Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025 ASEE
Paper ID #47096

Fruitful Endeavors: Continuous Peer Feedback to Develop Positive Team Dynamics

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Introduction

In a first-year engineering Cornerstone course, teams are formed at the beginning of the term to collaborate equitably and engage in course projects involving a prototype's design, construction, and programming addressing a complex problem. The final project driving this course is open-ended, allowing student teams to determine what hands-on requirements they will choose. The breadth of options available requires decision-making within teams, a complex skill requiring practice and maturity of many other abilities. The high expectations that first-year students sometimes have of their peers and a mismatch of backgrounds in effective teamwork have led to conflicts among teammates over the years that instructors inevitably need to solve.

To help students navigate the many decisions they must make with their team on this open-ended project, the Cornerstone instructors first implement a team contract assignment early in the semester. This group assignment has the purpose of establishing mutually agreed-upon team standards. These norms encompass five aspects of team success, which are derived from best practices we gathered from the 2023 Interprofessional Education Collaborative (IPEC) Competencies [1]: (1) Respect, (2) Commitment, (3) Transparency, (4) Communication, and (5) Justice. Students answer a series of questions surrounding their mutual expectations for each other in these categories and thus set themselves up for a clearer understanding of the people they are working with and, most importantly, the tools for individual governance. Furthermore, teams were asked to conduct two 360-degree feedback evaluations of each other, which are performance-based assessments. One evaluation was performed midway through the project and another at the end of the term to ensure they developed the desired teamwork skills to successfully and equitably finish their projects.

While this intervention had been modestly successful for the instructional team and our students in the past, there was still the occasional conflict where team members were surprised that the team dynamics broke down at the time of evaluation and hard feelings developed. Students mentioned negative topics such as unequal workload distribution, communication breakdowns, and free-riding. To encourage more frequent communication and to have a window into individual commitment, the instructional team decided to utilize a newly available tool, FeedbackFruits, for more optimized peer feedback and reporting. They integrated this tool into the project curriculum to enable more frequent peer feedback evaluation.

The evaluation would be conducted following each project assignment, either weekly or biweekly. Instead of a larger 360-evaluation that was generalized, this new evaluation mapped all questions back to the individual definitions of the five aspects of team success. Each team member was tasked with evaluating themselves and their teammates on the degree to which they adhered to four of the five expectations (respect, commitment, transparency, and communication) outlined in the team contract they wrote for themselves. This limitation to these 4 was due to the first broad implementation of this evaluation and those metrics being deemed more immediately visible and measurable for the students. The justice portion of their contracts is intended to be addressed internally and through the grading adjustments resulting from the evaluations to help students see the consequences of their actions. A copy of this evaluation, with a rubric designed by the authors, is provided in Appendix A. This continuous peer feedback intervention was intended to facilitate the early identification of issues and provide a constructive space to help individuals recognize areas where they may not meet established expectations. It also allowed instructors to identify when grades should be adjusted to promote equity,

negatively when a student was identified as a “free rider,” and positively for those undertaking the resulting increased burden.

This paper investigates the results of implementing a continuous peer feedback evaluation process, using FeedbackFruits to facilitate a significant increase in peer review sessions throughout a design project that directly influences performance. With this intervention, we intended to cultivate a learning environment where students truly improved their ability to maturely and equitably handle a large integrated hands-on project. To measure the success of this initiative, the team analyzed the collected peer evaluations to examine the data provided by the tool and data obtained from reflective reports both pre and post-intervention to provide comparative insight on the success of this intervention. Additionally, the paper describes the use of the software in various projects and analyzes the outcomes, offering recommendations for broader implementation. While acknowledging the complexity and nuance of team dynamics, we anticipate this research will establish a baseline for improving motivation and addressing teamwork challenges in first-year engineering courses.

Literature Review

Team dynamics play a critical role in determining whether there is a successful outcome to a project-based learning experience in the classroom. Peer feedback is a key mechanism for reinforcing positive team interactions, and providing structured opportunities for reflection and improvement. Prior research has identified several factors that contribute to high-functioning teams: fairness, responsibility, trust, cooperation, accountability, ownership, shared commitment, effective communication, adaptability, and willingness to learn to name several [2], [3], [4], [5], [6], [7], [8]. While many of these factors are crucial to team success, structured peer evaluation has been shown to support several of these attributes directly. This literature review will focus on the factors that align most closely with the constructs guiding this study: Respect, Commitment, Transparency, Communication, and Justice [1].

Respect is central to effective teamwork, ensuring that all members' contributions are valued. Psychological safety, which allows team members to express ideas without fear of negative repercussions, is a crucial component of respect in team settings [6]. Mutual recognition of contributions and active listening strengthen team cohesion, reinforcing a culture of respect. Structured peer feedback ensures that students systematically evaluate peer contributions, fostering a culture of mutual accountability. Research has shown that structured evaluation tools can enhance team cohesion by encouraging members to acknowledge each other's efforts [9], [10].

Commitment to a team’s success involves responsibility, engagement, and follow-through on assigned tasks. Research indicates that when individuals feel accountable to their peers, they are more likely to contribute equitably and take ownership of their responsibilities [3]. Team-based learning models emphasize structured accountability mechanisms to ensure that all members remain engaged in the project’s success [11]. Regular peer feedback reinforces commitment by making individual contributions transparent to both teammates and instructors. Studies on engineering team performance show that frequent assessments encourage students to reflect on their engagement levels and take proactive steps to improve participation in upper-level engineering design courses [12].

