

Abstract

Employers are placing growing importance on effective teamwork, communication skills, and emotional intelligence, leading many engineering undergraduate programs to focus on developing these competencies in their students.[1,2] Recent trends in engineering education towards challenge and problem-based learning (CBL & PBL) as a means of developing these skills introduces significant challenges for first year students as many of them have little or no experience of working effectively in groups. [3,4,5,6] The aim of this study is to improve team dynamics among First Year engineering undergraduate students through peer assessment. Tuckman's Model was used to provide a framework of understanding and common language for students to reflect on the development of their group and a web-based self and peer assessment tool called SPARKPLUS allowed students to confidentially rate their own and their peers' performance. Metrics on SPARKPLUS and anonymous student questionnaire's were used to assess the solution's effectiveness. For this study a group-based challenge was selected in Semester 1: Design Engineering CanSat Project and in Semester 2: Engineering Challenge Pipe Climbing Robot.

Our findings indicate that the integration of Tuckman's model with SparkPlus effectively supports and structures students' learning experiences in group-based projects. The study also underscores the importance of reflective practice in cultivating lasting trust, strengthening team cohesion, and developing the essential skills needed for professional success.

1. Introduction

The Engineer of 2020 report by MIT highlights the ability to work effectively in teams as a critical skill for engineers. However, for many first-year engineering students, university represents their first experience with structured teamwork in group-based projects. This project aims to scaffold students' learning in teamwork, providing guidance without direct solutions, allowing them to make mistakes, reflect, and develop their own understanding of effective collaboration. To facilitate this scaffolded learning, the project integrates Sparkplus, an online self and peer assessment tool, to highlight areas of improvement and strengths among first-year engineering students. Students rate both themselves and their teammates in teamwork, communication, efficiency, responsibility, and contribution. They then engage in structured reflective practice sessions within their groups, using their Sparkplus results and the Tuckman's Team Development Model, which outlines the life cycle of a team through the stages of Forming, Storming, Norming, Performing, and Adjourning.



This approach offers a structured yet student-led method for enhancing teamwork skills, ensuring that first-year engineering students develop essential collaborative competencies that are foundational for their academic and professional success.

2. Research

Universities are placing increased emphasis on the development of soft skills, dedicating more attention to these competencies than in previous years [3]. This heightened focus is supported by education authorities and is largely driven by the changing demands of industry, where employers now seek graduates who possess not only strong technical abilities but also well-developed interpersonal and collaborative skills [4].

To meet these evolving industry expectations, many universities are turning to Challenge-Based Learning (CBL), an approach that engages students in practical, real-world problems to foster hands-on learning and the development of essential soft skills [5,6].

In their review paper, Van Helden et al. 2023 [7] concluded that when it comes to student performance only positive outcomes were reported from peer assessment tools like SparkPlus, FeedbackFruits, Sciorion, CATME etc. The quality of work produced by students increases as peer assessment reduced the number of free riders. Peer assessment also leads to higher group satisfaction by improving collaboration and reducing conflict.

However, Van Helden et al. 2023 [7] do caution that it is only as good as the people using it and it must be perceived by students as a fair tool. Willey and Gardner 2010 [8] also cautioned that first year students have lower response rates compared to second-year students when completing peer and self-assessment tasks.

3. Methodology

Fun and engaging workshops were rolled out in Semester 1 as a way to introduce students to Tuckman's Model and familiarise them with Peer Assessment using Sparkplus. Students were assigned groups in random for both projects: Semester 1: Design Engineering CanSat Project and in Semester 2: Engineering Challenge Pipe Climbing Robot.



Students rated their team performance in Sparkplus at pre-defined intervals during each project. Each student received a Relative Performance Factor (RPF) given by the formula:

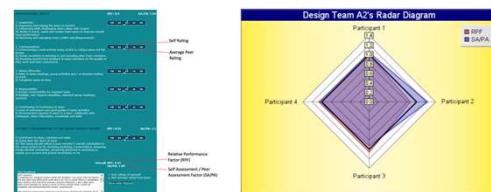
$$RPF = \frac{\text{Individual Score}}{\text{Group Average}}$$

An RPF less than 1.0 indicates that a student contributed less than their peers, while a value greater than 1.0 suggests they contributed more. Ideally, each student would have an RPF of 1.0, reflecting equal contributions across the group.

Reflective Practice sessions were facilitated with student groups after each Sparkplus Assignment where each team was asked 3 Questions:

1. What stage of Tuckman's model is the team currently?
2. What stage of Tuckman's model does the Team want to be?
3. What improvement will the Team make?

