

Assessing the Impact of Peer Feedback on Team-Based Learning in Environmental Engineering Education

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Abstract

The engineering design process in environmental engineering and sustainability often requires students to work in teams, yet team performance and cohesion can vary widely. Peer feedback has been proposed as a mechanism to enhance both accountability and collaboration, but its effects on learning outcomes and team dynamics remain debated. This study investigates whether varying the intensity of peer feedback meaningfully influences team cohesiveness and individual performance in an undergraduate engineering design course.

Students ($n=166$ across ten cohort sections) were randomly assigned to one of three conditions: control (no feedback), limited feedback (numeric survey only), or extensive feedback (numeric survey plus written comments). Approximately 30% of course points were allocated to team-based design work centered on water, sanitation, and health scenarios in a low-income country. To assess outcomes, students completed pre- and post-quizzes aligned to a targeted learning objective, participated in team projects, and immediately responded to a questionnaire measuring perceptions of team cohesion.

Quantitative data from quizzes, project scores, and cohesion surveys were analyzed to test for statistically significant differences across the three feedback conditions. The design controls for instructor variability and grading methods to better isolate the effect of peer feedback on team processes and individual learning. Results indicated no statistically significant differences in individual learning outcomes or team cohesion across feedback conditions, with effect sizes suggesting minimal practical impact.

These findings suggest that increasing the intensity of peer feedback, as implemented in this study, does not substantially influence short-term learning gains or perceived team cohesion. These insights are valuable for engineering educators seeking to optimize team-based learning environments and may inform best practices in environmental engineering and sustainability education.

Keywords: team cohesion, student learning, engineering design, collaborative learning

1. Introduction

Team based learning has become central to engineering education, reflecting the collaborative and interdisciplinary nature of professional engineering practice [1], [2]. Teams can be understood as interdependent groups of two or more individuals who share common goals, assume distinct roles, and collaborate within a structured organizational or instructional environment [3], [4]. In an engineering design project (EDP), teams of students must integrate technical knowledge, contextual constraints, and stakeholder considerations to address complex problems. The Accreditation Board for Engineering and Technology (ABET) identifies

teamwork as a required student outcome, reinforcing the expectation that engineering graduates can function effectively in high-performing teams [5].

Team-based projects are widely used in engineering education, but the effects of specific instructional design choices on student learning and team dynamics remain inconsistently understood [6]. While collaborative work is intended to promote deeper learning and professional skill development, substantial variation in team performance, equity in contribution, and team cohesion persists as challenges across courses and institutions [7], [8]. Students' experiences vary widely when assigned to teams, depending on their teammates' effort, communication, and reliability, which can lead to frustration and disengagement when team dynamics break down.

Research suggests that peer feedback and assessment can enhance individual responsibility, reduce social loafing, and enhance team cohesion [9], [10]. Prior work suggests that structured peer feedback can encourage individual responsibility and provide students with insight into their own teamwork behaviors [11], [12]. This feedback is most effective when it is timely, specific, and aligned with clear performance criteria [13], [14]. Additionally, peer feedback has been linked to psychological factors such as psychological safety and trust, which are critical for effective collaboration in design teams [15], [16]. Additionally, recent research reports that peer feedback implemented early and at multiple times during a project give team members the chance to make positive changes [17]. Peer feedback may stimulate individual performance, incentives effort, and that repeated use of peer feedback results in greater contributions to teamwork [18] - [20].

However, findings related to peer feedback are mixed regarding the relationship between peer feedback, individual learning outcomes, and team cohesion [21] - [23]. Some studies report improvements in teamwork behaviors or perceptions following peer evaluation interventions [4], [24], while others find limited or inconsistent effects on individual learning outcomes or overall team cohesion [25]. Although peer feedback has been widely examined, comparatively fewer studies experimentally isolate specific design variables within controlled instructional contexts, making it difficult to determine the causal impact of feedback structure on team cohesion or performance. The intensity of peer feedback is pedagogically meaningful because more detailed and reflective feedback may promote greater self-awareness, accountability, and behavioral adjustment than the mere presence of feedback alone. In this study, feedback intensity refers to the depth and modality of feedback provided, ranging from no feedback to numeric ratings only, to numeric ratings supplemented with written qualitative comments. Moreover, many studies treat peer feedback as a single intervention and do not examine the level of intensity of feedback, which may impact student learning and team cohesion. There is limited experimental evidence isolating the effects of different levels of peer feedback within the same course context while controlling instructor variability and grading practices.

This study addresses these gaps by experimentally isolating feedback intensity as an instructional design variable to examine the impact of varying levels of peer feedback on both individual learning and perceived team cohesion in an undergraduate environmental engineering design course. Guided by prior work on peer feedback and collaborative learning, this study tested two primary hypotheses. First, consistent with mixed findings in prior research, the level of peer feedback would not result in statistically significant differences in individual learning outcomes, as measured by changes in quiz performance. This null hypothesis was selected to evaluate whether increasing feedback complexity yields learning gains beyond those produced by existing instructional and collaborative structures. Second, increased levels of peer feedback would be associated with modest improvements in perceived team cohesion, given theoretical links between feedback processes, accountability, and team awareness. The findings of this paper offer practical insights for instructors seeking to balance pedagogical benefits of peer feedback with its implementation costs, while contributing experimental evidence to ongoing conversations about the design of peer evaluation systems in engineering education [26].

