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Integrating Peer Review to Strengthen Team-Based Learning in Engineering Programs

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Abstract

Peer review in team-based learning aims to promote students' assessment of their own and their peers' contributions while building professional skills in developing and receiving feedback and in collaboration. In addition, peer reviews can help discourage social loafing, ensuring that the workload is fairly distributed among team members. This study examines students' perceptions and preferences regarding the integration of peer review in team-based learning, particularly it's impact on teamwork, fairness, and accountability. A literature review was conducted to present the state of the art in the use of peer reviews in engineering classrooms and to highlight both effective and less successful strategies. In addition, the paper describes strategies used by the authors in a Civil Engineering Program at a university in Canada as well as in an Engineering Technology Management Program at a university in the United States for engaging students in teamwork, including the integration of peer reviews and team contracts into the course curriculum. The paper also presents students' reflections on the use of peer reviews and team contracts in group work. Findings from this work highlight the impact of students' assessment of their own contribution and the contribution of their peers on collaboration, fairness, and the development of soft skills.

Introduction

Communicating and working with peers is a vital part of being an engineer, and the engineering classroom should be one of the first places where students begin to develop these skills. Additionally, when performing group work, it is essential that students can evenly distribute work and contribute to the project [1]. The use of peer reviews in this study focused on encouraging and motivating students to participate actively in teamwork, promoting accountability, teaching students how to provide meaningful feedback, and enhancing reflection of performance both as an individual in a group and at a group level.

Peer reviews were employed in projects for first-year Mechanics 1 course at the University of Waterloo. Students were shown how to implement and use team contracts for group projects. In one project students were also tasked with providing feedback to another group, which contributed to their final grade. Additionally, they were required to write a final self-reflection report on their performance during the final project. Question prompts (see Appendix B) were provided for the reflection report, allowing for standardization of feedback from students, and analysis of student opinion of peer reviews in the Mechanics 1 course.

At the University of South Carolina Upstate in the United States, students in two different courses, Engineering Teams Theory and Practice and Engineering Cost Analysis, within an

Engineering Technology Management program engaged in structured self and peer assessments of their team projects. The projects were assigned in the accompanying lab for each course. In Engineering Teams Theory and Practice, a senior-level course, students also used team contracts to define expectations for their teams. Across both courses, students evaluated both their own contributions and those of their teammates using provided evaluation criteria to support the development of transferable teamwork skills.

This implementation approach was designed to provide students with practical tools for managing teamwork which can be used in future teamwork settings. Self and peer reviews were incorporated into the project grading structure to ensure consistent engagement while prioritizing core course content. This also helps to mitigate the risk of students disregarding the process if it were offered as an optional exercise. Ultimately, the goal is for students to understand the value of teamwork, accountability and feedback, and to adopt some of the strategies in future academic and professional teamwork settings.

The remainder of the paper examines the use and implementation of peer reviews in engineering and technology classrooms, followed by an in depth discussion of the implementation of peer review in the Mechanics 1 course at the University of Waterloo and the Engineering Technology Management courses at the University of South Caroline Upstate. Finally, conclusions are presented

Background

To encourage student participation, strategic systems such as peer reviews and team contracts have been implemented within group assessments. The ability to collaborate effectively with colleagues is an essential skill in the engineering profession; therefore, strategies that cultivate successful teamwork are heavily emphasized in post-secondary engineering programs.

Peer reviews and team contracts have demonstrated benefits, with course instructors using these systems to improve the quality of student submissions and enhance the overall team experience [2]. In engineering education specifically, peer review methods have also been implemented to increase student involvement and develop skills such as critical thinking, particularly when supported by structured processes and clear evaluation expectations [3]. More broadly, peer review activities are frequently used to support learning by prompting students to evaluate work against criteria and provide actionable feedback. Similarly, design education research emphasizes the importance of helping students connect theory to practice through structured learning activities [4].

By collaborating with others, students are exposed to different perspectives and can identify areas of improvement that may not have been apparent when working independently; in engineering project based learning (PBL) contexts, students' engagement in teamwork is associated with deeper learning approaches and stronger acknowledgement of the value of collaboration [5]. Collaboration is integral to the nature of engineering practice, where professionals routinely work in multidisciplinary teams to solve complex problems.

In an academic context, peer review involves individuals with sufficient competence or expertise evaluating the work of others with the goal of identifying errors, ensuring accuracy, and improving the quality of the final product. Across disciplines, peer review functions as a central mechanism for quality control—validating rigor, detecting inaccuracies, and improving the clarity and reliability of research reports [6], [7]. Studies of peer review practices in software engineering likewise describe peer review as foundational to quality assurance while documenting variability in review quality and perceptions of current reviewing regimes [8], [9]. Academic peer review is widely recognized as essential for upholding publication standards and supporting trustworthiness of research outputs, even as debates continue about its limitations and how best to strengthen it [10]–[12]. Practical guidance also emphasizes the role of rubrics, reviewer support, and transparency as mechanisms to improve review quality [13].

More generally, peer review can be described as the process of having one or more individuals who can reasonably be considered peers based on their capabilities or competencies, evaluate work for potential issues or improvements. Within academia, peer review most commonly takes one of three forms: single anonymized, anonymized, double-anonymized, or open peer review [7], [9]. In professional engineering practice, work must also be verified for correctness and safety; this is typically ensured through review by other engineers, serving as a real -world analogue to academic peer review [2].

Literature Review

Concerns and implementation challenges

Peer reviews that are associated with grades may face issues of inconsistency and validity. Recent work with engineering undergraduates found that, while students recognized benefits of peer feedback, confidence in giving feedback and variable engagement affected outcomes; moreover, acceptance of peer assessment as part of summative grading can be mixed [14], [15]. Broader research on peer assessment similarly notes that reliability and validity can vary by context and student seniority, often improving with scaffolding, training, and sufficient numbers of raters [16], [17].

Another practical challenge is effort: for peer review to be effective, students must invest meaningful time and provide substantive comments. Survey and mixed methods findings report cases of low- quality or incomplete peer reports and superficial feedback when participation is not well supported or incentivized [14], [15]. Interventions such as explicit feedback such as literacy instruction and rubrics have been shown to improve the quality of peer feedback artifacts [18]. Additionally, in engineering design contexts, collaborative “team reviewer” models (where a small group produces a single joint review) have been shown to improve feedback quality and student engagement relative to individual reviewing [19]. Finally, the literature highlights ongoing debates about bias, subjectivity, and the limits of peer review. Particularly when used for high stake decisions, recommending clearer accountability, transparent processes, and better data infrastructures to study and enhance peer review systems [12].

Teamwork skill gaps and social loafing

Team based skills are not explicitly taught in many university engineering programs, with the assumption that students will naturally acquire them over time. For example, engineering education interventions have been developed to explicitly teach teamwork conflict recognition and resolution strategies [20], and complementary skills training initiatives have been implemented to strengthen applied engineering competencies within programs [21]. At the same time, engineering students often report increasing frustration with group work overtime, frequently tied to interpersonal difficulties and the presence of low contributing teammates [22].

