ASEE 2022 ANNUAL CONFERENCE
Excellence Through Diversity
MINNEAPOLIS, MINNESOTA, JUNE 26TH-29TH, 2022 ASEE
Paper ID #36995

Students' Perception of Peer-to-Peer Evaluations in a Project-Based First-Year Engineering Course

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Abstract:

This paper highlights findings from a study that compiled data from a three-pronged survey investigating students' perceptions after using peer-to-peer (P2P) evaluations. The surveys were designed with a mixture of quantitative and qualitative questions to capture students' opinions and experiences after they completed an assessment. Our findings showcase that the P2P evaluations effectively improved team dynamics and performance in functioning teams but fell short when addressing the dysfunctional teams with social loafing issues. In addition, students preferred anonymity, which is a challenge to implement in small project-based groups or teams.

Introduction:

This study examines students' perceptions of peer-to-peer (P2P) evaluations and their effectiveness as assessment tools in teamwork. Engineering is an interdisciplinary field that develops solutions to real-world problems collaboratively. In recent years, there has been a collective effort to make teamwork and group projects a norm in STEM education [1]. From Kindergarten to College (K2C), experiential learning and collaborative work are highly recommended in education to help students develop relevant team dynamics skills, both interpersonal and social skills[2]. Several studies show that collaborative learning increases students' motivation and engagement. However, other works denote that teamwork can often introduce limitations or even negate the benefits due to team members' social loafing, mistrust, and conflicts [3]. The definition of social loafing has been revised over the years. However, the authors adopt Gilovich et al. definition that social loafing is a phenomenon or tendency for a team member to exert less effort when working on a group task in which individual contributions cannot be accurately measured or monitored [4]. For example, when carrying a heavy load like a sofa with others, you may give less effort assuming that others will get the job done without noticing your minimal effort.

The study was conducted in a foundational, 4-hour first-year engineering course at a Northeastern university, broadly populated with first-year students from all engineering disciplines: Electrical Engineering, Computer Engineering and Computer Science, Mechanical, Bioengineering, Chemical, Civil, Industrial, and undeclared too. The course is project-based and involves several hands-on activities that utilize various foundational engineering topics such as computer programming, engineering design process, computer-aided design and drafting (CAD), and basic electronics circuits (Arduino). It is a unique course with no typical student as there is a broad contrast between student levels of experience and prior knowledge on the course content.

Typically, students complete coursework in groups, and two projects are assigned at specific intervals within the fall semester. Projects are designed to be integrative, where students collaboratively build an original design solution to a particular problem. However, teams primarily work on project activities outside of class, making it difficult for the instructor to evaluate individual contributions. Additionally, students have less developed social skills to work face-to-face with others due to the COVID-19 pandemic impact and the constant use of

texting, Instagram, Snapchat, Facebook, etc. [5]. Due to these factors, it is challenging for the instructor to quantify each student's contribution to the project accurately and reliably.

Several studies recommend P2P evaluations as effective assessment tools that instructors can use to gain a better insight into the team dynamics and individual contributions [6]. P2P evaluations are mainly surveys that an instructor uses to obtain more information about a student's contributions to a team project. The P2P evaluation may include criteria such as meetings preparation, personal contribution percentage to the end product, time commitment, etc. So, the instructor can use the P2P results to assign individual grades or provide individual feedback. However, the use of P2P evaluations places confidence in teammates to be better positioned to objectively evaluate and give a fair assessment of other team members. This premise introduces all kinds of challenges, and thus, it is not surprising that there are mixed and varying student responses in both favor and against the effectiveness of P2P assessments. Specifically, the literature doesn't provide a consensus about what design attributes lead to such a variation in student responses, even when the schemes are similar. But typically, studies report practical experiences with particular schemes or provide insights based on reflective teaching practices. Despite these concerns, there is significant support for the benefits of using P2P evaluations [7] to mitigate social loafing.