2. Methods

The study design involved the enrollment of 163 undergraduate students taking a senior design course for non-engineers. As part of the undergraduate curriculum, students whose academic major is not an engineering field must take three engineering courses, which can include this senior design course. Due to the low risk to the subjects, the Human Research Protections Program determined this study to be Institutional Research Board Exempt (CA-2026-6).

Students were taught by four (4) different instructors who collaborated with each other and oversaw 10 total cohort sections. 30% of the course point allocation was allocated to team assessments. Instructor teaching experience ranged widely among the four instructors, from zero to twenty-nine years. Cohorts were randomly assigned to one of three peer feedback methods (Table 1). One instructor had only an extensive feedback cohort because that person taught only one section of the course. All other instructors had cohorts for each feedback method. All teams in the same cohort used the same peer feedback method. The control condition neither provided nor received formal peer feedback; instead, it completed a ten-question Likert-scale survey measuring students' attitudes and perceptions toward peer feedback in teamwork. The limited feedback condition provided and received formal peer feedback after completing a ten-question Likert-scale survey that quantitatively evaluated each teammate. The extensive feedback condition completed the same quantitative feedback survey as the limited feedback condition, with an additional question to provide a constructive qualitative assessment of each teammate. For the limited and extensive feedback conditions, the course director formatted students' teammates' responses and then sent them directly to the students via email. Survey questions for each feedback method are provided in Appendix A.

Table 1. Distribution of students and project teams across peer feedback conditions by instructor. Student counts are shown, with the number of teams in parentheses; feedback conditions include no feedback, limited feedback, and extensive.

Instructor	No Feedback	Limited Feedback	Extensive Feedback	Total
Instructor A	-	-	13 (5)	13 (5)
Instructor B	16 (6)	17 (6)	13 (5)	46 (17)
Instructor C	18 (6)	18 (6)	17 (6)	51 (18)
Instructor D	18 (6)	17 (6)	16 (6)	53 (18)
Total	52 (18)	52 (18)	59 (22)	163 (62)

The peer feedback surveys were adapted from established teamwork evaluation constructs commonly used in CATME-style instruments [27]. These instruments assess teammate effectiveness across behaviorally grounded dimensions such as contribution, interaction, task management, quality expectations, and relevant knowledge and skills [28]. Items were modified for the course context using a five-point Likert scale and focusing on observable project behaviors, including attendance, preparation, communication, and dependability [29], [30]. The extensive feedback condition also included an open-ended prompt to elicit actionable comments.

To measure individual student performance, the experiment began with all students individually completing a pre-quiz to establish baseline knowledge and performance related to specific learning objectives. Those objectives pertained to the EDP, which was designed to evaluate student comprehension of latrine design in low- and middle-income countries. The EDP desired learning outcomes were that students could (1) estimate the volume of waste generated by a community and (2) solve for the size of a ventilated improved pit (VIP) latrine. In the four weeks following the pre-quiz, students collaborated within their assigned teams on the EDP. The project consisted of a series of designs addressing water, sanitation, and health scenarios in low- and middle-income countries. Two questions directly assessed the same latrine design learning objectives in the pre- and post-quizzes. After completing the team project, all students took an individual post quiz to assess learning outcomes and the impact of their team experience. Individual performance was measured using the pre- and post-quiz scores. Both pre- and post-quizzes are provided in Appendix B.

To measure overall team cohesion and team climate, students completed a ten-question Likert-scale survey for their team, focused on assessing how unified, trusting, and supportive the team felt as a whole. Like the student performance assessment, students took a baseline pre-survey before the intervention and a post-survey after the intervention. Team cohesion survey questions are provided in Appendix C. The team cohesion questionnaire was designed to capture students' perceived team unity, trust, support, and inclusive climate, consistent with cohesion and team

climate constructs used in prior teamwork research [31]. Items were written to be behaviorally interpretable by students and suitable for pre and post measurement within a single course.

Nonparametric statistical methods were used to evaluate differences in learning outcomes and team performance across feedback conditions. Normality was assessed using Shapiro–Wilk tests and graphical inspection of score distributions; although quiz score change did not significantly deviate from normality, outcomes were treated as non-normal because they were based on discrete Likert-scale responses and integer-valued quiz scores, resulting in bounded ranges and tied values. Accordingly, the raw differences in quiz performance change and EDP scores across the control, limited feedback, and extensive feedback were evaluated using Kruskal-Wallis tests. Pairwise comparisons were conducted on an exploratory basis to examine potential differences between feedback conditions. Within-team pre- to post-quiz changes were evaluated using Wilcoxon signed rank tests to determine the significance of the changes. Effect sizes were quantified using Cohen’s d for pairwise comparisons to assess the practical magnitude of observed differences, with conventional thresholds defined as negligible ($|d| < 0.20$), small ($0.20 \leq |d| < 0.50$), medium ($0.50 \leq |d| < 0.80$), and large ($|d| \geq 0.80$). Although non-parametric tests were used for hypothesis testing due to non-normality, Cohen’s d was used to provide an interpretable estimate of effect magnitude, widely used in engineering education research. Statistical significance was evaluated at $p < 0.05$.