Without explicit instruction, students often default to divide and conquer strategies that minimize the need for collaboration. This can lead to inequitable workload distribution, reduced learning opportunities, and issues such as social loafing. Evidence from capstone design teams further shows that clarity of roles, alignment of skills to tasks, explicit project management plans, and lower levels of conflict are associated with higher perceived team effectiveness and enjoyment, underscoring the value of structured teamwork supports in engineering education [23]. Work-integrated learning research likewise suggests that workplace design experiences can develop students' design skills and mindsets beyond classroom settings, including teamwork and coordination practices in authentic environments [24]. Iterative design experiences that incorporate feedback and reflection have also been studied as mechanisms for improving student outcomes across design phases [25].

Importantly, peer review mechanisms inside teams (e.g., peer ratings of contribution) can reduce social loafing by increasing individual accountability and making differential contribution visible. In cooperative learning contexts in engineering, peer rating ("autorating") systems have been used to adjust team grades based on individual contribution and to address "hitchhikers," improving fairness and reinforcing accountability within teams [26]. Individuals who struggle within group contexts are more likely to disengage or give up altogether [2].

Mitigation strategies (evidence-aligned)

To address reliability/validity and effort concerns in graded peer review, the literature supports:
(a) rater calibration and feedback literacy training prior to reviewing [15], [18];
(b) sufficient numbers of raters and/or mixed reviewer pools to stabilize scores [16], [17];
(c) structured rubrics and criterion level prompts to elicit actionable comments [14], [18]; and

(d) incentives and accountability mechanisms (e.g., evaluating feedback quality) to discourage superficial participation [14], [15].

Overall, the literature supports peer review and team contracts as valuable mechanisms for participation, quality control, and professional preparation in engineering education; yet challenges remain around graded implementation, student confidence, and consistent engagement. A clear opportunity is to integrate calibrated peer review with structured teamwork scaffolds (roles, project management plans, conflict- resolution processes) and explicit feedback- literacy training, then evaluate outcomes longitudinally across years to track changes in reliability/validity and team effectiveness [16], [17], [23].

Implementation:

Mechanics 1 Implementation

The Mechanics 1 course for first-year engineering students in architectural, civil, environmental, and geological engineering programs at the University of Waterloo is an introductory course teaching Newtonian mechanics, force systems, equilibrium and free body diagrams, and mechanics of simple structures. There were 355 students divided over 3 sections in this implementation of the course.

The course was separated into four intended learning outcomes containing the entirety of the grades for the course, with the first three learning outcomes covering all intended academic learning material that would be taught during class. The fourth and final learning outcome occupied approximately 15% of the total course weight and would consist of three group projects spread over the term. Within this section, only project three would include weighted activities that are related to peer reviews.

For all group projects, students were provided with a preprepared contract form designed to help them distribute work effectively within their group. The form allowed students to record assigned roles and included a Gantt chart to support task planning and timeline development. It also required students to specify their communication methods and expected response times. Once completed, the contract was signed by all group members and submitted as an attachment to the project deliverables, previous studies have shown that this ensured that students take the contracts above seriously, especially when they are able to affect grades [27]. A copy of the contract provide to the students has been attached in Appendix A.

After the first group project, the contract form was expanded to include a mechanism for penalizing group members for non-performance, with the specific consequences to be determined and agreed upon by the group, allowing for the students to develop different variations of the contract. The signed contract would be enforced by the teaching team, should members of the group bring to their attention that the terms on the contract needed to be put into effect.

For Project Three, students worked in groups of four to design a lesson plan for Grade 7/8 students on one of five engineering structures. Their task was to teach the relevant engineering principles and concepts, as well as the societal and environmental impacts associated with their chosen structure. In addition, each group was responsible for creating an assessment tool to evaluate their Grade 7/8 audience's understanding without relying on tests or quizzes. Student created assessments took the form of games such as Jeopardy, Kahoot, or fill in the blank puzzles. At the end of the assignment, students were required to deliver their lesson plan to the teaching team consisting of the instructor and teaching assistants, as well as their peers in a short presentation before presenting at the schools.

Presentation to the teaching team and peers takes the form of a seven-minute presentation where the students must explain the key points of their lesson plan which consisted of the following:

1. Clear Scope and Activity
2. Testing Student Understanding
3. Real-Life Examples and Societal Impact
4. Structured Presentation Plan
5. Team Collaboration and Communication

The lesson plan is presented during the 50 minutes tutorial session that was divided into three fifteen-minute increments, with seven minutes dedicated to the presentation and eight minutes to receiving feedback. As such, the groups then participated in three rounds of feedback in total. In the first round, each group presented to members of the teaching team and received formative feedback. In the second round, they presented to another group and received peer feedback. In the third round, they attended a different group's presentation and provided feedback on how that group could improve their lesson. This structure allowed students to explore ideas from external sources, offer constructive suggestions, and build upon the work of others. Note that each team would have their lesson plan posted on the wall under their group number, and whomever was giving feedback, would go to the group station to listen to their presentation. As such, multiple presentations were occurring at the same time. Accordingly, the orders of the presentation for the different groups would vary depending on who was giving feedback. The order of presentations and feedback cycles were given to the students ahead of time and posted on the screen so that they know which station to attend.

Additionally, each group evaluated the quality of the feedback they received from their peer reviewers. This was intended to encourage groups to provide thoughtful, meaningful feedback that would genuinely help improve the lesson design. The presentation and feedback were performed in person, and face to face.

The feedback received was then used to complete the lesson plan and the presentation to the grade 7/8 students in local schools.

Engineering Technology Management Implementation

In the Engineering Technology Management program at the University of South Carolina Upstate, peer reviews were used for team projects in two courses, including Engineering Teams Theory and Practice and Engineering Cost Analysis. Both courses have accompanying labs, and the projects were a significant component of the labs. The reviews were completed at the end of the project.

Evaluation categories for the Engineering Cost Analysis course are described below:

- Task Completion & Reliability: Considered tasks completion, timely completion, and accountability
- Quality of Work: Focused on accuracy, comprehensiveness, and quality
- Collaboration and Team Engagement: Considered participation in team activities, support for team decisions and contribution to team dynamics.
- Idea Generation & Contribution: Captured creativity of ideas, as well as contribution to problem solving and team decisions
- Attitude & Professionalism: Focused on attitudes toward team members and teamwork, ethical behavior, and professional behavior

Peer reviews for both courses included similar elements. A key difference was that Engineering Teams Theory and Practice peer reviews also considered adherence to project timeline & team assigned team roles.

The junior-level course did not require a team contract. In the senior-level course, however, peer reviews and a team contract were required. Students submitted the contract signed by all team members early on during the project along with a project proposal. This contract was part of the project proposal grade and required instructor approval before the team could proceed with their project.