An anonymous survey was conducted using Google Forms at the end of each project to assess student experiences in relation to Sparkplus Peer Assessment and Tuckman's Model. The results of each survey were compiled and analysed.



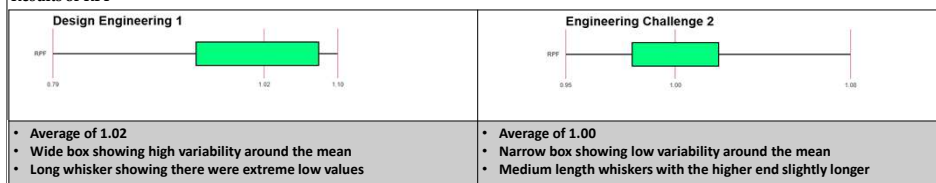
4. Results

Participation Rates

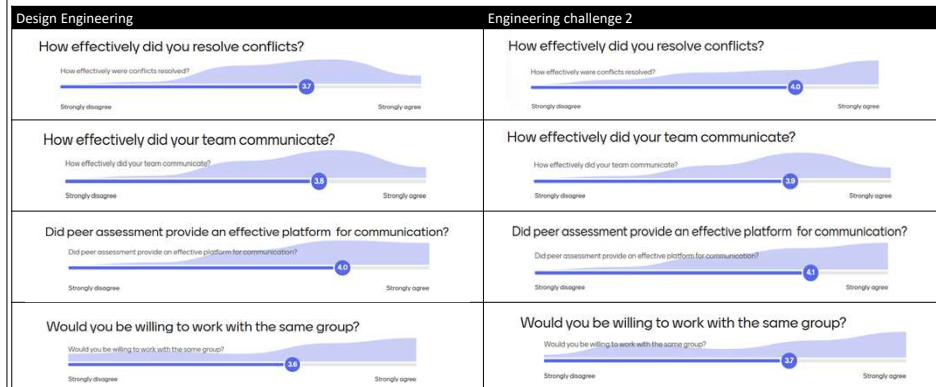
SparkPlus participation rate for Design Engineering was 33 out of 36 students (92%). SparkPlus participation rates for Engineering Challenge were 89%, 91%, and 85%, averaging 88.3%.

The Design Engineering survey had 26/36 responses (72%), and the Engineering Challenge survey had 24/34 (71%). Although not all students responded, the team-based nature of the questions means all teams were represented.

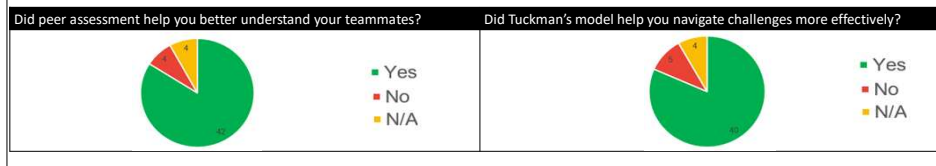
Results of RPF



Survey



Both surveys showed an appreciation for Peer assessment and Tuckman's model



5. Conclusions

Balanced Contributions

Reduced RPF variability (narrower box and lower range) → Peer feedback increased accountability, resulting in more balanced contributions and fewer free riders (shorter whisker on the lower end).

Enhanced Team Processes

Conflict resolution (3.7 → 4.0) and communication effectiveness (3.8 → 3.9) → Students improved their emotional awareness in handling conflicts and became more effective communicators.

Peer assessment effectiveness (4.0 → 4.1) → Consistent appreciation for the peer assessment process.

Sustainable Outcomes

Increased willingness to work again as a team (3.6 → 3.7) → A key indicator of sustained trust and team cohesion. The synchronised nature of these improvements, though individually incremental, demonstrates that structured peer assessment (SPARKPLUS) and Tuckman's model gradually enhanced teamwork. As illustrated in the Pie Charts students acknowledge the value of peer assessment in better understanding their teammates and the role of Tuckman's model in addressing team challenges.

6. Future Recommendations

- It is recommended that the program be implemented over a two-year period, spanning students' first and second years of study. Research indicates that engagement levels are higher among second-year students compared to those of first-year students.
- Greater emphasis should be placed on the reflective practice sessions, as they support students in identifying areas for potential improvement.
- Future research should explore effective methodologies for assessing team dynamics, aiming to make changes in team dynamics more observable and measurable in practice.

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