It is commonplace to think that first-year students arrive with extensive teamwork experience due to the concerted efforts and push for STEM courses in K-12 education. A year ago, we used the P2P evaluations in a similar class. We had an exigency moment with a student who made a statement that intrigued us and perhaps questioned the tool's effectiveness and how we applied it in class. The student had both excellent and detestable experiences with the team. When asked if their P2P evaluation reflected their experience, the student stated, "not really as I don't want to look like a teacher's pet, reporting my colleagues. So, I just continued to shoulder and complete most of the teamwork." Such experiences highlight that teamwork may negatively affect student experience in teams, and P2P evaluations may fail to capture these experiences. So, we were curious about how students perceived the use of P2P evaluations on teamwork. Additionally, we were interested in the efficacy of the P2P evaluations as an assessment tool in First-year courses.

Methodology:

The study was divided into three phases and started in the fall semester of 2021. After completing several milestones, the students completed three surveys: a pre-survey, a mid-semester survey, and an end-of-semester survey. All surveys were conducted confidentially to aid researchers in tracking each participant's responses across all surveys. The pre-survey focused on prior teamwork experience, and students completed it in the first week of the semester after a 40-minute collaborative marshmallow challenge activity. The survey focused on three questions:1) You worked as a team today to complete a task; have you worked on a team before this activity? 2) If so, how many times have you worked on teams before today? 3) What if the instructor asked you to evaluate each team member's preparation, dependability, and contributions towards your team's success? What are your thoughts if the instructor used your assessment for the overall grade for that student?

Next, we placed four students on heterogeneous teams considering attributes such as prior programming, CAD, and/or hands-on prototyping experience. As a team, they were tasked to complete a 4-week research project with equal contributions that ended with an oral presentation and short report paper. After the project, we used TEAMMATES, a web-based peer-to-peer evaluation platform, to create a P2P form that included several questions about self-evaluation, teammates' evaluation, and overall team efficiency, as shown in the Appendix. Students were asked to complete the P2P online form within five days after the project. Once the survey closed, the instructor read through all the comments and feedback to ensure they were appropriate, and then they released the feedback to each student. Finally, in class, everyone was asked to review and reflect on feedback received from their peers, with emphasis on qualitative questions 1 and 4 (See Appendix).

With lessons learned from the first project, teams were tasked to complete a hands-on project with equal contributions that ended with a practical design that solved a specific problem for a marginalized population. Examples of design solutions varied from smart walking canes, measuring cups for the blind and deaf, small family tracking devices for refugees, etc. The project was more involved than the first one and embraced failure and lots of testing to be successful. The project ended with a product demonstration at a First-Year Expo at the end of the semester. Consequently, teammates were asked to complete the last P2P form that included questions provided in the Appendix. Similarly, the instructors read all comments to ensure they were appropriate before releasing the feedback and evaluation to each team member for future team performance improvements.

As stated above, the surveys had a mixture of qualitative and quantitative questions. The results for quantitative questions were tallied, and the related graphics and statistical relevance are presented in the results section. Additionally, the authors applied inductive coding for qualitative questions to explore themes in the collected data. Coding is a well-developed qualitative methodological approach that has been used in several studies within the literature [8-10]. In a word, the authors used qualitative coding to systematically and rigorously identify, codify, and interpret themes in students' responses by dynamically determining relevant keywords or phrases that contribute to this study.

Results:

About 128 students completed the pre-survey, and the results are shown in **Figure 1**. Approximately 6% of the students had not or were not sure about working on a team before, and about 82% of those with prior team experience had worked on teams more than six times. These results highlight the impact of the K-12 STEM emphasis on teamwork activities. Also, we asked a hypothetical question: What if the instructor asked you to evaluate each team member's preparation, dependability, and contribution towards the success of your team, and they use your assessment for the overall grade for that student? How would you feel, or what are your thoughts about such a request? Based on our coding, most of the students acknowledged that instructor feedback was necessary, and they were confident enough to provide assessments. However, most students requested anonymity to maintain integrity on such evaluation forms (Note that at this point, they did not know each other well). The merits and demerits of incorporating anonymity in P2P evaluations were discussed in [11].