A contract template was provided to help students complete key components:

- Goals: Outlined project goals as well as skills teams will develop or refine during the course of the project. While this information was already provided in course documents such as the syllabus and project instructions, the contract required teams to revisit this information and collectively articulate it. Teams also had an opportunity to outline additional goals or skills.
- Expectations: Focused on outlining team standards including but not limited to standards for meeting attendance, participation, frequency of communication, and quality of work.

- Policies and procedures: Captured agreed-upon rules to support the team in meeting their project goals and expectations. Prior to the start of the project, students were provided a team participation policy for the course, which outlines expectations and procedures for managing dynamics and emphasizes equitable participation, accountability and respectful collaboration among team members. In addition, teams included other team-specific rules in this section.
- Consequences: Described consequences for non-performance related to goals, expectations, policies, and procedures. This aspect incorporated elements of the team participation policy for the course as well as other consequences agreed-upon by the team.

Post-Project Reflection

At the end of Project 3 in Mechanics I, all students were required to complete and submit an individual reflection report that answered a list of provided questions. The topics covered how the project affected their understanding of the material, how it affected their interest, what they liked and disliked about the project, as well as reflecting on several aspects of working as a group and providing feedback to their peers.

In Engineering Teams Theory and Practice and Engineering Cost Analysis, students completed a survey at the end of the semester which included reflection on the use of peer reviews and contracts. The survey included Likert-scale questions as well as an open-ended component, allowing students to elaborate on their responses.

The three courses shared common reflection items. The main items analyzed for this paper are as follows:

- Did assessing your peers lesson plan help you learn different /more content? How? (Mechanics 1 only)
- The use of peer reviews improved communication and collaboration in the team (Engineering Teams Theory and Practice and Engineering Cost Analysis only)
- The use of peer reviews fostered equitable contribution to the project by all team members. (Engineering Teams Theory and Practice and Engineering Cost Analysis only)
- I felt that my individual contribution would be accurately assessed by my peers
- I felt more accountable for my individual contribution to the project because I would be evaluated by my peers.
- The team contract fostered equitable contribution to the project by all team members.
- I felt more confident that the workload would be distributed fairly among all team members because of the team contract.

- The team contract made me feel more accountable for my individual contribution to the project.
- I would prefer to have peer reviews for future team projects.
- I would prefer to have team contracts for future team projects.

A copy of the reflection report questions list for Mechanics I has been provided in Appendix B.

Results and Discussion

Mechanics 1

This section includes the discussion of the results from project 2 and project 3 described in the previous section.

For project 2, 87 distinct groups submitted their reports along with a group contract. The group contract allowed for an academic penalty to be applied, with the project assumed to be worth "10 points" maximum for each person. The results noticed could be sorted into seven different categories as shown in Table 1.

Table 1 Project 2 Type of Penalty

Type Of Penalty	Number of Groups	Percentage of Groups
No Academic Penalty	19	22%
Contribution	17	20%
Points per instance	14	16%
Decide Penalty Later	11	13%
Flat Number	18	21%
Flat -10	6	7%
Minimum Number of Points	2	2%

No academic penalty means that the group did not list a form of penalty in the area, often to instead opt to talk with the non-contributing individual or a teaching assistant/the professor.

Contribution means that the team chose to write that points deduction would vary according to how much the individual has contributed.

Points per instance means that an individual would take a penalty for failure that would scale by a metric. Examples would include the number of days late, or how many questions were incomplete by set deadline.

Decide penalty later means that the group chose to discuss a penalty after the need occurs instead of coming to an agreement beforehand.

Flat number means that in the event of a member that does not carry out their work in a professional and timely manner, that member will take a flat reduction out of the given “10 points”

Flat -10 means that the group member that fails to meet requirements would be subject to have the entirety of the “10 points” that the project is worth deducted. The category is similar to Flat number but while flat number rarely goes higher than a deduction of 5 points, multiple groups chose to have a full 10-point deduction. In this category there is one group that stated that a member could gain back points by contributing and being approved by other members of the group.

Minimum number of points: two groups chose to set the minimum number of points an individual would be able to receive. One group decided that a member could not lose more than half of the 10 points the project was hypothetically worth, while the other group set the condition that if a member showed up to the lab, they would be eligible to receive 5 points.

Groups that chose not to write a specific penalty made up 33 percent of the groups combining no academic penalty and decide penalty later, the two largest categories.

Only one group noted a single penalty and belonged to Points per instance, where an individual was late by a day and was deducted points.

For project 3, students were in the same 87 distinct groups as project 2. Groups would grade their peers from other groups for their feedback received during the presentations. Each person on the group graded the team separately to evaluate how the feedback was helpful to them. In addition, at the end of the project delivery, each student would write an individual reflection report that was later graded. Out of the 355 students, only 345 students submitted the reflection reports. The report was weighted for approximately 3% of the final grade to provide incentive for completion while not providing an excessive influence on the final grade.

It was noticed that instead of providing honest feedback, students would provide high marks when grading the review provided by their peers. This was observed to be due to high loyalty and was particularly obvious in the civil cohort, where all students graded their peers with “Level 4” the highest grade possible.

This signifies that there needs to be further refinement in the peer review process, with further considerations given to what reasons a cohort would unanimously choose to reach such a decision and how to mitigate or circumvent a further reoccurrence without inducing rifts in the displayed strong cohesion of a cohort.

It is important to note that in University of Waterloo, students are in cohorts by programs, were students stay together in all classes they take during the term. It is likely that for cohort-based studies, it would be difficult to have peers give feedback that would affect grades, however this also could be because the form of the peer review is an open peer review with potential social pressures and impacts of giving a more accurate grade reaching far beyond the classroom.

In contrast to findings from other studies—where students openly reported that they struggled to learn when they received subpar feedback [14]—the comparison between other studies that made use of double anonymized peer review and this study, that had students openly peer review one another, suggests that the use of double anonymized peer review helped mitigate pressures that could otherwise influence the outcomes. Even when the goal of having a more open peer review was to prevent the situation of having a student give thoughtless advice, we ran into the unaccounted issues of bias from students' misinterpretations of the question on the student's end.

From the reflection report results, it is clear that students found peer review to be helpful, as more than 90% of the students stated that assessing peers lesson plan helped them learn different/more content. They've stated that they learned from the review themselves as well as the presentations from the other groups.

When reflecting on peer reviews within a team, Figure 1 results show that more than 70% of the students found that peer reviews fostered equitable contribution to the project by all team members. 15% of the students stated that they already feel accountable without the need for peer reviews. Less than 5% found it not helpful. Similar trends are seen in Figure 2 where more than 60% of the students stated that they felt more accountable for their individual contribution to the project because they will be evaluated by their peers. The rest of the class thought that peers' evaluations did not help them feel more accountable (12%); felt already accountable irrespective of peer reviews (10%) or self motivated (8%).

