. We hope others can use these ideas to think about what strategies might work best in their context, informed by a better sense of how students might perceive those efforts.

Conclusions

Fortunately, it seems that effort put into supporting student design teams is unlikely to be wasted, at least as far as the students themselves are concerned. Though hands-on, in-person support was deemed most useful, a majority of our students reported appreciating and benefitting from each of the wide variety of support approaches we implemented in our course. This might be comforting to instructors who struggle to find space in their courses for support strategies and activities that facilitate teaming; students may well appreciate *any* thoughtful support approach, so instructors can more easily justify implementing those approaches that more naturally and easily fit into their courses and pedagogical styles.

References

[1] Felder, R. M., & Brent, R. (2016). *Teaching and learning STEM: A practical guide*. John Wiley & Sons.

[2] Meadows, L. A., & Sekaquaptewa, D. (2013). The influence of gender stereotypes on role adoption in student teams. In *Proc. 120th ASEE Annual Conf. Exposition* (pp. 1-16). Washington, DC: American Society for Engineering Education.

[3] Fowler, R., & Su, M. P. (2018). Gendered risks of team-based learning: A model of inequitable task allocation in project-based learning. IEEE Transactions on Education, 61(4), 312-318. DOI: 10.1109/TE.2018.2816010.

[4] Linder, B., Somerville, M., Eris, Ö., & Tatar, N. (2010, October). Work in progress—Taking one for the team: Goal orientation and gender-correlated task division. In *Frontiers in Education Conference (FIE), 2010 IEEE* (pp. F4H-1). IEEE.

[5] Fowler, R. (2015). Talking teams: Increased equity in participation in online compared to face-to-face team discussions. *Computers in Education Journal*, *6*(1), 14-19.

[6] Hirshfield, L., & Koretsky, M. D. (2017). Gender and participation in an engineering problem-based learning environment. *International Journal of Problem-Based Learning, 12*(1), 2.

[7] Oakley, B., Felder, R. M., Brent, R., & Elhajj, I. (2004). Turning student groups into effective teams. *Journal of student centered learning*, *2*(1), 9-34.

[8] Stoddard, E., & Pfeifer, G. (2018). Working Towards More Equitable Team Dynamics: Mapping Student Assets to Minimize Stereotyping and Task Assignment Bias. In *ASEE Conference: 2018 CoNECD-The Collaborative Network for Engineering and Computing Diversity Conference*.

[9] Alford, L. K., Fowler, R., and Sheffield, S. (2014). Evolution of student attitudes toward teamwork in a project-based, team-based first-year introductory engineering course. *Paper Presented in 2014 at the ASEE Annual Conference*, Indianapolis, IN.

[10] Coller, J. A., Su, M. P., Alford, L. K., Sheffield, S., Fowler, R. (2017). Assessment of peer mentoring of teams in a first year design-build-test-communicate class. *Proceedings of the 2017 ASEE Annual Conference and Exposition*.

[11] Jones, J. E., & Pleitter, J. W. (1981). *The 1981 Annual Handbook for Group Facilitators*. San Diego: University Associates.

[12] https://tinyurl.com/ASEE19teams

[13] Brainard, S. G., & Carlin, L. (1998). A six-year longitudinal study of undergraduate women in engineering and science. *Journal of Engineering Education, BLAH,* 369-375.

[14] Good, J. M., Halpin, G., & Halpin, G. (2001). A promising prospect for minority retention: Students becoming peer mentors. *Journal of Negro Education, 69*(4), 375-383.

[15] Crisp, G., & Cruz, I. (2009). Mentoring college students: A critical review of the literature between 1990 and 2007. *Research in Higher Education, 50*(6), 525-545.

[16] Hug, S., Thiry, H., & Tedford, P. (2011). Learning to love computer science: Peer leaders gain teaching skill, communicative ability and content knowledge in the CS classroom. *Proceedings of the 42nd ACM Technical Symposium on Computer Science Education,* (201-206).

[17] Johnson, E. C., Robbins, B. A., & Loui, M. C. (2015). What do students experience as peer leaders of learning teams? *Advances in Engineering Education, 4*(4).

[18] Kolb, A. Y., & Kolb, D. A. (2012). Experiential learning theory. In *Encyclopedia of the Sciences of Learning* (pp. 1215-1219). Springer, Boston, MA.

[19] Field, A., Miles, J., & Field, Z. (2012). *Discovering Statistics Using R*. Los Angeles: Sage.

[20] Gelman, A., & Loken, E. (2013). The garden of forking paths: Why multiple comparisons can be a problem, even when there is no "fishing expedition" or "p-hacking" and the research hypothesis was posited ahead of time. *Department of Statistics, Columbia University*.

Appendix 1 - Example of tailored feedback based on surveys

Based on student surveys at multiple time points in the project, we “closed the loop” by sending out messages to each student. Because we start from a few ‘skeleton’ messages, this process is not as onerous as it sounds. Here is an example email sent at the end of the semester to a student who was not completing his portion of the work on a team:

Hi, $NAME:

One of the $COURSE goals is that you get experience working in a team environment, and our hope is that you grow as a team player during this time. Your co-workers' impressions of you (and your boss's impressions of you) as a team player will make a big difference in terms of your success as an engineer.

This third round of teammate feedback has been similar to the first two; according to your own scores as well as those from your teammates, you’ve been unable to contribute reliably to the team work products. Specifically, your teammates indicate that you have not submitted your portion of reports and have not done significant work on the $PROJECT. If you want to talk about this-- if you're surprised by the feedback, for example, and want an instructor's input/perspective-- any of the instructors would be happy to talk to you more about this. (Send any of us an email to set up an appointment).

Based on your teammates' ratings of you, our observations in the lab, and conversations with IAs, peer mentors, and your teammates, you've been assigned a scaling factor of $SCORE [Ex. 0.6]. This scaling factor means we think you were not as high as your teammates in terms of your contributions. We try to apply scaling factors conservatively, if that makes sense – affecting scores less than or equal to how much effect we think is appropriate. (If we'd used the straight score, for example, your scaling factor would have been a $RAW_SCORE [Ex. 0.4]. That's the worst we've ever seen). If you want to talk to me about how these scaling factors were determined, please make an appointment. I'll be around for most of May as well as in the Fall.

This score isn't meant to penalize you, exactly. You and I had talked after $PREVIOUS_PROJECT about how, to be successful in this class, you'd need to devote more time to your team projects. I'm sorry that it didn't seem to improve for the $PROJECT team. With the score, we're trying to reward the people on a team for the work they do, and to fairly assign grades to people who did less with the grade they would have earned without hard-workers carrying them through a project.

We hope you've had fun in this section of $COURSE. It's a blast to teach, and we enjoy getting to know so many talented students. Have a terrific summer!

$INSTRUCTOR, on behalf of all of the $COURSE instructors