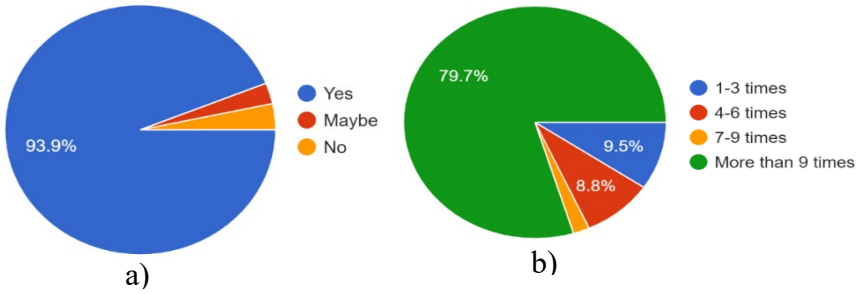

Figure 1: Pre-survey prior teamwork experience; a) Have you worked on a team before, and b) How often have you worked on teams?

One nice tool of the TEAMMATES P2P tool is the option that allows a team member to evaluate their contributions to the project compared to their teammates' evaluations. **Table 1** shows an example of the overall instructor's view for each student's evaluation based on MQ1 in **Table 2** of the Appendix: Please, give your honest estimate of how much each team member has contributed. The labels are defined as follows: **E** is for equal share or measure of work done, **CC** is the student's Claimed Contribution, **PC** is the average value or Perceived Contribution, **Diff** is the difference between CC and PC, and **Rating received** holds the teammates' evaluation of the student's contribution [12]. In this example, all Team 1 members contributed equally, while in Team 2, Students 3 and 4 contributed more than students 1 and 2. This is the first indicator that students 1 and 2 may be social loafing, but the instructor must incorporate other comments on the form to grasp the whole picture.

Table 1: Snippet of TEAMMATES Student assessment

Team	Recipient	CC	PC	Diff	Ratings Received
1	S#1	E	E	0	E, E, E
1	S#2	E	E	0	E, E, E
1	S#3	E	E	0	E, E, E
1	S#4	E	E	0	E, E, E
2	S#1	E	E -5%	-5%	E, E -6%, E -9%
2	S#2	E	E -5%	-5%	E, E -6%, E -9%
2	S#3	E +22%	E +6%	-16%	E +18%, E, E
2	S#4	E -7%	E +4%	11%	E +13%, E, E

In this study, we asked how confident the students were to assess each other's contributions in both the mid and end-of-semester surveys. In particular, MQA: I was confident in my ability to evaluate and provide feedback to my peers and EQC: Having used this evaluation tool before, I am confident in my ability to evaluate and provide feedback to my peers in **Tables 3** and **5** in the Appendix, respectively. Both quantitative questions had a Likert rating scale and the values were plotted with totals for each scale at the end of the bar in **Figure 2**. Based on these results, we

deduce that continued use of P2P improved confidence from $\frac{46+64}{128}$ ≈86% for the mid-semester to $\frac{54+67}{128}$ ≈ 94% for the end-of-semester assessment. Such improvements in confidence were also observed by [13], implying that continued use improves confidence and evaluation efficacy.

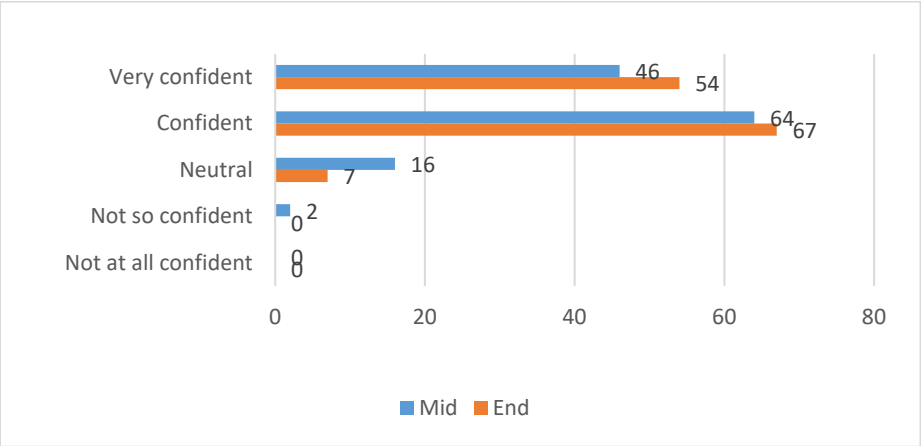

Figure 2: Student's comfort level in their ability to evaluate teammates.