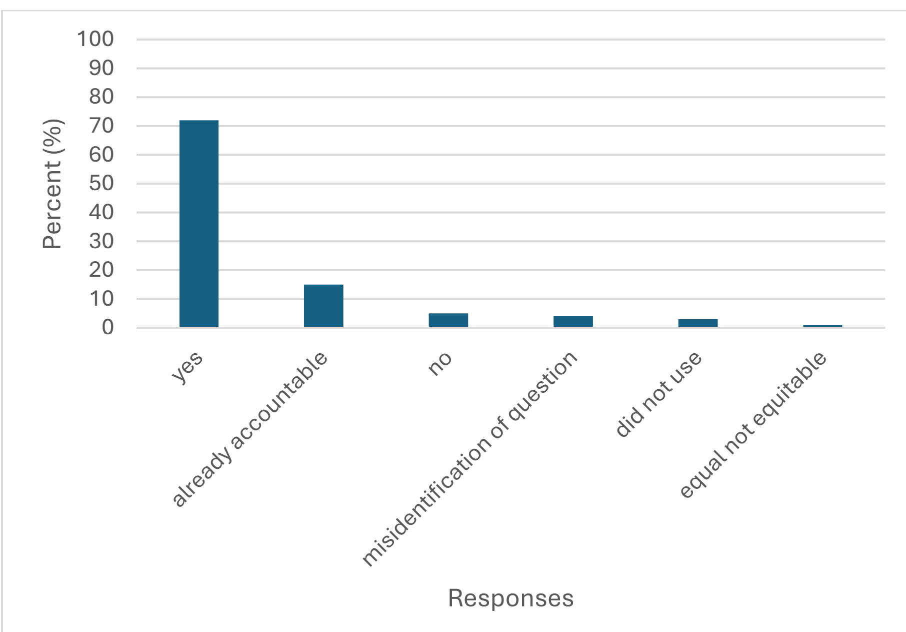

Figure 1: Reflection Report Results for: The use of peer reviews fostered equitable contribution to the project by all team members.

On another aspect, students also valued team contracts, where more than 70% of the students stated that team contract fostered equitable contribution to the project by all team members (Figure 3). Also, more than 80% of the students stated that they felt more confident that the workload would be distributed fairly among all team members because of the team contract (Figure 4). More than 75% of the students stated that team contracts made them feel more accountable for their individual contribution to the project (*Figure 5*).

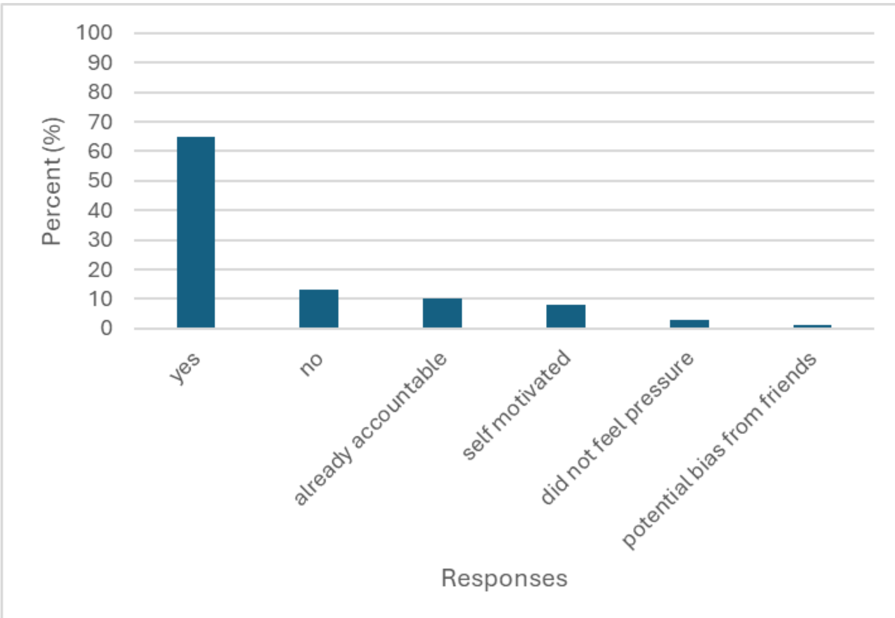

Figure 2: Reflection Report Results for: I felt more accountable for my individual contribution to the project because I would be evaluated by my peers.

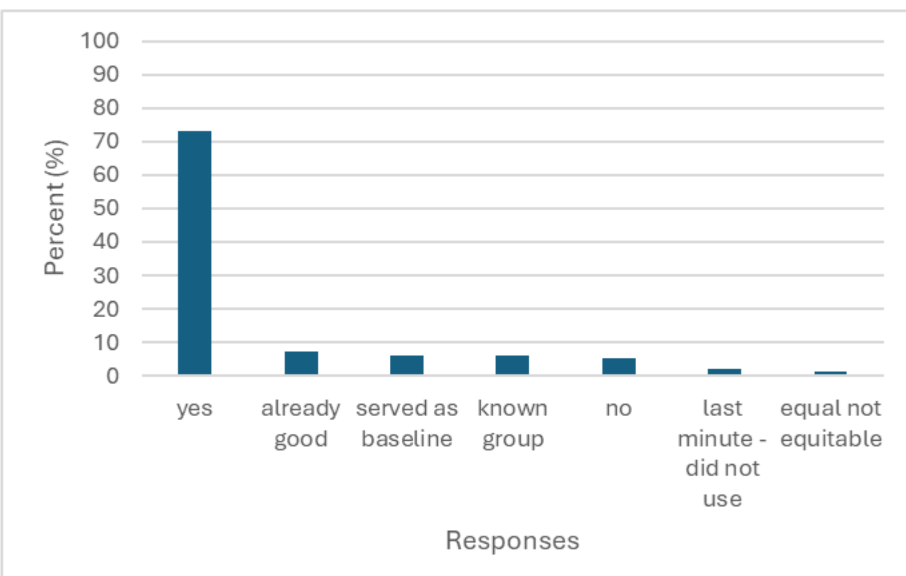

Figure 3: Reflection Report Results for: The team contract fostered equitable contribution to the project by all team members

Over 90% of the students found that peer review is beneficial and expressed preference for peer review in future projects, citing that the feedback and exposure to different opinons improved the quality of of their work. Suggestions were also received form students that ungraded peer reviewswould be better to prevent potential bias.