Transparency ensures that all team members have access to necessary information and that expectations remain clear. Research highlights the importance of openness in decision-making to prevent misunderstandings and promote trust among team members [7]. Transparent communication is particularly critical in collaborative learning environments, where clarity regarding roles and responsibilities improves workflow efficiency. Peer evaluation frameworks provide an opportunity for structured transparency, allowing students to explicitly document their contributions and any concerns

regarding workload distribution. Structured feedback mechanisms help teams set clear expectations and reduce resentment over perceived workload inequities [4], [8].

Effective communication is a cornerstone of teamwork, influencing everything from task coordination to conflict resolution. Research on engineering team communication suggests that structured dialogue enhances group cohesion and problem-solving capabilities [4]. The ability to provide and receive feedback constructively is a critical skill that supports long-term professional development [13]. The iterative nature of continuous feedback strengthens communication skills by requiring team members to articulate their concerns and commendations in a structured manner [14].

Justice in teamwork refers to fair treatment, equitable work distribution, and mechanisms for addressing grievances. Organizational justice research underscores the importance of procedural fairness in evaluating performance, ensuring that all team members are assessed equitably [5]. Peer assessment tools help enforce fairness by allowing students to identify disparities in contributions, ensuring that effort is recognized and rewarded appropriately. Research on grading adjustments based on peer evaluations suggests that structured assessment models mitigate common issues like free-riding and disproportionate workloads [15].

Peer evaluation supports these constructs by offering a structured approach to monitoring and enhancing team dynamics, ensuring accountability and equity. Studies indicate that when teams engage in regular peer feedback cycles, they become more self-aware and proactive in resolving conflicts, reducing the likelihood of issues such as poor communication, inequitable workload distribution, and disengagement. Various peer evaluation tools in engineering education enhance teamwork by promoting accountability, transparency, and effective communication [8], [9], [13]. Additionally, the use of these student team-focused software tools has been shown to be effective in creating balanced teams to optimize performance and efficiently allow students to evaluate the performance of their peers [9], [15], [16], [17]. These findings underscore the importance of continuous peer feedback in project-based learning, equipping students with the essential teamwork skills necessary for professional engineering practice.

Background

Cornerstone of Engineering I and II at Northeastern University are standard for all engineering majors, and two general engineering courses are offered each semester. Approximately 30 separate sections are run, with each section accommodating around 32-36 students, totaling approximately 1,000 students annually. Provided through the First-Year Engineering Program, these courses incorporate hands-on design projects, computer-aided design (CAD), programming, and the use of microcontrollers. In project-based Cornerstone courses, a key instructional challenge is managing the inherent mismatch between the linear delivery of course content and the nonlinear nature of engineering problem-solving and design. While content must be taught in a structured, sequential manner to ensure consistency across students, the application of that content, especially in team-based projects, often emerges in a more organic, networked fashion, reflecting the realities of professional engineering practice. By explicitly framing this incongruence as both expected and beneficial, we can better support students with diverse learning styles and aptitudes, helping them recognize that integrating a range of competencies at different times and in various ways is a critical part of real-world problem-solving. In this way, Cornerstone serves not just as a curriculum foundation but as a lens through which students experience how engineering knowledge coalesces to create practical solutions.

The curriculum focuses on learning the principles of engineering and design, which is accomplished through active learning in areas such as problem definition, conceptual design, preliminary and detailed design, design communication and implementation, and engineering ethics. The courses emphasize

technical communication through report writing and presentations related to the projects. There is a strong emphasis on applying technical knowledge, developing problem-solving and decision-making skills, and using computer-aided design (CAD) to communicate graphically.

Algorithmic thinking and programming with C++ and Mathworks' MATLAB are introduced along with the basic use of microcontrollers. Procedural programming using functions is covered to facilitate using Arduino-based micro-controllers and common electronic components such as LEDs, potentiometers, servos, motor controllers, and other sensors. CAD packages like AutoDESK's AutoCAD and SOLIDWORKS are taught and used for the graphical communication of design elements. These are done through individual assignments and advanced by the technical requirements of the design projects, encouraging the advanced use of these tools. All these elements are taught to help facilitate the solution to the design problem at hand.

Methodology

Team Formation

During the first week of the semester, students were invited to complete a detailed Google form to gather various information. The information included demographics, prior skills and competencies assessments, self-identified leadership qualities, and time availability. The collected data was imported into an innovative open-source team-forming tool, Gruepr [15]. This is all part of standard practice for team formation in these courses, independent of the new use of the peer review tool. Gruepr facilitates the formation of optimal student teams by utilizing a set of specific preferences and weighting options established by the instructor [16]. In this study, the teams were formed based on heterogeneous work preferences and schedule availability. Factors like avoiding the isolation of female students on a team and requests for preferred and non-preferred teammates were considered in the process.

The instructors significantly reduced the effort and time required to balance resources by utilizing this tool. The aim was to minimize common issues like groupthink, free-riders, and suboptimal team member evaluations [18], [19]. Once the teams were successfully formed, teammates met and collaboratively created a team contract. This contract served as a foundational guide that outlined the expectations and conflict resolution criteria. The team formation process has been consistently applied for several semesters and validated through previous studies [15], [16].

Data Collection

For this study, the FeedbackFruits platform through Canvas was used as a medium for self-assessment and to provide feedback to teammates on their team project contributions to improve team dynamics. The utilization of this tool, FeedbackFruits, repeatedly throughout the projects served as the intervention this study examined. The cohort in the FeedbackFruits study included two classes in the Fall semester of 2024 with 64 participating students and a control cohort of two classes in the Spring semester of 2024 with 51 participating students. All these courses are identical in structure and have a service learning component. Since the tool was new to all students, the two milestones of the introductory mini-project were used for training and acclimatizing the students to the tool and the type of feedback expected, but no grade adjustment was implemented. At the end of each project milestone, a new survey/assignment was completed by all students in the study cohort.