The data were further divided by overall students' exam performance to examine potential interactions between peer feedback and individual performance. Exam score categories were based on two test scores and the final exam score. “High” performers were those who scored on average 90-100% (A- to A+), while “Medium” performers scored 83-89.99% (B to B+), and “Low” performers scored <83% (B- and below). These analyses aimed to clarify how each team's feedback method affected individual learning paths, in addition to the overall comparison of score variations among teams. Portions of the data analysis workflow, including code generation for statistical testing and figure formatting, were assisted by an AI-based language model (ChatGPT, OpenAI), with all analyses reviewed, validated, and interpreted by the authors.

3. Results and Discussion

3.1 Student Feedback Analysis

As shown in Table 2, overall ratings were high in both feedback conditions, with identical averages (mean = 4.57), with slightly lower variability in the extensive-feedback condition. The most frequent rating (mode = 5) occurred under both conditions, and the median was also at or near the highest possible score. These results suggest a potential ceiling effect, with limited differentiation between conditions as indicated by descriptive statistics.

Table 2. Descriptive Statistics for Limited and Extensive Feedback Conditions

Feedback Condition	Mean (Standard Deviation)	Median	Mode
Limited Feedback	4.57 (0.72)	5.00	5
Extensive Feedback	4.57 (0.59)	4.90	5

To increase transparency regarding how students interpreted the 1–5 Likert scale and the level of specificity provided in written feedback, anonymized examples from the extensive-feedback condition are presented. Examples were selected to reflect the range of specificity observed in written comments at the most common overall rating of 5, and to include one lower-rated example. These examples show that written justification varied substantially even at the highest ratings.

Table 3. Examples of Extensive-Feedback Responses

Overall Rating	Anonymized Excerpt
5 / 5	“We started early... breaking the work into roughly equal portions. Everyone met and we made it clear who was responsible for what. Each person has done their share.”
5 / 5	“[Teammate] did a phenomenal job... responsible for question two... dependable and reliable. Specific example: The night the project was due... my computer stopped working, so she completed the chart and submitted the project. Improvement: meeting earlier to avoid technical problems.”
4 / 5	“This person did a decent job... could have been more active at completing their parts... started on a problem but didn’t finish it yet... could be more proactive about communication.”

3.2 Individual performance effects

Across all three peer feedback conditions, changes in individual quiz performance did not differ significantly between teams. A Kruskal-Wallis test was used to compare changes in scores across the three peer feedback methods. This test provided insight into whether the teams had statistically significant differences in performance changes. Performance changes were calculated as the difference between post-quiz and pre-quiz scores. Additionally, medians and interquartile ranges were calculated to summarize the central tendency and variability within each condition. A paired analysis was conducted to examine the individual performance changes within each team formation method. This analysis focused on paired pre- and post-quiz scores of each participant, allowing for a direct assessment of learning improvements within each team. A Kruskal-Wallis test comparing changes in quiz scores across the three peer feedback conditions

showed no significant effect ($p = 0.41$) from the peer feedback method on the median scores within each team type. The median change in performance scores for control, limited feedback, and extensive feedback was -1.0%, 1.3%, and 3.9%, respectively (Figure 1).

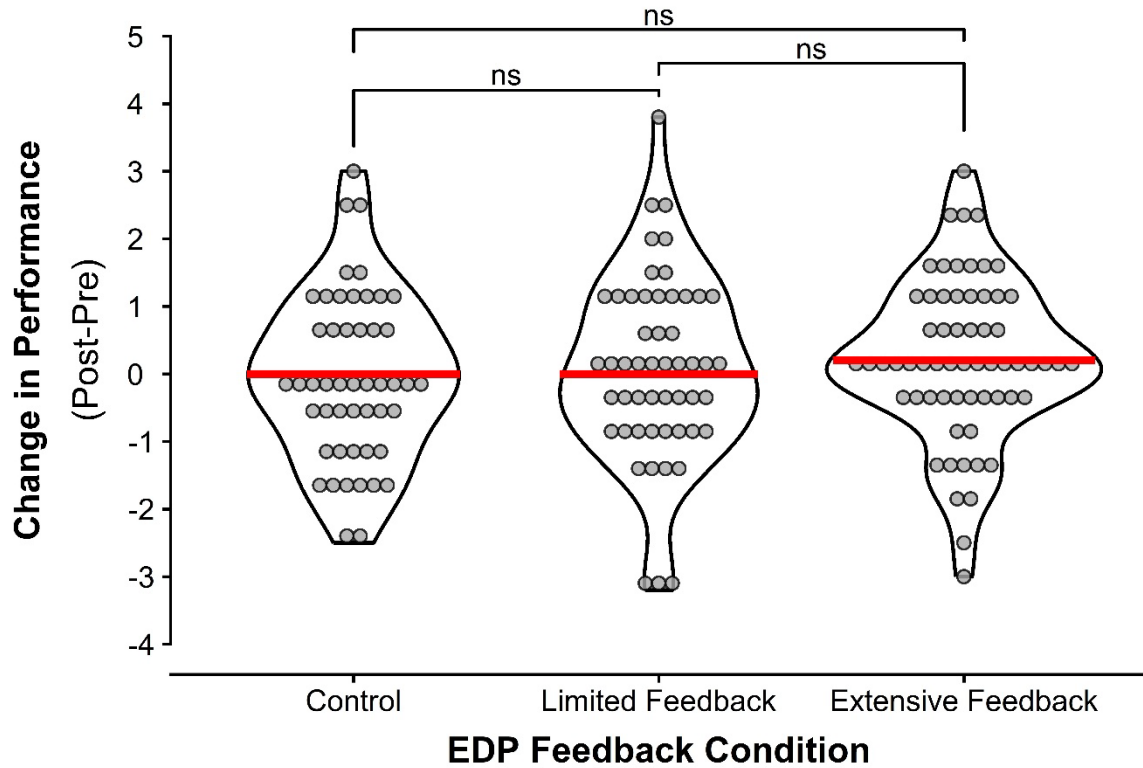


Figure 1. This graph illustrates the distribution of score changes (post-quiz minus pre-quiz) across the three feedback conditions. Plots show the spread of data, while the red line indicates median values. Individual data points are represented to highlight trends and variability within each feedback condition. Statistical comparisons indicate no significant differences (“ns”) in performance changes between feedback conditions.