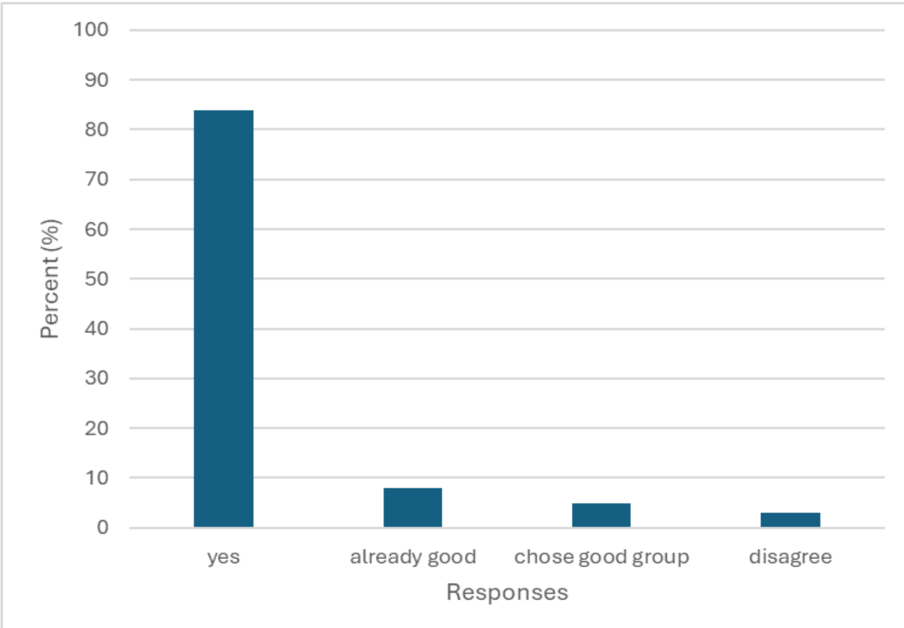

Figure 4: Reflection Report Results for: I felt more confident that the workload would be distributed fairly among all team members because of the team contract

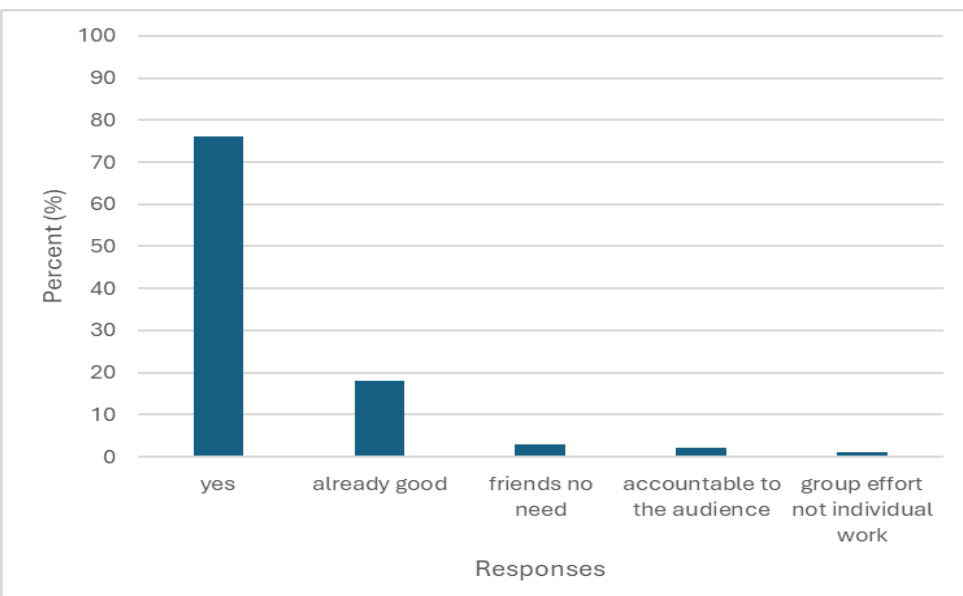

Figure 5: Reflection Report Results for: The team contract made me feel more accountable for my individual contribution to the project

Figure 6 shows that more than 80% of students would prefer to have team contracts in future group projects. Those who elaborated on their decison to choose no, stated that the benefits of team contracts already reflected skills the students had already developed, while others felt the contracts were too restrictive and should be less formal. Several students also noted that, although they personally would not choose to use team contracts in the future, they could still recognize the value such contracts may offer to other teams.

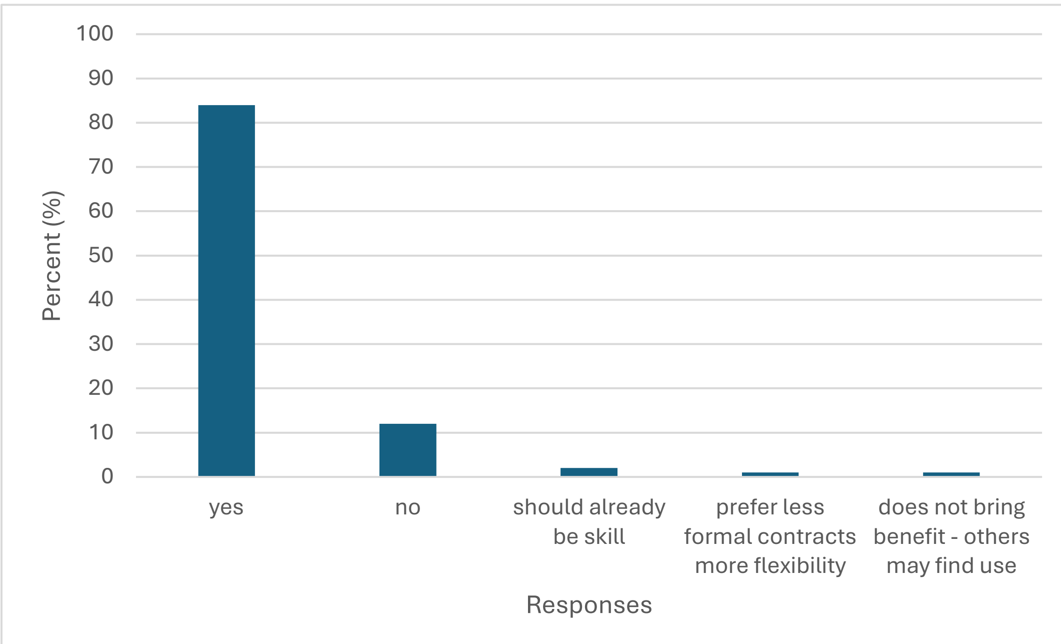

Figure 6: Reflection Report Results for: I would prefer to have team contracts for future team projects

Engineering Technology Management

At the University of South Caroline Upstate, eight students from the junior-level class and eleven students from the senior-level class completed the survey.

In response to the statement, "The use of peer reviews fostered equitable contribution to the project by all team members," approximately 80% of respondents agreed or strongly agreed, while 10.5% disagreed (see figure 7). Another 10.5% neither agreed nor disagreed. Overall, students reported generally positive perceptions of peer reviews. Several students indicated that peer reviews fostered accountability and equitable participation because team members were aware that their contributions would be evaluated. Some students also noted that peer evaluation enabled more balanced teamwork. However, a smaller number of students reported that peer reviews had limited or no impact on equitable contribution.

In response to the statement, "The use of peer reviews improved communication and collaboration in the team," 63% of students agreed or strongly agreed, while just 5% disagreed as illustrated in figure 8. Approximately 32% of students neither agreed nor disagreed. In their comments, students generally indicated that communication, collaboration, and accountability within teams improved due to peer reviews. Many students reported that knowing they would be evaluated by their peers motivated them to work more closely with their teammates. However, a few comments noted challenges, such as scheduling difficulties and concerns about potential bias in peer review scores.