After the training phase, six sessions were selected from the major project milestones. These were selected as the study's focus as they were the instances where the tool was being used to its full and intended extent where peer feedback directly influenced students' overall grades. The complexity of the

milestones increases as the project progresses, with the prototype developing in complexity and the remaining time reducing. However, the level to which becomes dependent on the team's selected project. It was assumed that the impact on grades heightened students' engagement with the feedback process, and, as they were instructed to do, students treated each session independently. These assumptions were not verified for all students, representing a potential limitation in the study. Each peer review assignment consists of three stages in this order: 1) Evaluation of self and teammates, 2) Feedback review by the students, and 3) Reflection on the feedback. Each phase had a different due date, and based on the feedback received, the platform made a suggested grade adjustment. The instructors could accept the suggested grade adjustment or manually change the grade based on the feedback and any initial accommodations granted to the student in question. At the end of the semester, the FeedbackFruits tool offers a comprehensive suite of data from each of the six feedback sessions, encapsulating various elements such as peer evaluations, proposed grade adjustments, assessments of feedback quality, and participation metrics. The standard analytics for each evaluation were collected and aggregated, resulting in a wealth of data for a thorough exploration of team dynamics and individual contributions.

Additionally, for comparison purposes, student reflections were gathered from two distinct semesters: one prior to implementing FeedbackFruits and the other after its application. The reflections were captured in the final report for their major design project for the semester, utilizing an existing scholarly artifact that has been consistently used for several years by all involved instructors. The analysis focused exclusively on a sub-section of the reflection that prompted them to discuss their experiences working on a design team. Each participant provided reflective statements regarding their experiences with teamwork, leadership, and project management. Reflections were structured to include insights on challenges faced, leadership styles, group dynamics, and personal contributions. Though not specifically asked for, this data was analyzed for the level of engagement pertinent to team dynamic concepts. The analysis utilized a systematic qualitative approach, incorporating iterative validation, refinement, and categorization strategies informed by best practices in qualitative research and emerging AI-based techniques[20], [21], [22], [23].

Data Handling and Analysis

This report compares Cohorts A, B, C, and F Datasets, summarized in Table 1. The quantitative analysis focuses on the FeedbackFruit group-level results for Cohorts C and F. The qualitative analysis focuses on the overall cohorts' engagement with key team dynamics (Respect, Communication, Transparency, Commitment, and Any). Datasets A and B were conducted in the same semester under Prof X, while Datasets C and F were from the subsequent semester. Dataset C was under Prof X&Y (Co-teaching), and Dataset F was under Prof Z, all employing the same project assignments, peer review surveys, and interventions to enhance engagement.

Table 1: Dataset Details and Content Counts Used in Analysis

Dataset	Semester	Prof.	Groups	Students	Reflections	Total Statements
A	S24	X	7	32	22	450
B	S24	X	8	36	29	562
C	F24	X&Y	8	33	30	601
F	F24	Z	8	34	34	655

There is a discrepancy between the total number of students and the total number of reflections. This is due to a lack of usable digital copies of some reports and incomplete transcriptions. Some students also did not complete the team dynamic reflection portion either.

Quantitative Study

The study aimed to explore overarching “first glance” trends observed within the tool’s data. One of the key focus areas pertains to the FeedbackFruits’ ‘suggested adjustment,’ which was identified as a significant indicator of overall team engagement. This metric directly reflects the outcomes from peer evaluations, effectively capturing team members' perceived contributions and engagement levels. It integrates quantitative metrics and qualitative insights from peer feedback into a consolidated and actionable value. To further analyze this indicator, we calculated each team's standard deviation of the ‘Suggested Adjustment.’ This statistical measure was then plotted to identify emerging trends, allowing us to visualize variations in team engagement and providing deeper insights into group performance dynamics.

Qualitative Study

Student report reflections were preprocessed using ChatGPT for high-level analysis. Datasets were manually formatted to ensure consistent wrangling by the AI, using standardized key phrases and structured formatting to enhance the AI's ability to parse and interpret the information accurately. This study implemented a simplistic segmentation, considering each sentence as a single statement, to improve reliability and repeatability. This process was systematically repeated and refined by utilizing subsets of the data with established qualities until preprocessing consistently achieved accurate parsing following emerging best practices [23].

Throughout the analysis, refinements were made to prompts and categorizations, ensuring alignment with the nuances of each reflection. Reanalysis occurred in ambiguous or context-dependent statements, maintaining the integrity of findings. The process included data parsing and categorization checks as validation measures. These involved checking statement and reflection counts against confirmed values and human confirmation of categorization of randomly selected passages. Validation failures led to rechecks and adjustments of the internal procedure. As changes were made to the analysis process, all datasets were reevaluated until validations consistently passed [20], [22], [23], [24].

Categorization and Quantification

Once the tool demonstrated reliable information handling, all datasets were fully processed, loading in all reflections and categorizing them by cohort, group, and individual. Subsequently, these were segmented into individual statements for granular analysis.

The analysis focused on four key dimensions in the FeedbackFruits peer evaluations: Respect, Communication, Transparency, and Commitment. Each dimension was operationalized as follows:

- Respect: Statements involving mutual appreciation or acknowledgment of contributions.
- Communication: Explicit or inferred mentions of dialogue, feedback, or information exchange.
- Transparency: References to honesty, openness in processes, or clear expectation-setting.
- Commitment: Indicators of dedication, responsibility, and follow-through.