Pairwise Cohen’s d effect sizes for percent change in quiz performance across feedback conditions were small to negligible ($|d| \leq 0.20$; Table 2). These results indicate minimal practical differences in performance gains between the control, limited feedback, and extensive feedback conditions, consistent with the non-significant omnibus test.

Table 4. Pairwise Effect Sizes for Quiz Performance Gains (Cohen’s d)

Comparison	Cohen’s d	Effect Size Interpretation
Control vs Limited Feedback	-0.09	Negligible
Control vs Extensive Feedback	-0.20	Small
Limited Feedback vs Extensive Feedback	-0.10	Negligible

Next, quiz score changes were computed for each student as the difference between post and pre quiz scores, preserving the paired structure of the data. Students did not improve on average between the control and limited feedback conditions, with the extensive feedback condition achieving a 4% improvement. Differences in individual quiz performance change across feedback conditions were not statistically significant (Kruskal-Wallis, $p = 0.40$). Within-condition analyses indicated no significant pre- to post-quiz changes for the control ($p = 0.67$), limited feedback ($p = 0.72$), or extensive feedback ($p = 0.16$) conditions (Figure 2). Additionally, the condition type did not reveal any clear trend when analyzing individual quiz score changes.

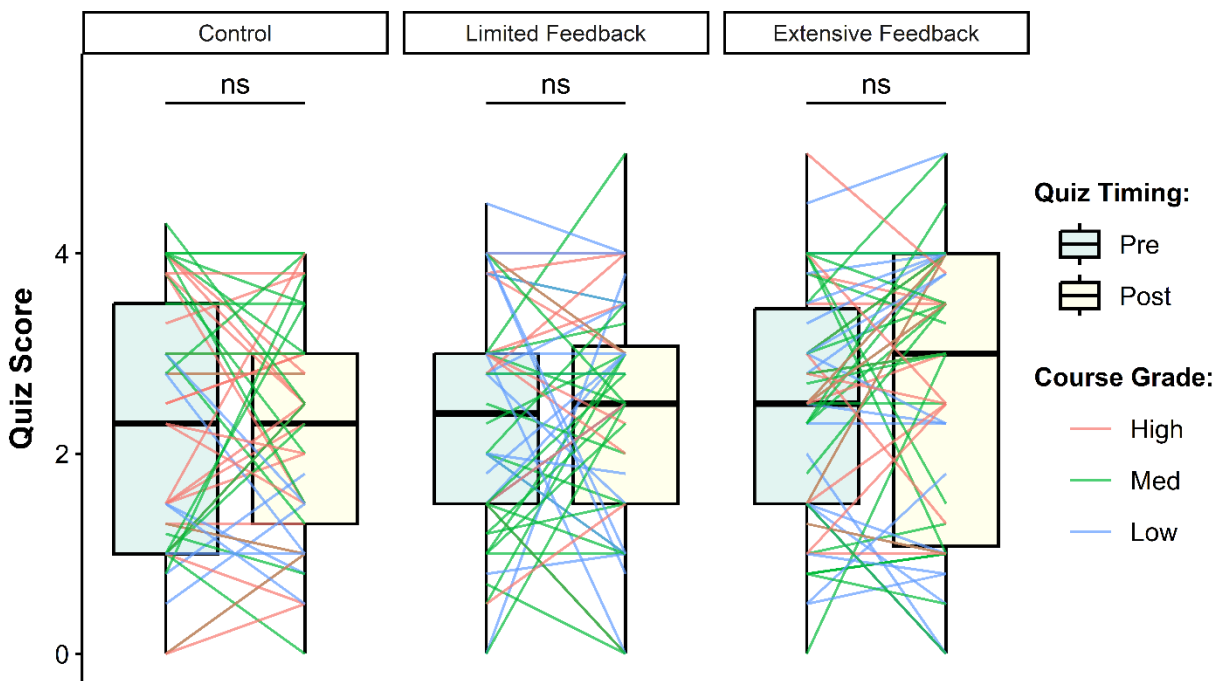


Figure 2. This graph depicts individual and group-level changes in quiz scores from pre- to post-assessment for each feedback condition. Boxplots show the distribution of scores at each time point, while lines connecting individual data points illustrate within-subject changes. Color coding represents participants' performance categories. Statistical comparisons indicate no significant differences (“ns”) in performance changes within groups, as determined by paired Wilcoxon signed rank tests.

These results can be explained by qualitative observations from instructors grading the pre and post quizzes. The quiz was relatively difficult compared to other course work and carried a low point value (5 points in a 1,000 point course). As a result, students may have prioritized more heavily weighted assessments and were less likely to reflect on instructor feedback between the pre and post quizzes. Consequently, limited changes in individual quiz performance were observed, consistent with the hypothesis that peer feedback would not result in statistically significant differences in individual learning outcomes.