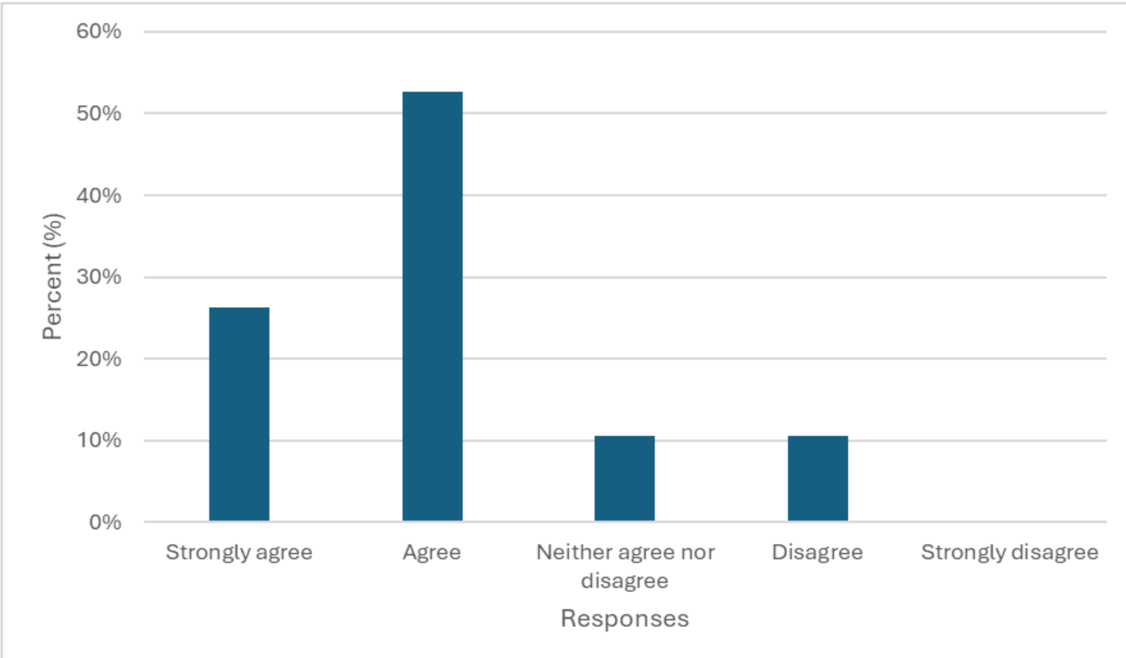

Figure 7: Reflection Report Results for: The use of peer reviews fostered equitable contribution to the project by all team members.

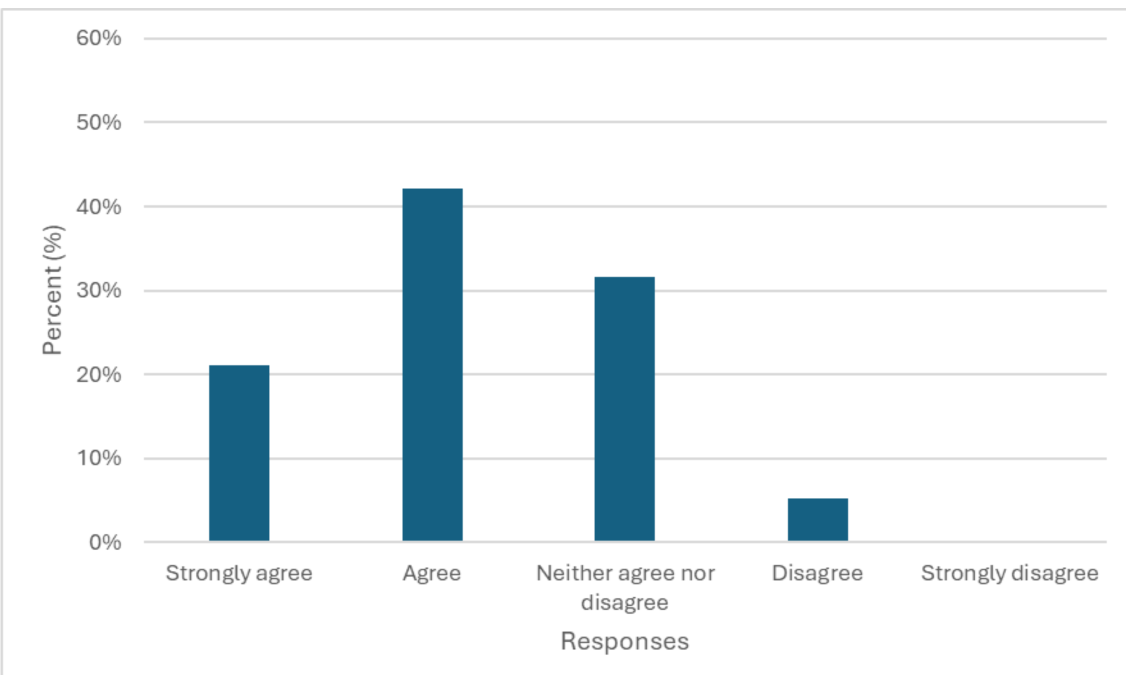

Figure 8: Reflection Report Results for: The use of peer reviews improved communication and collaboration in the team

As shown in Figure 9, most students agreed or strongly agreed that they felt accountable for their individual contributions to the project because they would be evaluated by their peers, with approximately 58% strongly agreeing and 37% agreeing. Students reported that the knowledge of the pending evaluation by teammates increased their sense of responsibility for completing assigned tasks on time, incentivized them to put in extra effort, made them more conscious of how their work impacts others, and encouraged collaboration.

Overall, most students expressed confidence that their individual contributions were accurately assessed by their peers, with 31.6% strongly agreeing, 57.9% agreeing, and 10.5% neither agreeing nor disagreeing. Factors contributing to this confidence included strong individual effort, regular communication and active collaboration, trust in team professionalism, meeting deadlines, and providing support to other team members. Two students expressed partial confidence due to frustration within the team, noting that this could influence scores, with one further commenting that he was unsure if his teammates fully understood the effort he put into the project.