Leveraging ChatGPT’s natural language processing capabilities, reflections were analyzed in the following stages regarding the four key dimensions:

- Explicit Identification: Statements containing explicit mentions of key concepts were tagged using keyword and phrase matching (e.g., "respectful," "communicated clearly") [24]. This included common synonyms and other word classes of the keywords.

- Implicit Categorization: AI-assisted inference was used to identify implicit mentions of concepts. For instance, a statement about resolving conflicts by seeking help may indicate respect and communication [21], [23].

Each segmented statement was categorized under the relevant dimensions. Counts and percentages were calculated to quantify the representation of explicit and implicit mentions per category. To account for the simple definition of a "statement," double coding was allowed when a statement reflected multiple dimensions. This approach was explicitly accounted for in the "Any Category" count to avoid inflating results due to overlapping categorizations. Additionally, the methodology ensured that categorization decisions were consistent using iterative validation and researcher cross-checking. For this initial analysis, cohort-wide data was aggregated to provide a high-level comparison of the overall student outlook and internalization of the four key dimensions of team dynamics. A statistical analysis using a *p*-value threshold to determine statistical significance changes in pre and post-intervention datasets was applied across all metrics.

Results

This initial analysis focuses on high-level, readily accessible data provided by the FeedbackFruits analysis after each assessment in the form of their 'Suggested Adjustment,' their recommended change in the individual student's grade from assigned group grade based on the feedback and evaluations of the team. The analysis identifies potential trends based on that in combination with grade performance and instructor observations. Other possible trends may exist within the FeedbackFruit data available through the analytics provided for individual responses and reflections, but a more granular examination is required to determine if these exist. The more qualitative analysis of student open-ended reflections, comparing cohorts pre and post-introduction of FeedbackFruits, served to see any overall trend in engagement with the key team dynamic concepts, recognizing that these data sources will not be available for immediate curricular intervention regarding them.

Quantitative Analysis

Table 2, on the next page, presents a representation of the 'Suggested Adjustments' for each team from the peer review tool. Instead of presenting them by group and then individually with 'Suggested Adjustment' as the tool's interface does, the following presents the information in a more condensed form. The standard deviation of the suggested adjustments for each group indicates the equity of team assessment. A low deviation indicates all members felt the team distributed work and effort equitably. In contrast, a high deviation suggests a lack of equity due to large variations between the suggested adjustments for individual team members. There is no inherent limit, with the most significant suggested increase being +7.9% and the largest suggested decrease being -26.1%. High positive adjustments are uncommon, as it's typically the case that the incomplete workload, and therefore suggested adjustment, gets distributed among the remaining team members. Any value greater than one standard deviation about the cohort's average (>4.27) has been highlighted to showcase instances where abnormally large score variations occurred.

This data shows some trends, like teams having very low deviations, even 0, most of the time (C1 & F3) and some having large and varying deviations (C7 & F2) throughout. However, these data alone don't paint the full picture regarding group dynamics. When viewed in combination with the groups' performance via milestone grades and instructor observations, some possible trends emerge that may speak to specific team dynamics.

To simplify parsing the results and discussing the trends, the following data is limited to those that will be discussed as possible exemplar cases. These groups, highlighted in Figure 1 and Table 3, were selected based on observable trends within their performance and peer review data as well as observations and noted interactions by Prof. X, Y, and Z. They showcase some interesting trends that may speak to team dynamics of pedagogical interest, the reaction in the data to specific team issues, and potential issues that are difficult to discern through the data alone.

Figure 1 visualizes the above data for the exemplar groups, showing the standard deviation of the 'suggested adjustments' from each project milestone peer review. Table 3 provides the initially assigned group grade for each team and its standard deviations from the mean for that milestone for that cohort.

Table 2: Standard Deviation of the Suggested Adjustments for Each Design Group for Each Project Milestone (Values greater than 1 deviation about cohort average highlighted)

Group	M1	M2	M3	M4	M5	M6
C1	0.00	0.35	0.00	0.00	0.00	0.00
C2	0.35	0.33	0.78	0.54	0.27	0.82
C3	0.50	1.29	2.79	0.00	0.55	6.28
C4	1.65	1.71	2.33	4.60	0.40	1.10
C5	2.78	0.67	0.35	1.02	3.82	5.45
C6	0.61	0.35	1.05	1.31	0.00	0.35
C7	3.26	4.24	6.47	6.98	3.84	15.89
C8	8.17	1.51	0.77	1.87	0.82	1.43
F1	0.77	2.60	1.10	0.00	2.20	0.61
F2	6.49	3.08	1.26	1.18	9.52	6.82
F3	0.00	0.00	0.00	0.00	0.00	1.33
F4	0.00	0.00	0.22	0.38	0.00	0.00
F5	0.00	4.36	0.46	1.29	5.40	1.56
F6	0.35	0.00	0.80	1.70	2.88	2.17
F7	0.85	0.00	0.00	0.00	0.00	0.00
F8	1.97	2.25	1.47	0.58	0.51	2.77