Similarly, **Figure 3** highlights the compiled data about the use of P2P versus face-to-face feedback based on MQB and EQD in **Tables** 3 and 5, respectively. Both used the Likert rating scale and the values were tallied and plotted with totals for each scale at the end of the bar in **Figure 3**. Based on the figure, we observed about a 9% increase in appreciation of P2P tools compared to face-to-face feedback from mid to end of the semester. Such a small increase may be because the students had worked with each other for the entire semester and were comfortable providing face-to-face feedback. However, the slight increase was basically for those who preferred the anonymity feature of the P2P tool.

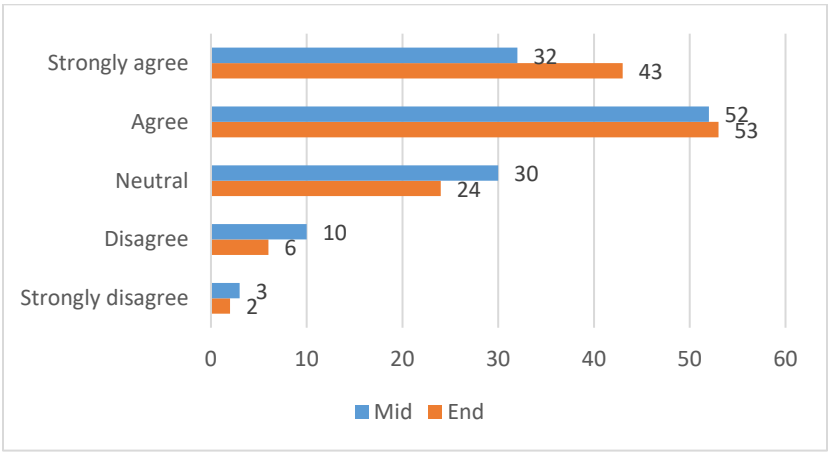

Figure 3: Student's Comfort with anonymous feedback vs. face-to-face feedback

The effectiveness of the P2P tool was considered only in EQA of the end-of-semester survey. We asked students to consider how teammates evaluated their contribution on the mid-semester survey, and how accurate the evaluation was. The tallied values are plotted in **Figure 4** and

approximately 85% of students agreed with their overall evaluation and feedback that was provided by their teammates on the P2P form. Similar findings were observed in [6, 7] validating the merits of using the tool for assessment and feedback.

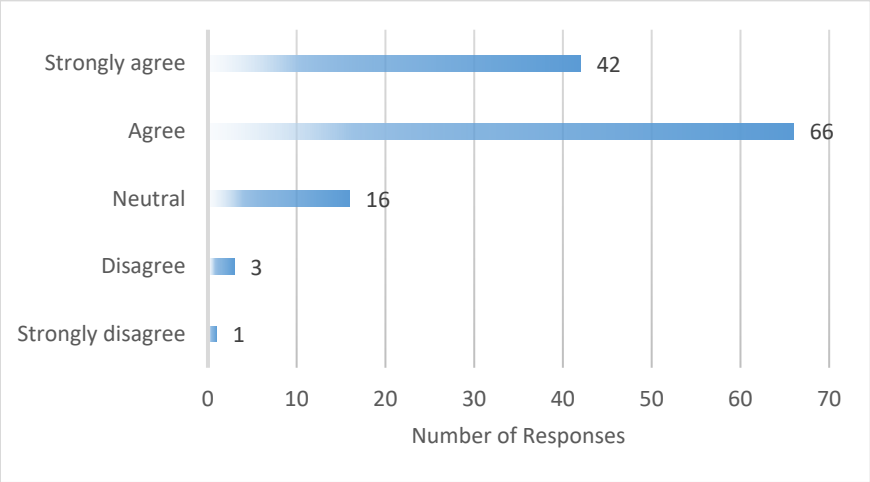

Figure 4: Overall P2P evaluation effectiveness

Combining the findings above, we agree with previous conclusions that P2P assessments are effective in teamwork and do help to improve team dynamics and functionality [6, 7]. However, we also observe that when a team member doesn't participate and other teammates can do the work, teammates are hesitant to provide that information on the P2P form. Specifically, if they believe that their evaluation will impact the student's overall grade. We coded the open-end responses in MQC, MQD and EQE in the Appendix to better understand this phenomenon. **Figure 5** highlights the common themes and factors that students highlighted as impactful to fair evaluations.