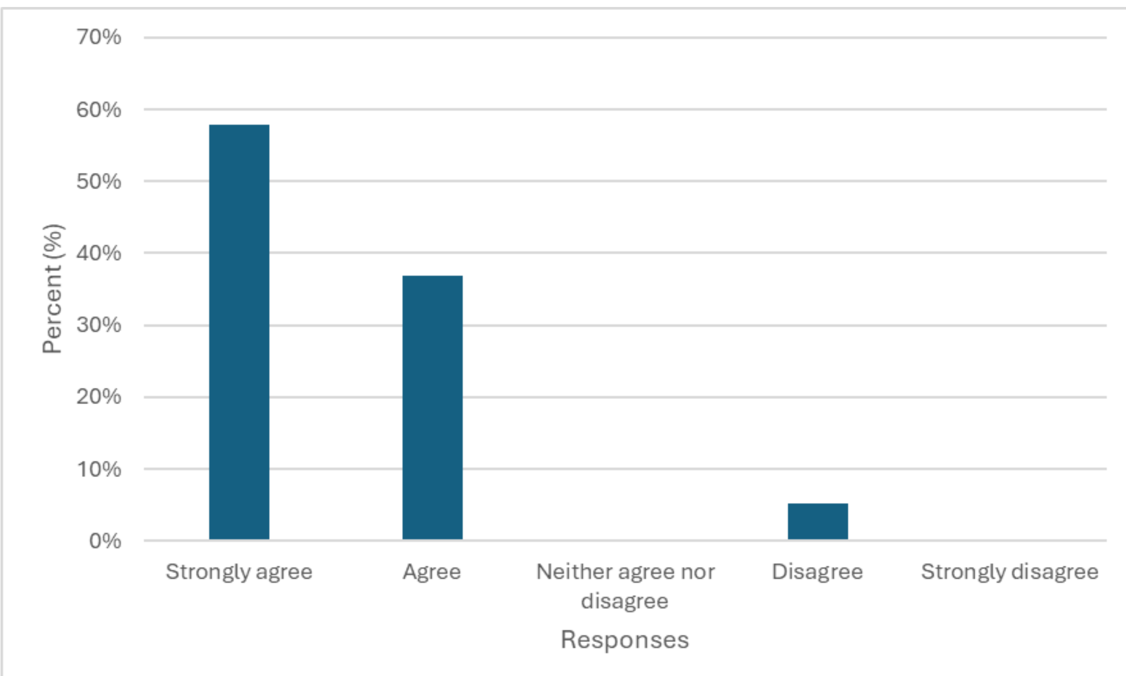

Figure 9: Reflection Report Results for: I felt more accountable for my individual contribution to the project because I would be evaluated by my peers.

The majority of students (84%) also indicated that they would prefer to include peer reviews in future team projects (see Figure 10). The open-ended reflections included additional information about the students' support for peer reviews. Improved accountability emerged as the dominant theme. Other reasons cited include fairness, recognition of contributions, reflection and self-awareness, as well as engagement. Several students noted that the peer review process encouraged consistent participation throughout the project. A few students expressed conditional support for peer reviews, including a preference to use them in larger groups and if they did not have a significant impact on the project. One student indicated that they did not really like peer reviews but believed they were necessary because they are a good tool for the instructor to evaluate students' performance. Another student noted that their team was professional and kept each other accountable and, as a result, did not think peer review were helpful.

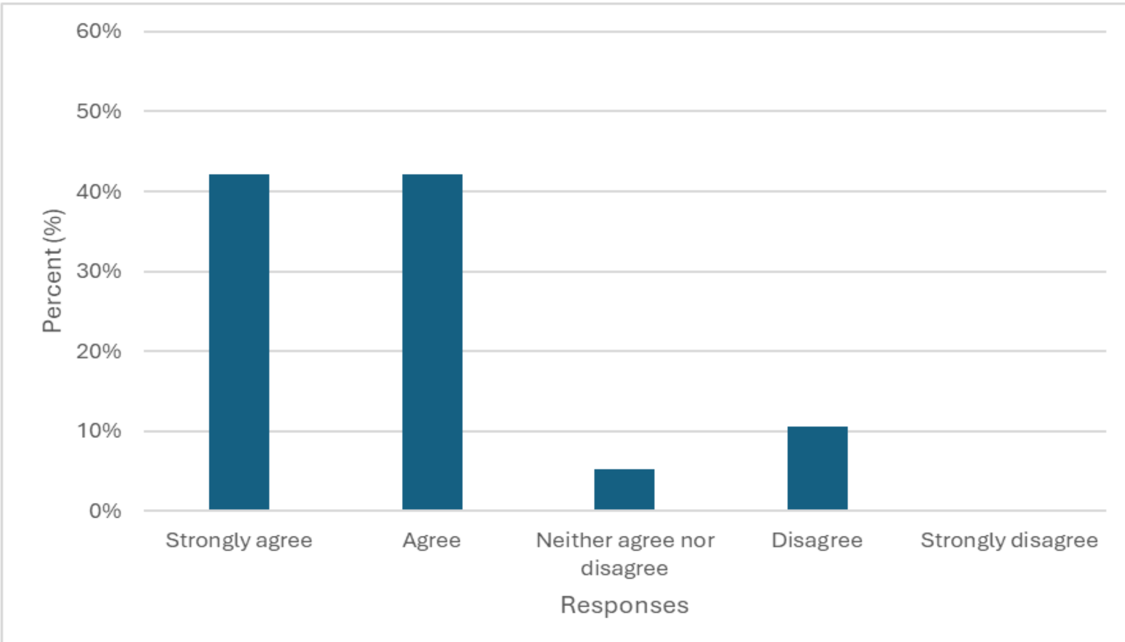

Figure 10: Reflection Report Results for: I would prefer to have peer reviews for future team projects.

Figure 11 shows that all students (n=11) in the course that utilized a team contract for their project indicated that the contract supported equitable contribution by all team members, with approximately 36% strongly agreeing and 64% agreeing. In comparison, students in the junior-level class that did not utilize team contracts were asked to respond to the statement, "Team contracts foster equitable contribution to the project by all team members." Among these students, 37.5% agreed, 50% neither agreed nor disagreed, and 12.5% disagreed. These results suggest that students who utilized a team contract for group work had a more favorable perception of its effectiveness in promoting equitable contribution than students who did not have experience using team contracts. All students in the senior-level class that utilized team contracts also agreed or strongly agreed that the team contract made them feel more accountable for their individual contributions to the project. Furthermore, all students in the senior-level class reported that they felt more confident that the workload would be distributed fairly among all team members as a result of the team contract.

The majority (73.7%) of students in both classes either strongly agreed (42.1%) or agreed (31.6%) with the statement, "I would prefer to have team contracts for future team projects." In addition, 21.1% neither agreed nor disagreed, while 5.3% disagreed. It is important to note that this result reflects responses from both the senior-level class, where team contracts were utilized and students had a significantly more favorable view, and the junior-level class, which did not utilize team contracts and had a less favorable view.