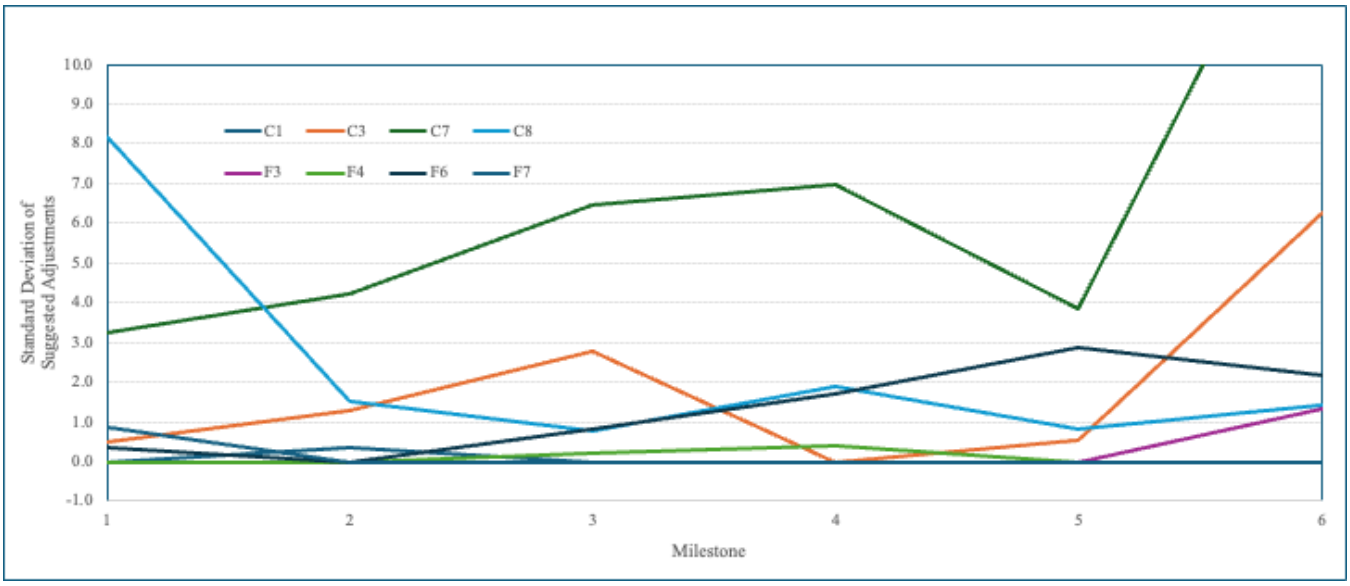

Figure 1: Standard Deviation of the Suggested Adjustments for selected exemplar groups for each project milestone

Table 3: Milestone Grade and its standard deviations from the cohort mean for selected exemplar groups for each project milestone

Group	M1		M2		M3		M4		M5		M6	
	grade	Dev	grade	Dev	grade	Dev	grade	Dev	grade	Dev	grade	Dev
C1	95	1.31	84	0.31	89	1.39	90	0.26	91	0.13	88	-0.29
C3	77	-0.70	79	-1.31	89	-0.77	88	-5.21	66	-2.55	93	-0.19
C7	70	-1.26	79	0.02	88	-1.61	77	-0.18	91	0.51	81	-0.20
C8	82	0.24	89	2.02	90	-0.17	98	0.80	95	0.49	94	0.58
F3	97	1.00	98	0.76	89	-0.27	96	0.71	100	1.03	80	-1.53
F4	85	-1.17	85	-1.69	89.0	-0.26	93	0.47	90	-0.96	92	0.20
F6	91	-0.05	99	0.94	94	0.67	80	-0.62	100	1.03	89	-0.34
F7	100	1.31	98	0.76	77	-2.34	97	0.80	97	0.43	100	1.49

Team Dynamic Indicators

The following narratives begin to emerge when examining the trends in those readily available data points and combining them with instructor insights.

Improvement Narrative: C8

One of the most desirable outcomes of this peer evaluation tool is fostering improved team dynamics, enabling teams to move from a lack of cohesion to equitable collaboration. C8 begins with significant deviations in suggested adjustments, reflecting early team dysfunction. Over time, however, these deviations decrease steadily, indicating the resolution of team issues and a shift toward equity in contributions. This trend aligns with instructor observations of the team initially struggling with mismatched expectations regarding effort and scope. By the end of the project, the team demonstrated a greater understanding of individual capabilities and goals, highlighting their ability to adapt and grow.

Equitable Dynamics: C1, F3

While not the highest-performing teams, C1 and F3 consistently exhibited minimal deviations in suggested adjustments. Despite minor fluctuations in performance, their evaluations remained relatively equitable, suggesting strong collaboration and fairness in contributions. This finding is supported by observations of team dynamics, where members demonstrated mutual respect and accountability, collectively embracing successes and failures. For instance, C1 performed near the average in Milestone 5 and below average in Milestone 6, yet the team maintained a united approach throughout, reflecting their commitment to equity.

Equity Concerns: F4, F7

In contrast, teams F4 and F7 displayed consistently high grades with near-zero deviations in suggested adjustments, raising potential concerns about collusion in the peer review process. F7's dramatic drop in performance during Milestone 3, while maintaining no deviations in peer review data, may indicate a prearranged agreement among members. F4 presents a subtler case, with no single milestone showing significant performance deviation that might reveal team inequities hidden by internal agreement, even showing a later increase in performance. These patterns underscore the need for deeper instructor reviews of peer review comments and specific task contributions to ensure fairness and accountability.

Challenging Dynamics: C3 and F6

Teams C3 and F6 exhibit significant variability in their suggested adjustments and deviations from the mean grade across milestones. While this variability suggests active engagement with the peer review process, it also reflects shifts in team dynamics and uneven collaboration. These fluctuations require further analysis to identify underlying causes and potential interventions. For C3, deviations are more pronounced, occasionally signaling team dysfunction. For F6, the fluctuations, while notable, remain within an acceptable range. Identifying these trends earlier could help instructors address emerging issues before they significantly impact performance.