3.3 Team cohesion effect

Using paired Likert-scale composite scores for the pre- to post-cohesion data there was a small change in team cohesion scores as feedback increased. The control condition's cohesion score decreased by -1.0%, while the limited feedback condition improved 2.7% and the extensive peer feedback condition improved 3.8%. There were no statistically significant differences in team cohesion scores across different feedback conditions (Kruskal-Wallis, $p = 0.83$). Further analysis within each group showed no significant changes within the control ($p = 0.64$), limited feedback ($p = 0.82$), or extensive feedback ($p = 0.29$) conditions (see Figure 3).

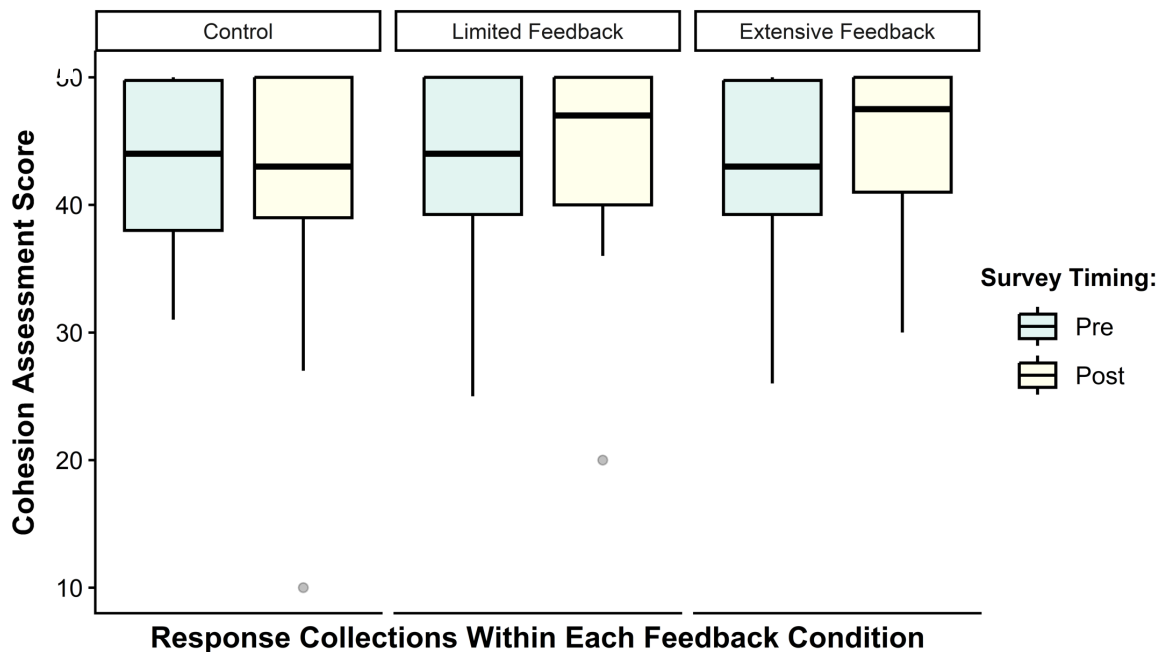


Figure 3. This graph depicts changes in cohesion assessment scores from pre- to post-assessment for each feedback method. Boxplots show the distribution of scores at each time point.

The absence of statistically significant effects for both individual performance and team cohesion indicates that peer feedback, as implemented in this study, does not meaningfully influence these outcomes. This interpretation is reinforced by the consistently small or negligible Cohen's d value, suggesting limited practical impact. Several features of the feedback process help explain the null findings. While the peer feedback instrument captured key dimensions of accountability and communication, it did not explicitly assess leadership adaptability or conflict negotiation behaviors emphasized in structured teamwork rubrics [32]. This narrower behavioral focus may partially explain the limited impact observed on overall team cohesion.

In the absence of instructor curation or explicit evaluation criteria, student feedback may have been overly vague or generic, limiting the usefulness of actionable guidance for improvement [13]. When feedback does not clearly signal how performance can be strengthened, it is unlikely to influence subsequent work [14]. Additionally, students may not have trusted or valued peer

feedback, particularly when differences in perceived expertise or effort existed within teams [10]. In such cases, feedback may be acknowledged but discounted, reducing the likelihood that it is meaningfully integrated into future team activities [25]. It is also possible that the duration of the study was insufficient for the peer feedback process to produce detectable changes in either outcome, as such effects may require repeated exposure over time. Together, these limitations help explain why peer feedback did not produce measurable effects in this study [24].

Despite the lack of measurable effects on individual performance or team cohesion, peer feedback may still serve important instructional purposes. Instructors often use peer feedback to promote accountability and reflection, shaping how students engage with tasks and teammates even when short term performance gains are not observed. However, when peer feedback is poorly structured, its benefits may not be distributed evenly. Vague or generic comments may leave lower performing students unsure how to improve while offering little added value to higher performing students. Pairing peer feedback with structured assessment and clear performance criteria may reduce these disparities by strengthening expectations and accountability.

End of course survey responses provide additional context for the quantitative findings and reveal mixed perceptions of team dynamics. Several respondents reported frustration with uneven contribution, and few described peer feedback as actionable or influential to learning. Instead, feedback was often perceived as procedural or secondary to instructor guidance. These observations suggest that without explicit scaffolding and clear criteria, peer feedback may lack sufficient specificity to influence individual performance or team cohesion, consistent with the null findings.