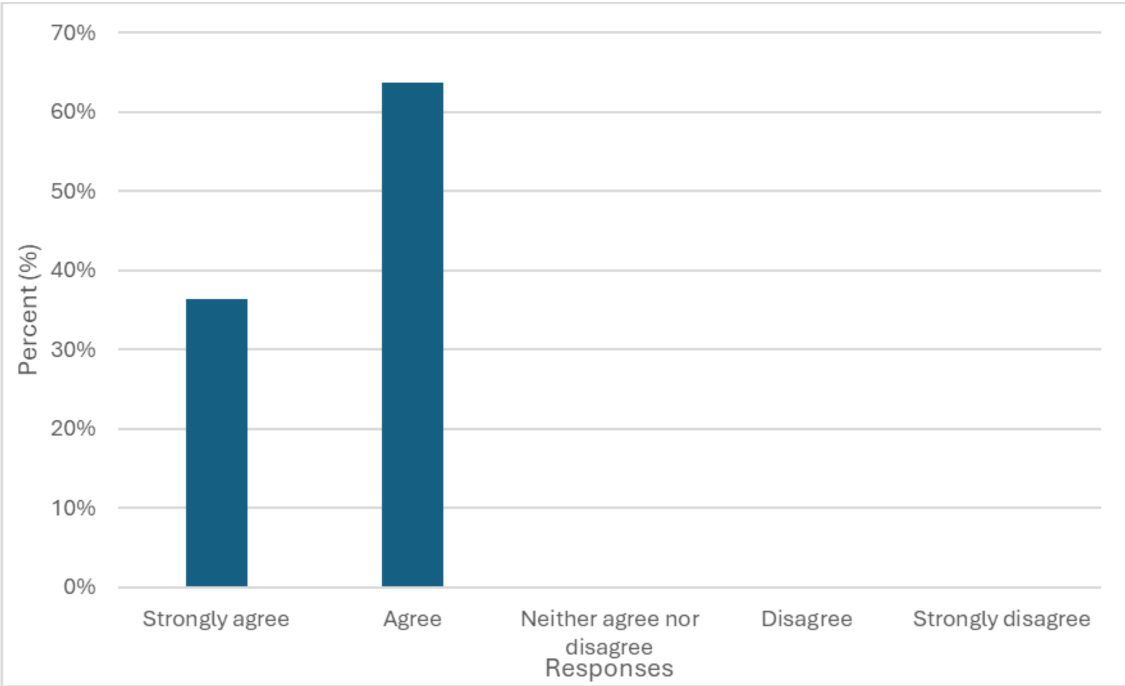

Figure 11: Reflection Report Results for: The team contract fostered equitable contribution to the project by all team members.

Similarly, most open-ended responses were positive, with frequent references to accountability and responsibility, often linked to fairness and equitable contribution. Many students also indicated that contracts clearly define roles, expectations, tasks, and consequences, which helps reduce ambiguity before the start of the project. Another benefit identified was improved communication. One student commented that they would be more supportive of team contracts if they were combined with peer evaluations. Mainly from the course that did not utilize team contracts for their project, some students stated that they were neutral or unsure about contracts because they had not used them and were uncertain of their effectiveness, or because their team worked well without one.

Conclusion

In conclusion, peer reviews appear to be welcomed and viewed as beneficial in engineering classrooms. In both universities considered in this study, the majority of students reported that peer reviews increase accountability. Over 80% of students in both universities indicated that they would prefer to include peer reviews in future team projects.

Students in both universities also expressed strong support for team contracts. In University of Waterloo sample, over 80% of students indicated that they would like to continue using team contracts. In University of South Caroline Upstate sample, which included both students who had used team contracts and those who had not, approximately 73% indicated a preference for using contracts in future projects. Students noted that these tools improved the quality of their work and increased accountability for both themselves and their teammates. Among students at the University of Waterloo who had used contracts in their classes, more than 80% reported that the workload was distributed fairly, and over 75% felt that the contracts made them feel more accountable. For University of South Caroline Upstate, 100% of students in the course that where team contracts were used agreed or strongly agreed that the use of team contracts increased accountability, fostered equitable contribution, and ensured a fair distribution of workload among team members. At the same time, both studies reported limited or no additional impact on students who already perceived themselves as possessing strong teamwork and accountability skills.

Overall, these results illustrate that peer reviews and team contracts are broadly effective in fostering accountability and equitable contribution [2]-[4], and both studies highlight the importance of combining peer reviews with team contracts. However, careful consideration is needed in how peer reviews are implemented. Many students, particularly at the University of Waterloo, expressed discomfort with providing feedback that could affect the grades of their peers, especially in a cohort system. Other areas for consideration include developing peer review methods that reduce bias. Potential mitigation strategies include implementing double-anonymized peer review to reduce social pressures or using non-graded peer review to encourage honest and constructive feedback.

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Appendix A:

General Activity Contract

This contract is to be used for all Activities except the Beam Activity.

1) Who is the team leader?
2) Who is the official recorder of decisions made?
3) List the main tasks to be performed. Try to identify the strengths and interests of each group member relative to these tasks. Then assign the tasks by writing the names of one or more group members against each task.

Task	**Assignee(s)**

4) Figure out the number of days from the date the Activity will be done until the due date. Fill in the Gantt chart shown below. You may not need all of its rows and columns.

Project step (Assignee)	**Day in Project Timeline**											
	-1	0	1	2	3	4	5	6	7	8	9	10
Read Activity instructions (All)												
Submit deliverable												

5) Report below how you plan to ensure that communication will be maintained, noting the primary means and expected times.

6) What will you do if one or more group members do not carry out their work and do so in a professional and timely manner? For purposes of this Activity, you have been granted the right to impose academic penalties on group members for non-performance. Assume the project is worth “10 points” maximum for each person.

7) Sign and date the agreement by the date the Activity is carried out.

I hereby agree to the terms of this contract. Date

Group members (names)	Signatures	

8) Just before the deliverable is submitted, indicate below any mark adjustments made by your group consistent with the performance terms (Clause #6) of your contract.

Appendix B:

Question Prompts for Engineering Reflection Report.

Question 1: How did teaching middle school kids impact your understanding of the concepts?

Question 2: How confident were you in answering questions the middle school kids had?

Question 3: How would you rate your level of interest in the topic you taught after teaching middle school children? Answer: Increased, Decreased, Unchanged, and why?

Question 4: How confident do you feel in your knowledge on the topic you taught now compared to before? Answer: More Confident, Less Confident, Unchanged, and why?

Question 5: Did researching/learning about the societal impact of the topic you taught change your perspective on your engineering discipline? How?

Question 6: Do you feel better connected to the local community after participating in this project? Why or why not.

Question 7: What did you like and/or dislike about this project?

Question 8: Would you recommend something be done differently for this project?

Question 9: Do you have any other comments or questions about this project?

Question 10: Did assessing your peers lesson plan help you learn different/more content? How?

Question 11: What was your experience working with your team members, and what could have improved your experience?

Question 12: What ethical or unethical behavior did your group experience and how did it affect the group's performance?

Question 13: The use of peer reviews fostered equitable contribution to the project by all team members,

Question 14: I felt more accountable for my individual contribution to the project because I would be evaluated by my peers.

Question 15: The team contract fostered equitable contribution to the project by all team members.

Question 16: I felt more confident that the workload would be distributed fairly among all team members because of the team contract.

Question 17: The team contract made me feel more accountable for my individual contribution to the project.

Question 18: I would prefer to have peer reviews for future team projects.

Question 19: I would prefer to have team contracts for future team projects.