Intervention-Driven Shifts: C7

Group C7 highlights the role of targeted interventions in restoring equity and accountability. Initially, the team displayed observable issues not adequately captured in the peer reviews. Some were even hidden by their grades improving during the first few milestones. However, this was later revealed to be their actively accounting for a team member's extreme unreliability. Following discussions initiated by the affected members at Milestone 4, the instructor intervened, emphasizing the importance of using peer reviews to reflect workload imbalances. The intervention led to short-term improvements and reinforced the justice-oriented purpose of the peer evaluation process. By the final peer review, a 26% grade reduction was assigned to one member due to consistent underperformance, a result accepted without contest. This case demonstrates the dual benefits of instructor intervention and structured peer evaluations in fostering accountability and fairness.

Qualitative Analysis

The qualitative analysis of the year-end reflection content serves as an engagement check to see if introducing this tool into the process has any effects. As this assignment has a long history of use and was applied both before and after the introduction of this peer review tool, it was thought to be a useful artifact for comparing pre- and post-engagement through examination of student reflections.

Table 4 details how different cohorts engaged with these key team dynamics, both positively and negatively, through their reflection discourse: Respect, Communication, Transparency, Commitment, and the overarching category labeled ‘Any.’ The table distinguishes between statements that directly convey engagement with each dynamic and those that suggest engagement either explicitly or implicitly. The ‘Any’ column aggregates overall engagement while avoiding double-counting statements that pertain to multiple dynamics, so a statement that showed engagement with ‘Respect’ and ‘Communication’ would be counted once in each of those categories as well as once in ‘Any’. No accounting was made for positive or negative associations, as we were only interested in their level of awareness of these team dynamics. This is calculated based on the total number of statements amongst the cohort, not by the individual reflections then averaged.

Table 4: Average Explicit (E) and Explicit + Inferred(E+I) Student Engagement with the 4 Key Dynamics as a Percent of Total Reflection Statements

	Respect		Communication		Transparency		Commitment		Any	
Dataset	E	E+I	E	E+I	E	E+I	E	E+I	E	E+I
A	14.0%	27.8%	17.8%	34.9%	10.2%	20.9%	12.2%	24.7%	43.8%	70.4%
B	13.9%	27.4%	18.5%	34.0%	11.9%	23.3%	12.8%	23.8%	45.7%	72.4%
C	15.0%	29.1%	18.6%	35.3%	12.5%	24.6%	15.0%	28.3%	48.8%	83.9%
F	15.3%	30.5%	19.9%	37.9%	11.8%	24.0%	15.6%	29.2%	47.6%	82.9%

Statistical Significance

The statistical analysis used a *p*-value threshold of 0.05 to determine statistically significant changes in the recognition and articulation of team dynamics between the pre-intervention (datasets A and B) and post-intervention (datasets C and F) cohorts. Mean values for respect, communication, transparency, commitment, and overall engagement were examined, comparing them before and after the intervention. The results are provided in Table 5.

Table 5: Comparison of the Mean Engagement Pre and Post Intervention utilizing Absolute Change and P-Value (Threshold of 0.05)

Metric	Pre-Mean	Post-Mean	Absolute Change	P-Value
Respect (Exp.)	13.94%	15.13%	1.19%	0.0324
Respect (Exp. + Inf.)	27.59%	29.83%	2.24%	0.0412
Communication (Exp.)	18.14%	19.24%	1.10%	0.0287
Communication (Exp. + Inf.)	34.44%	36.57%	2.13%	0.0338
Transparency (Exp.)	11.07%	12.12%	1.05%	0.0449
Transparency (Exp. + Inf.)	22.10%	24.30%	2.20%	0.0401
Commitment (Exp.)	12.52%	15.28%	2.76%	0.0352
Commitment (Exp. + Inf.)	24.26%	28.73%	4.47%	0.0386
Any (Exp.)	44.76%	48.19%	3.43%	0.0221
Any (Exp. + Inf.)	71.43%	83.38%	11.95%	0.0305

The statistical analysis comparing the pre and post-intervention datasets (See Table 5) suggests some benefits to the continuous reflection on these metrics throughout the semester. Across all metrics, the analysis reveals meaningful improvements, underscoring the intervention's impact on fostering greater reflection and equity in team dynamics.

Overall Engagement Trends

Post-intervention datasets exhibited a marked improvement in overall engagement with key team dynamics. Specifically, mentions of "Any" dynamic, which includes both explicit and inferred references, increased from a pre-intervention mean of 71.43% to 83.38% post-intervention. This absolute change of 11.95% was statistically significant (p-value = 0.0305), indicating that the continuous peer feedback intervention successfully encouraged students to engage more deeply and reflectively with team dynamics throughout the project. The substantial increase highlights the intervention's effectiveness in fostering greater awareness and articulation of team attributes across the cohorts.

Respect

Respect, an essential component of effective team dynamics, significantly improved both explicit and inferred mentions. Explicit mentions of respect rose from 13.94% to 15.13%, with an absolute change of 1.19% (p-value = 0.0324). When combining explicit and inferred mentions, the increase was from 27.59% to 29.83%, reflecting a more nuanced recognition of respect within the teams. These results suggest that students became more attuned to the importance of respect in fostering equitable and supportive collaboration. The statistically significant changes demonstrate the intervention's capacity to reinforce this attribute as a key pillar of successful teamwork.