First, it was easy for students to complete the P2P forms when the team performed as expected. Second, students who recorded ease with completing the open-ended questions also showed minimal divergence from the equal contribution on the team project by every team member. These findings are supported by Topping [14], who suggested that peer assessments promote a sense of ownership, personal responsibility, and motivation that increase bonding, self-confidence, and empathy. However, students who struggled with open-ended questions showed some disfunction within the team and struggled to provide constructive criticism based on the learning goals (Metacognition limitations). But, they appreciated the ease of multiple-choice questions. In [15], the authors stated that using P2P tools could enhance a better understanding of assessment requirements which encourages students to consider the purposes and objectives of the assignment.

Third, the feedback and assessment quality improved with repetition, and anonymous feedback was helpful for students who had moderate challenges as a group. Intuitively, P2P evaluations accuracy improved as students consistently used the tool. There is an initial fear or anxiety of using this new tool with significant ramifications that students must overcome. After using the P2P tool a few times, they overcame their fears and confidence, mainly if the initial evaluations were low stakes. However, we observed that teams with elements of social loafing did not

benefit from using the P2P tool to support individual improvements. Specifically, students did not enjoy using the tool to assess or grade their teammates. Thus, the evaluations were exaggerated or short on helpful feedback hiding behind the anonymity curtain. For instance, a student stated, "My teammate evaluation experience was quite interesting because I was able to see how in-depth each person did and how much effort they put. The questions that were easy to complete were those that did not ask for paragraphs because with paragraphs; you have to go in-depth where the multiple-choice gets right to the point." Another stated, "The anonymity contributed to my honest feedback. Nothing limited my honesty, but the chance that my evaluation might alter my teammates' grades made me uncomfortable while evaluating." Finally, another student stated, " I am typically uncomfortable with having to critique others which may have limited my feedback, but some feedback felt wrong given face-to-face, as it could prompt a negative reaction from my teammates."

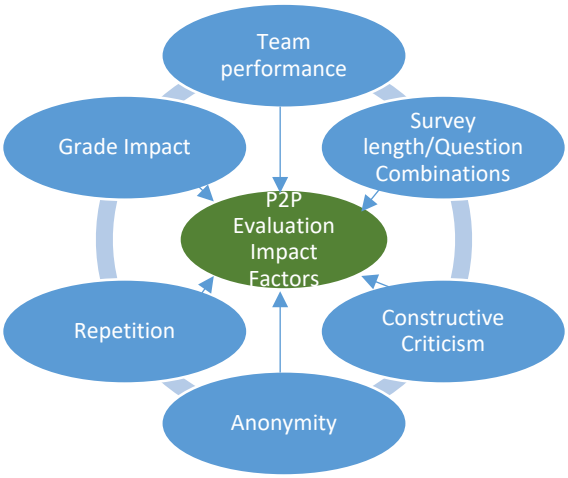

Figure 5: Contributing factors to effective P2P Evaluations.

Summary:

P2P evaluation approaches are effective tools for providing feedback to teammates and improving team performance. Additionally, anonymity offers an extra sense of comfort to students that contributes to honest evaluations. Despite the merits of P2P evaluations, social loafing is a significant challenge in teamwork and still may elude the P2P assessments. One student summed it best by stating, "I think it's a big responsibility to be even partially accountable for a teammate's grades. I would feel very guilty to affect my teammate's grades negatively. I think putting that pressure on students will decrease their honesty on P2P evaluation." Thus, we conclude that P2P evaluations should be coupled with other approaches to limit social loafing.

Based on our findings that students were more comfortable the second time around, we intend to adjust the criteria and use the Mid-semester survey as a test run to provide feedback and the end-of-semester for evaluation. We will keep the anonymity feature but appreciate the benefit of releasing the peer comments to each student despite students overwhelming preferring anonymity. Additionally, we shall use the mid-semester results to address social loafing and emphasize the equal effort policy from all team members.