Future research should examine whether modifications to the implementation of peer feedback enhance its effectiveness. Providing explicit training on how to deliver high-quality, actionable feedback may improve both the substance and credibility of peer comments. Additionally, verbal peer feedback may be more effective than written feedback by enabling clarification, dialogue, and immediate follow-up. Investigating these approaches may help identify conditions under which peer feedback contributes more meaningfully to student learning and team processes.

4. Conclusion

This study examines the effects of varying levels of peer feedback on individual learning and team cohesion in an undergraduate engineering design course. The results indicated no statistically significant differences in individual learning outcomes across feedback conditions, with effect sizes suggesting minimal practical impact. These findings suggest that instructors may have flexibility in selecting the intensity of peer feedback without substantially affecting short-term learning outcomes and highlight the importance of structuring peer feedback to support effective team dynamics. The authors thank MAJ William Vass for his assistance in generating key figures for this conference paper.

References

- [1] J. E. Mathieu, J. R. Hollenbeck, D. van Knippenberg, and D. R. Ilgen, "A century of work teams in the Journal of Applied Psychology," *J. Appl. Psychol.*, vol. 104, no. 3, pp. 452–467, Mar. 2019, doi: 10.1037/apl0000356.
- [2] T. L. Rapp, L. L. Gilson, J. E. Mathieu, and T. Ruddy, "Leading empowered teams: An examination of the role of external team leaders and team coaches," *J. Appl. Psychol.*, vol. 106, no. 6, pp. 885–904, Jun. 2021, doi: 10.1037/apl0000811.
- [3] S. W. J. Kozlowski and D. R. Ilgen, "Enhancing the effectiveness of work groups and teams," *Psychol. Sci. Public Interest*, vol. 7, no. 3, pp. 77–124, Dec. 2006, doi: 10.1111/j.1529-1006.2006.00030.x.
- [4] A. P. Petkova, M. A. Domingo, and E. Lamm, "Let's be frank: Individual and team level predictors of improvement in student teamwork effectiveness following peer evaluation feedback," *The International Journal of Management Education*, vol. 19, art. no. 100538, Jul. 2021, doi: 10.1016/j.ijme.2021.100538.
- [5] ABET, *Criteria for Accrediting Engineering Programs, 2025–2026*, ABET Engineering Accreditation Commission, Baltimore, MD, USA. Accessed: Feb. 18, 2026. [Online]. Available: <https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2025-2026/>
- [6] Huang, K.-S. & Lei, H.-C. (2025) — Exploring the Influence of Team-Based Learning on Self-Directed Learning and Team Dynamics in Large-Class General Education Courses, *Education Sciences*, vol. 15, no. 9, article 1207, 2025, doi: 10.3390/educsci15091207.
- [7] J. M. Hatfield and J. T. Tester, "Assessing individual performance within a team using peer evaluations," in *Proceedings of the American Society for Engineering Education Annual Conference & Exposition*, Jun. 2004.
- [8] T. A. Powers, J. Sims Knight, R. A. Topciu, and S. C. Haden, "Assessing team functioning in engineering education," in *Proceedings of the American Society for Engineering Education Annual Conference & Exposition*, Jun. 2002.
- [9] C. M. Cestone, R. E. Levine, and D. R. Lane, "Peer assessment and evaluation in team based learning," in *Team Based Learning: Small Group Learning's Next Big Step*, New Directions for Teaching and Learning, no. 116, San Francisco, CA: Jossey Bass, 2008, pp. 69–78, doi: 10.1002/tl.334.
- [10] K. Topping, "Peer assessment between students in colleges and universities," *Review of Educational Research*, vol. 68, no. 3, pp. 249–276, Fall 1998.