Communication

The analysis also highlights statistically significant growth in communication metrics. Explicit mentions of communication increased from 18.14% to 19.24%, an absolute change of 1.10% (p-value = 0.0287). Explicit and inferred reflection on communication grew from 34.44% to 36.57%, reflecting a 2.13% increase (p-value = 0.0338). These findings emphasize an enhanced ability among students to recognize and articulate the importance of communication, both explicitly and in more subtle, inferred contexts. The results align with the intervention's goal of fostering consistent and clear communication as a cornerstone of effective teamwork.

Transparency

While transparency showed the smallest improvement in explicit mentions among the metrics analyzed, the changes were still statistically significant. Explicit mentions of transparency increased modestly from 11.07% to 12.12%, with an absolute change of 1.05% (p-value = 0.0449). However, when explicit and inferred mentions were combined, transparency exhibited a more pronounced improvement, rising from 22.10% to 24.30%, with an absolute change of 2.20% (p-value = 0.0401). These results suggest that while students began to recognize transparency's role in team success, it remains an area requiring further emphasis in future interventions to deepen its explicit acknowledgment within teams.

Commitment

The most significant improvement observed across all metrics was in the domain of commitment. Explicit mentions of commitment rose from 12.52% to 15.28%, reflecting a notable absolute change of 2.76% (p-value = 0.0352). The combined explicit and inferred mentions saw an even larger improvement, increasing from 24.26% to 28.73%, an absolute change of 4.47% (p-value = 0.0386). These results highlight the intervention's particular effectiveness in fostering a sense of accountability

and dedication among team members. The marked improvements in commitment metrics underscore the importance of continuous feedback in encouraging students to recognize and fulfill their responsibilities to their teams.

Discussion

While these findings are derived from a limited sample, they suggest promising directions for managing student design teams in project-based learning environments utilizing FeedbackFruits analytics. These trends highlight areas of potential benefit that, with further analysis and replication, may support broader instructional strategies:

Early Identification of Team Dynamics Issues

The continuous peer feedback evaluation offered an opportunity to identify and address challenges in team dynamics in real-time. By linking feedback to contract-defined attributes—respect, commitment, transparency, and communication, with grading justice—teams could respond to inequities and collaboration challenges earlier in the process. These preliminary findings suggest that such a system could reduce the frequency of unresolved issues impacting project outcomes. However, broader confirmation of this trend would require further analysis and validation across more diverse cohorts and datasets.

Promotion of Equity and Accountability

Mapping evaluations to measurable teamwork attributes provided a structured framework for fostering accountability and promoting fairness/justice within the team. While initial results indicate that teams were more likely to address workload imbalances and acknowledge individual contributions, these observations need to be explored in greater detail, particularly through granular analysis of specific peer feedback entries. The potential for this approach to encourage equitable participation and transparent grading adjustments is compelling but requires additional study for wider generalization.

For example, students stated the following regarding their acknowledgment of feedback:

> "... I had already taken a few years of engineering classes in college, and I could complete the projects without any help. I quickly learned that this [class project] would be too much work so I would need to work better with my group to get them done and done well. *I have made an effort to listen to my group's feedback on the team evaluations and done a lot of work to make sure I can make sure everybody feels like they are included and are being listened to on the project.* Even though this can be hard for me slowing things down a little bit and letting other people contribute more has made our group dynamic a lot better."

> "…Often, I felt that I needed to improve in a specific area, *which group members corroborated when I read my evaluation feedback…*"

Development of Key Teamwork Competencies

The intervention encouraged students to reflect on these essential teamwork skills, such as communication, transparent decision-making, and just/equitable workload distribution, based on the increased explicit and implicit references in their final reflections. While critical in collaborative learning and professional environments, these skills were evaluated at a high level just for general conceptual engagement. The trends observed warrant further exploration through detailed analysis of

qualitative feedback to better understand how continuous peer evaluation contributes to the development of these competencies.

For example, students shared these insights regarding their development in their reflections:

> "…This project has significantly improved my collaboration skills. *I have actively taken feedback through personal conversations and peer evaluations to improve my communication skills and level of engagement and become an overall more productive team member*…"

> "…The weekly peer evaluations were a motivation for me to share any and all relevant updates with my group—not just the ones that I considered significant—which improved my communication skills and helped me realize that even minor details, when communicated, can be greatly helpful…"

These early insights suggest continuous peer feedback can provide valuable support for team-based learning management. However, confirming their broader usefulness will depend on discovering similar trends in other settings and conducting more granular analyses of feedback data at the individual metric level. This intervention represents a promising step, but further study is essential to refine its application and assess its long-term impact on team dynamics and student outcomes.

Continuous Feedback Promotes Team Communication and Cooperation

The statistical analysis confirms the intervention's overall success in improving team dynamics and fostering reflective practices. Transparency, while showing statistically significant improvement, still lags behind other metrics, indicating the need for targeted strategies to enhance its explicit recognition in future cohorts. The significant improvement in commitment, particularly in the combined explicit and inferred category, highlights the intervention's success in addressing one of the most critical dynamics for equitable teamwork. Finally, the substantial increase in "Any" mentions (explicit and inferred) reflects a broad and positive impact on student engagement with team dynamics, suggesting that the intervention effectively fostered a more reflective and equitable approach to collaboration.

Continuous Feedback Helps Instructors Identify Team Issues and Provides Evidence to Address Them

The continuous peer feedback evaluation enabled instructors to gain nuanced insights into group dynamics on a weekly basis. This approach effectively identified underperforming group members and enabled instructors to intervene and administer fairness that the group might not independently achieve. Rather than allowing "free-riders" to benefit from high grades at others' expense, the tool suggested grade adjustments predicated on peer evaluations. Instructors retained the discretion to refine these adjustments by incorporating qualitative insights from written comments or direct discussions with group members. This proactive approach replaced the traditional labor-intensive process of addressing complaints and conducting investigations after grading. Instead, both qualitative and quantitative feedback collected before grades were assigned ensured a more accurate and timely assessment of the team's performance.