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Appendix:

The first questions of the P2P form were focused on teamwork and teammates' evaluations and feedback, as highlighted in **Table 2**.

Table 2: Mid-semester survey questions:

	Teamwork Questions
MQ1	Please, give your estimate of how much each team member has contributed.
MQ2	Self-Evaluation: Assess your work and sense of belonging in the team.
MQ3	Your feedback to any teammate (shown anonymously to the teammate). What do you prefer and or request from your teammate?
MQ4	Your constructive feedback to any teammate aimed at helping them improve not to break them down (shown anonymously to the teammate). Consider what they did well and/or what they did not do well? What you learned from your teammates and what would you have done differently, given another opportunity?
MQ5	What is one thing about your team that you are most proud of and/or abject to?
MQ6	Overall, how effectively has your team work together on this project?

At the end of the P2P form, we appended research questions that focused on student's reflection on their overall experience using the P2P evaluation tool provided in **Table 3**.

Table 3: Mid-semester Overall P2P tool experience survey questions:

	Tool Experience Questions
MQA	I was confident in my ability to evaluate and provide feedback to my peers.
MQB	I was comfortable providing peer feedback on this form vs providing face-to-face feedback to my teammates.
MQC	Please, tell me about your teammate evaluation experience? Additionally, what questions were easy to complete? or What questions were challenging for you to complete and why?
MQD	Please, tell me about the factors that contributed to your honest evaluation and feedback? Or what factors limited your honest evaluation and feedback?
MQE	Please, tell me if you considered how others would evaluate you when providing your evaluation or feedback? If so, how did it impact your evaluation and feedback? If not, why not?
MQF	Overall, how effectively has your team worked together on this project?

The first questions of the end of semester P2P form were focused on teamwork and teammates' evaluations and feedback, as highlighted in **Table 4**.

Table 4: End-of-semester survey questions:

	Teamwork Questions
EQ1	Please, give your estimate of how much each team member has contributed. Consider their contributions to the success of the presentation, participation in developing ideas, project planning, willingness to discuss their ideas with the group, interest and enthusiasm, and leadership
EQ2	Reflect, consider, and discuss your overall contributions to the success of the project, team meetings, developing and sharing your ideas, working with other teammates, project interest and enthusiasm, and your leadership. Access how you belonged on this team and what changes can you make to improve its performance next semester?
EQ3	In answering this question, specify any qualities both positive and negative such as what you appreciate about your teammate and qualities that made them a good teammate. How did they help the team and work with each member? Additionally, share any issues or concerns that you request from your teammate? What challenges did your experience working with this teammate? *For example, I appreciate that you come to all the meetings well prepared. I think that you can work on responding to group communications promptly.* This is aimed at helping your teammate improve not to breaking them down.
EQ4	Your comments about this teammate (confidential and only shown to instructor). Are there any comments you wish to share with the instructor about this specific teammate confidentially? Or you can provide or share any other comments or recommendations that were not captured in the evaluation?
EQ5	Overall, how effectively has your team work together on this project?
EQ6	In this question, you can provide or share any other comments about your experience to evaluate and provide feedback to your teammates?

Similarly, we appended research questions shown in Table 5 to the end-of-semester survey form that focused on capturing their experience after using the P2P evaluation tool.

Table 5: Mid-semester Overall P2P tool experience survey questions:

	Tool Experience Questions
EQA	Please, consider how teammates evaluated your contribution to project #1, did your teammates accurately evaluate your contributions to the project?
EQB	Please, tell us about the feedback you received for project #1. Was the feedback helpful to you? Did you apply the recommendations when completing project 2?
EQC	Having used this evaluation tool before, I am confident in my ability to evaluate and provide feedback to my peers?
EQD	After the first time around, I was more comfortable providing peer feedback on this form vs providing face-to-face feedback to my teammates
EQE	Please, tell me about your teammate evaluation experience this time around. What factors made it easy or challenging to complete this evaluation and why? Did you make any adjustments when completing this evaluation compared to the first time? If so, what and why?
EQF	Now that you have used this evaluation tool several times, what are your overall thoughts about the instructor using the Peer-2-peer evaluation tool to determine your project contribution and grade?