- [11] D. R. Lane, "Peer feedback processes and individual accountability in team based learning," in *Team Based Learning for Health Professions Education*, Sterling, VA: Stylus Publishing, 2013, ch. 3, pp. 51–66.
- [12] R. A. Layton and M. W. Ohland, "Peer ratings revisited: Focus on teamwork, not ability," in *Proceedings of the American Society for Engineering Education Annual Conference & Exposition*, Jun. 2001.
- [13] D. J. Nicol and D. Macfarlane Dick, "Formative assessment and self regulated learning: A model and seven principles of good feedback practice," *Studies in Higher Education*, vol. 31, no. 2, pp. 199–218, Apr. 2006, doi: 10.1080/03075070600572090.
- [14] J. Hattie and H. Timperley, "The power of feedback," *Review of Educational Research*, vol. 77, no. 1, pp. 81–112, Mar. 2007, doi: 10.3102/003465430298487.
- [15] A. Edmondson, "Psychological safety and learning behavior in work teams," *Administrative Science Quarterly*, vol. 44, no. 2, pp. 350–383, Jun. 1999.
- [16] C. Cole, J. Marhefka, K. Jablokow, S. Mohammed, S. Ritter, and S. Miller, "What is the relationship between psychological safety and team productivity and effectiveness during concept development? An exploration in engineering design education," *Journal of Mechanical Design*, vol. 144, no. 11, Nov. 2022, doi: 10.1115/1.4054874.
- [17] C. M. Brooks and J. L. Ammons, "Free riding in group projects and the effects of timing, frequency, and specificity of criteria in peer assessments," *J. Educ. Bus.*, vol. 78, no. 5, pp. 268–272, 2003, doi: 10.1080/08832320309598613.
- [18] S. Brutus and M. B. L. Donia, "Improving the effectiveness of students in groups with a centralized peer evaluation system," *Acad. Manage. Learn. Educ.*, vol. 9, no. 4, pp. 652–662, Dec. 2010, doi: 10.5465/amle.2010.56659889.
- [19] J. Sol, "The effect of peer assessment on student effort and performance," *J. Econ. Educ.*, vol. 47, no. 2, pp. 125–140, 2016, doi: 10.1080/00220485.2016.1146098.
- [20] M. B. L. Donia, T. A. O'Neill, and S. Brutus, "The longitudinal effects of peer feedback in student teams," *Acad. Manage. Learn. Educ.*, vol. 17, no. 3, pp. 317–336, Sep. 2018, doi: 10.5465/amle.2016.0151.
- [21] E. Tavoletti, R. D. Stephens, and L. Dong, "Global virtual teams in education: Do peer assessments motivate student effort?," *Stud. Educ. Eval.*, vol. 70, Art. no. 101021, Sep. 2021, doi: 10.1016/j.stueduc.2021.101021.
- [22] E. Tavoletti, R. D. Stephens, and L. Dong, "The impact of peer evaluation on team effort, productivity, motivation and performance in global virtual teams," *Team Perform. Manage.*, vol. 25, nos. 5/6, pp. 334–347, 2019, doi: 10.1108/TPM-03-2019-0025.

- [23] K. G. Y. M. Kao, "Enhancing the quality of peer review by reducing student 'free riding': Peer assessment with positive interdependence," *Br. J. Educ. Technol.*, vol. 44, no. 1, pp. 112–124, 2013, doi: 10.1111/j.1467-8535.2011.01278.x.
- [24] B. P. O'Connell, K. Schulte Grahame, R. Whalen, C. Mukasa, and S. F. Freeman, "Fruitful endeavors: Continuous peer feedback to develop positive team dynamics," in *Proceedings of the American Society for Engineering Education Annual Conference & Exposition*, Jun. 2025.
- [25] N. A. E. van Gennip, M. S. R. Segers, and H. H. Tillema, "Peer assessment for learning from a social perspective: The influence of interpersonal variables and structural features," *Educational Research Review*, vol. 4, no. 1, pp. 41–54, 2009, doi: 10.1016/j.edurev.2008.11.002.
- [26] B. Krueger, W. Vass, D. Zgonc, and M. Baideme, "Collaborative learning in engineering: Analyzing the effects of group formation on student outcomes," in *Proceedings of the American Society for Engineering Education Annual Conference & Exposition*, Feb. 2025.
- [27] M. W. Ohland, S. D. Loughry, D. J. Woehr, L. G. Bullard, R. M. Felder, C. J. Finelli, R. A. Layton, H. R. Pomeranz, and D. G. Schmucker, "The comprehensive assessment of team member effectiveness: Development of a behaviorally anchored rating scale for self and peer evaluation," *Acad. Manage. Learn. Educ.*, vol. 11, no. 4, pp. 609–630, 2012, doi: 10.5465/amle.2010.0177.
- [28] S. D. Loughry, M. W. Ohland, and D. J. Woehr, "Assessing teamwork skills for assurance of learning using CATME team tools," *J. Mark. Educ.*, vol. 36, no. 1, pp. 5–19, 2014, doi: 10.1177/0273475313499022.
- [29] A. J. Kemppainen, A. Hamlin, M. Barron, and M. Raber, "Comparing team evaluation software (Team+ and CATME)," in *Proc. IEEE Frontiers Educ. Conf. (FIE)*, 2022, doi: 10.1109/FIE56618.2022.9962624.
- [30] S. Wei, R. Wang, M. Ohland, and G. Nanda, "Work in progress: Automating anonymous processing of peer evaluation comments," in *Proc. ASEE Annu. Conf. & Expo.*, Virtual Conf., 2020.
- [31] S. Wei and Y. Han, "A call to foster psychological safety to facilitate inclusive and effective engineering student teams and learning," *Eng. Educ. Rev.*, vol. 2, no. 4, pp. 172–181, 2024, doi: 10.54844/eer.2024.0839.
- [32] S. Thite, J. Ravishankar, I. Tomeo Reyes, and A. Martinez Ortiz, "Design of a simple rubric to peer evaluate the teamwork skills of engineering students," *Eur. J. Eng. Educ.*, vol. 49, no. 4, pp. 623–646, 2024, doi: 10.1080/03043797.2024.2338239.

Appendix A: Peer Feedback Forms (Limited and Extensive)

Limited Peer Feedback Form

Purpose: Provide quick, numeric feedback on your teammate's contributions to the engineering design project.

Instructions: Rate each statement on a scale from **1 (Strongly Disagree)** to **5 (Strongly Agree)** based on this peer's performance during the project. Circle the appropriate number.