Conclusion

The continuous peer feedback evaluation tool (FeedbackFruits) significantly increased student engagement with concepts like respect, communication, transparency, and commitment, as reflected in their final reports (Data sets A, B, C, F). The near-weekly use of the tool helped students to be mindful of these principles, thus encouraging students to make team-oriented decisions consistently. The

accountability built into the evaluation process motivated students to communicate more effectively, with greater clarity than they initially thought necessary, to pursue better grades.

This analysis highlights the power of continuous peer feedback to improve team performance, ensure equity, and equip students with essential teamwork competencies. The statistically significant improvements across multiple dimensions demonstrate that frequent and structured feedback is a valuable tool in cultivating effective and accountable teams. While we acknowledge the complexity and nuance of team dynamics, we anticipate that this research will establish a baseline for improving motivation and addressing teamwork challenges in first-year engineering courses.

Future Work

Possible case study: Granular analysis of individual team dynamics

Currently, teams are formed using an existing tool (Gruepr) that takes into account self-identified gender, ethnicity, and a few other factors. Leveraging demographic data in a future analysis would allow for a deeper understanding of how diverse perspectives and backgrounds could influence group dynamics. Analyzing the datasets with these factors in mind might identify potential inequities, such as whose voices are more prominent or whose contributions may be undervalued.

More refined quantitative analysis of FeedbackFruits data

This study focused on a select few sections of a Cornerstone class within a first-year department that follows an 8-credit, single-semester course model. Future iterations of this work could include sections of the course that currently use a two-semester, 4-credit model. Transitioning these sections to a continuous peer feedback model would broaden the scope of the study. Additionally, incorporating other classes with evaluation experience would enhance the historical data set and support the ongoing development of the feedback model. A larger data set could also offer deeper insights into how different instructors implement the tool and manage project paths, enabling more meaningful comparisons across teaching styles and approaches.

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Appendix A - Survey

Please take a few moments to complete the group evaluation form. Your feedback is valuable and will inform future group activities. For open-ended questions, you are encouraged to provide constructive and thoughtful responses. Your input should focus on positive aspects as well as areas for improvement, offering clear and helpful suggestions. Be mindful of the responses you get and take them as opportunities to improve yourself with each milestone. Imagine each week as a new opportunity to grow your team skills and communication.

Thank you for your thoughtful and honest feedback.

Step 1: Rate your Team Members

	No Evidence 0 points	Unsatisfactory 1 point	Needs Improvement 2 points	Satisfactory 3 points	Above Average 4 points	Exemplary 5 points
Respect	Completely lacks respect; consistently dismisses others' opinions and needs, with a pattern of disrespectful behavior.	Rarely shows respect; frequently disregards others' opinions and needs, showing a lack of empathy.	Shows limited respect; occasionally disregards others' opinions and needs, requiring reminders.	Generally respectful; listens to others but may occasionally overlook differing opinions or needs.	Often shows respect; listens and values others' opinions with few minor lapses.	Consistently demonstrates exceptional respect; actively listens, values different perspectives, and shows empathy in all interactions.
Communication	Communicatio n is almost non-existent or entirely ineffective; consistently fails to engage or listen, and provides no constructive feedback.	Communication is frequently unclear or ineffective; rarely engages or listens, and provides poor feedback.	Communication is often unclear or ineffective; struggles with engagement and providing meaningful feedback.	Communicates adequately; usually clear but may struggle with engagement or feedback at times.	Communicates effectively most of the time; clear in most interactions with minor areas for improvement.	Communicate s clearly, effectively, and consistently; actively engages in conversations, listens well, and provides constructive feedback.
Transparency	Completely lacks transparency and trustworthiness ; consistently dishonest and fails to provide	Frequently lacks transparency and trustworthiness; consistently withholds information or provides	Rarely transparent or trustworthy; often withholds information or provides incomplete details, needing frequent prompting.	Occasionally transparent and trustworthy; provides information when asked but may not be fully open or proactive.	Generally transparent and trustworthy; shares information regularly with minor omissions or delays and	Always open and honest; provides clear, timely information and updates, and proactively shares

	necessary information.	misleading details.			maintains honesty.	relevant details.
Commitment	Completely lacks commitment; consistently fails to meet deadlines or fulfill responsibilities, with no apparent effort.	Shows minimal commitment; frequently misses deadlines and shows little engagement or effort.	Shows limited commitment; often misses deadlines or falls short of expectations, needing frequent support.	Shows adequate commitment; meets deadlines and performs tasks but may need occasional reminders.	Shows strong commitment; generally meets deadlines and performs well with occasional minor lapses.	Demonstrates exceptional commitment; consistently meets deadlines, goes above and beyond expectations, and shows strong dedication.

(1) How did this group member contribute to the group's goals this week?

Please use complete sentences and maintain a positive and constructive tone.

(2) How can this person improve as a team member going into the next milestone?
Maintaining a positive tone and using complete sentences, please give constructive criticism to help your team member reflect and improve.

Step 2: Read your group member's reviews

Step 3: Individual Reflection Questions

(1) What have you tried to improve based on previous peer evaluations?

(2) What did you learn about yourself from this evaluation?

(3) What realistic goal can you set this week for yourself to improve your teamwork skills?