#	Question	1	2	3	4	5
1	This teammate regularly attended scheduled team meetings.	☐	☐	☐	☐	☐
2	This teammate arrived on time for team meetings and work sessions.	☐	☐	☐	☐	☐
3	This teammate came prepared for meetings, having completed assigned work in advance.	☐	☐	☐	☐	☐
4	This teammate actively contributed useful ideas during discussions.	☐	☐	☐	☐	☐
5	This teammate communicated clearly and respectfully with team members.	☐	☐	☐	☐	☐
6	This teammate listened to and considered the ideas of others.	☐	☐	☐	☐	☐
7	This teammate consistently completed their share of the work.	☐	☐	☐	☐	☐
8	This teammate demonstrated technical competence relevant to the project.	☐	☐	☐	☐	☐
9	This teammate was dependable and followed through on commitments.	☐	☐	☐	☐	☐
10	Overall, this teammate was a valuable contributor to the success of the project.	☐	☐	☐	☐	☐

Scale:

1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree

Extensive Peer Feedback Form

Purpose: Provide quick, numeric feedback on your teammate's contributions to the engineering design project.

Instructions: Rate each statement on a scale from **1 (Strongly Disagree)** to **5 (Strongly Agree)** based on this peer's performance during the project. Circle the appropriate number.

#	Question	1	2	3	4	5
1	This teammate regularly attended scheduled team meetings.	☐	☐	☐	☐	☐
2	This teammate arrived on time for team meetings and work sessions.	☐	☐	☐	☐	☐
3	This teammate came prepared for meetings, having completed assigned work in advance.	☐	☐	☐	☐	☐
4	This teammate actively contributed useful ideas during discussions.	☐	☐	☐	☐	☐
5	This teammate communicated clearly and respectfully with team members.	☐	☐	☐	☐	☐
6	This teammate listened to and considered the ideas of others.	☐	☐	☐	☐	☐
7	This teammate consistently completed their share of the work.	☐	☐	☐	☐	☐
8	This teammate demonstrated technical competence relevant to the project.	☐	☐	☐	☐	☐
9	This teammate was dependable and followed through on commitments.	☐	☐	☐	☐	☐
10	Overall, this teammate was a valuable contributor to the success of the project.	☐	☐	☐	☐	☐

Scale:

1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree

Purpose: Provide constructive, detailed feedback on your teammate's contributions to the engineering design project.

Prompt:

Please complete the following three sections when giving feedback to your teammate. Be honest, specific, and constructive.

1. Summary of Contributions

In 2–3 sentences, describe how this teammate contributed as a member of the engineering design project. Consider their attendance, preparation, quality of contributions, communication, respect for others' ideas, dependability, and whether they carried their fair share of the work.

2. Specific Example

Provide at least one specific example that illustrates how this teammate contributed to the project (positive or negative).

3. Areas for Improvement

List at least one suggestion for how this teammate could improve as a teammate in future team projects.

Appendix B: Pre and Post-Quiz

Name: _____

Section: _____

Research Pre-Quiz

*You have ten minutes to complete the pre-quiz. It is a **graded** individual assignment for which you can use only an unmarked EV450 Helpful Equation Sheet and a calculator.*

1. You are designing a VIP latrine for Binayo's household in Konso, Ethiopia, and six other households of nearby family members (30 people total). Water table depth is 8.0 m, and the soil is 40% clay. The design life is 12 yr and the anal cleansing material is toilet paper.

a. Calculate the required pit size (volume) to the nearest m^3 . Explicitly state and justify your solids accumulation rate assumption. Report the final answer in the gray box below.

Answer

Name: _____

Section: _____

b. Determine the appropriate pit dimensions considering the water table. State your final dimensions (round up to the nearest 0.1 m), including width and length (or diameter, if circular) and depth. Report the final answer in the gray box below.

Answer

Post-Quiz

You have ten minutes to complete this quiz. It is a **graded** individual assignment for which you can use only an unmarked EV450 Helpful Equation Sheet and a calculator.

1. You are designing a VIP latrine for Binayo's household in Konso, Ethiopia, and eight other households of nearby family members (40 people total). Water table depth is 7.0 m, and the soil is 25% clay. The design life is 8 yr and the anal cleansing material are corn husks (bulky).

a. Calculate the required pit size (volume) to the nearest m^3 . Explicitly state and justify your solids accumulation rate assumption. Report the final answer in the gray box below.

Answer

Name: _____

Section: _____

b. Determine the appropriate pit dimensions considering the water table. State your final dimensions (round up to the nearest 0.1 m), including width and length (or diameter, if circular) and depth. Report the final answer in the gray box below.

Answer

Appendix C: Cohesiveness Survey

Purpose: To assess your perceived level of team cohesion

Instructions: Rate each statement on a scale from **1 (Strongly Disagree)** to **5 (Strongly Agree)** based on this peer's performance during the project. Circle the appropriate number.

#	Question	1	2	3	4	5
1	Our team works well together to achieve common goals.	☐	☐	☐	☐	☐
2	Team members openly share their ideas and opinions.	☐	☐	☐	☐	☐
3	I feel a strong sense of belonging to this team	☐	☐	☐	☐	☐
4	We support each other during challenging tasks.	☐	☐	☐	☐	☐
5	Conflicts in our team are resolved constructively.	☐	☐	☐	☐	☐
6	Everyone in the team is committed to our shared objectives.	☐	☐	☐	☐	☐
7	Our team communicates effectively and regularly.	☐	☐	☐	☐	☐
8	I trust the other members of my team.	☐	☐	☐	☐	☐
9	We celebrate each other's achievements and contributions.	☐	☐	☐	☐	☐
10	Our team maintains a positive and inclusive atmosphere.	☐	☐	☐	☐	☐

Scale:

1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree