

Students' Teamwork Assessment based on Reflection, Peer Evaluations and Psychological Safety

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Abstract

Engineering projects involve a variety of stakeholders: some work within the engineering and construction field, while others do not. These projects entail complex technical facets and face challenges due to scheduling concerns, budget constraints, conflicting viewpoints, or performance issues. To prepare engineering students for the real-world, faculty assign students to teams. However, there are varying levels of commitment and skills regarding effective teamwork among students. To address this disparity, the faculty developed a student regulated learning reflection (SLR) assignment which asks each student to define leadership and teamwork, to complete a confidential peer-evaluation by assessing each team member's performance and answering a psychological safety questionnaire. The criteria looked at leadership, collaboration and inclusivity, responsibility, work quality, meeting deadlines, and communication. First, each student shares their opinion regarding each criterion through a SLR, where faculty review their reflections and provide instruction to improve gaps associated with leadership and teamwork. At the completion of the group project, students evaluate their teams' performance in each criterion using a Likert scale survey. Finally, each student responds to a series of questions in order to evaluate the psychological safety of the team. The results from the SLR, confidential peer-evaluation, and psychological safety questionnaire assisted faculty in evaluating team performance and implement instructional strategies to improve teamwork. Outcomes from this study allow us to develop a continuous improvement plan.

Introduction

Engineering educators must go beyond providing students with technical skills (i.e., analytical, integrative, and problem-solving) and develop opportunities to incorporate interpersonal and professional skills within the teaching framework to train successful future engineers [1]. Most engineering programs define the core of engineering curricula as mathematics, science, engineering analysis, and design; however, students need more than just technical skills [2]. In 2004, the National Academy of Engineering indicated that engineering graduates need to be prepared to address the complex technical, social, and ethical questions raised by emerging technologies [3]. In addition, at a recent department Industry Advisory Council (IAC) meeting, professional engineers indicated that entry-level engineers from our university have the technical skills, but need further training in interpersonal and professional skills. However, developing standalone courses on various skills within the major is not possible due to unit restrictions. Thus, our program evaluates how to imbed interpersonal and professional skills instruction throughout the core of the Civil Engineering and Construction Engineering and Management curricula.

This pilot study evaluates students' ability to function effectively on a team where members provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives (ABET Student Outcome No. 5) [2]. Teamwork is a topic that falls under a broader category of professional skills [4] taught to engineering students. In fact, Kulturel-Konak et al. [4] assessed professional skills as ethics, teamwork, global awareness, and creative problem

solving. In their approach, they argued for using model of domain learning (MDL) to connect the learning of a professional topic to improve students learning as opposed to duplicating expert performance, which is the goal of traditional models of learning (TML). Using MDL connects development of knowledge, as well as skills and attitudes to specific outcomes across three learning levels. Therefore, our approach to assessing teamwork within this paper is to develop a course-based assessment tool that is mapped to ABET Student Outcome Number 5 (SO 5). The assessment approach evaluates student artifacts and develops strategies for continuous improvement [5].

The department's "Teamwork" assessment faculty team, College of Engineering Leadership faculty, and select course faculty and students as the necessary stakeholder to ensure project success. The project allows us to improve the curriculum, instruction, and student success within our programs.

The department's "Teamwork" assessment faculty are responsible for the following:

- develop assessment tools (i.e., peer and psychological safety survey) for leadership and teamwork;
- develop a reflection assignment;
- evaluate artifacts of student learning; and
- work with course faculty and College of Engineering Leadership faculty to develop strategies to improve student performance.

The faculty teaching courses aligned to SO 5 are responsible for the following:

- assign students into teams/groups;
- assign and collect assessment assignments aligned to SO;
- work with department's "Teamwork" assessment faculty and College of Engineering Leadership faculty to develop strategies to improve student performance; and
- provide tailored instruction on teamwork and leadership within their course.

The students within a course are responsible for the following:

- work in teams throughout the semester (in and outside the classroom);
- submit assignment and projects aligned to SO 5 used for evaluation; and
- complete a peer-evaluation and psychological survey.

The College of Engineering Leadership faculty are responsible for providing guidance to department faculty (Teamwork assessment and course faculty) to develop teaching tools and strategies to improve student performance on teamwork.

The overall purpose of the pilot study is to support teamwork instruction within the department and college through the future development of teaching material, ultimately supporting student success. In order to test the proposed plan, the teamwork assessment was piloted in two upper-level courses in the Civil Engineering Department during fall 2020: Construction Estimating (n=37 students) and Water Resource Engineering (n=65 students).

Methodology

Students work in teams throughout their undergraduate experience; however, some state that teamwork is both frustrating and difficult [6],[7]. To reduce frustrations, this project looked to develop a systematic approach to evaluate teamwork and leadership that connected to ABET SO 5. To ensure the goals of the project were met, students were required to complete a self-regulated learning reflection (SLR), followed by two surveys. The first survey was a peer evaluation and the second survey measured team psychological safety (PS). The SLR was administered at the start of the term, followed by the group activities and projects. After completing the group activities and projects, students were asked to complete the peer evaluation and PS survey. Each assessment is described in more detail below.

Self-Regulated Learning Reflection

The project's first stage included a self-regulated learning reflection (SLR) assignment on leadership and teamwork. This assignment provided students with an opportunity to consider what leadership and teamwork meant to them and identified factors that contribute to high performing teams [8]. SLRs further provided students the opportunity to manage and change their behaviors, as well as consider a positive change for the future [9]. Students also read what others on their team wrote so they could create common ground as they continued to work together. The SLR is further tied to the research by Edmenson who states that leader coaching and belief sharing within the team supports successful teamwork and a willingness to take more risks [10], [11].

The assignment was aligned to ABET SO 5. The SLR assignment asked students to respond to the following five questions:

1. What actions or behaviors do you associate with being a leader?
2. What do inclusivity and collaboration mean to you when working on a team project?
3. What do you do to ensure that you are responsible (meeting deadlines, contributing to the overall project, completing assigned tasks) and submitting quality products?
4. How do you manage your time to complete assignments?
5. How do you like to communicate in a team?

It was required for each student to post their SLR to the course discussion board on the Learning Management System (LMS). The instructor as well as other students read and replied to several posts. This process allowed students to self-reflect and develop a shared understanding of leadership and teamwork within their groups.

To analyze the SLRs about teamwork, we used VOSviewer [12]. VOSviewer analyzing the frequency of keyword clusters from the student responses and provides a visual representation of common words. We developed in-class instruction to guide students in areas of leadership, teamwork, communication, and deadlines based on student responses to the SLR.

Course Embedded Lessons

The instructors engaged with students throughout the semester on the importance of teamwork and leadership. That is, they provided students with instructions on how to interact during small group working sessions and encouraged students to interact with their peers outside the classroom environment. In addition, a short lesson (2 to 3 mins) on how to work effectively together was provided each time students were working with their teams. Specifically, the lessons focused on communication, mutual respect, listening to all ideas and working together to achieve a common goal. It is important to note that this area of the project is still under development.

Confidential Peer Evaluation

To assess if the students met the student outcomes defined by ABET, we developed a peer evaluation tool to assess student perceptions of leadership, inclusivity, goals (outcome), participation, and performance. The peer evaluation tool invites each student to evaluate themselves and each team member on the following items using a five-point Likert scale: (5) Strongly Agree, (4) Agree, (3) Neutral, (2) Disagree and (1) Strongly Disagree:

- Leadership – The member provided leadership. (Note: A leader does not have to be the person that "serves as the Project Manager." A leader is someone who seeks every opportunity to communicate and mentor others within the team.)
- Collaborative & Inclusive Environment – The member contributed to creating a collaborative & inclusive environment. This means that the member being evaluated values everyone's opinions and ensures that all ideas are heard.
- Goals – The member contributed to establishing goals & planning tasks.
- Deadlines and Attendance – The member completed tasks to meet deadlines.
- Quality of Work - The member completed tasks with accuracy. (Note: It is ok if the member had to correct mistakes if the final submittal was accurate.)
- Responsibility - The member carried out assigned tasks.

Each question within the peer evaluation was directly aligned to the SLR that students completed during the first part of the semester. Using these two data points, we linked the students' perception with the evaluation. The results provided us an opportunity to develop strategies to improve student success.

The peer evaluation also included a short questionnaire, which asked students to identify which types of teamwork activities they took part in during the semester. The choices available were: Team Project; Individual Project; Breakout Sessions; Office Hours; Study Groups; Homework Groups; and All of the Above. This information allowed us to examine if intentionally designed group work is needed within the course.

Team Post-Evaluation Survey

There are many different team effectiveness surveys or questionnaires that can be conducted to identify the dimensions within the team that needs improvement [13] – [16]. Given that we wanted to support student learning from an MDL approach, we chose Edmondson's

Next, the student responses were disaggregated based on each question asked to students. The responses were imported as a text file to a VOSviewer software and each question was reanalyzed. A total of 102 student responses were analyzed based on the frequency and the co-occurrence of words the students wrote in response to the questions asked. The VOSviewer used a text mining and smart local moving algorithm to provide results. Table 1 summarizes a list of the frequently-used and associated words per each question.

Table 1 – Map between the Question and the Words

Question	Common Word/Phrases	Associated Words
What actions or behaviors do you associate with being a leader?	<ul style="list-style-type: none"> • Leadership • Confidence • Developing Schedule • Leading Discussions • Ability to teach • Ability to assign tasks 	<ul style="list-style-type: none"> • Progress • Question • Strength
What do inclusivity and collaboration mean to you when working on a team project?	<ul style="list-style-type: none"> • Opportunity • Same Page • Help • Consideration • Teamwork 	<ul style="list-style-type: none"> • Everyone • Duty • Voice • Chance
What do you do to ensure that you are responsible and submitting quality products?	<ul style="list-style-type: none"> • Priority • Date (calendar) • Check quality • Time management • Teammate 	<ul style="list-style-type: none"> • Same amount • Process • Planner • Timely • Reminder
How do you manage your time to complete assignments?	<ul style="list-style-type: none"> • Deadline • Complete assignment • Due Date 	<ul style="list-style-type: none"> • Evaluate classes/schedule • Weekly calendar
Provide how you like to communicate in a team?	<ul style="list-style-type: none"> • Microsoft Teams • GroupMe • Texting 	<ul style="list-style-type: none"> • App(s) • Discord

Leadership: Students identified leadership abilities as individuals whom exhibit confidence, knowledge, organization, and delegation of work. Students considered a leader as the project manager and did not separate the leadership role from the actions of leadership [17]. Additionally, many students answered the question by restating leader, suggesting that they do not have the vocabulary to explain what actions and behaviors are associated with being a leader.

Inclusivity and collaboration: Students identified inclusivity and collaboration with meeting the team on common ground, allowing everyone to participate and consider diverse perspectives. In an inclusive and collaborative team, everyone is given a chance to have their voice heard. Overall, the feedback on this criterion seemed to show that students understand what is needed for an inclusive and collaborative environment.

Responsibility and quality of the product: Students identified responsibility and quality of the product as planning, distribution of work, check work and timely submittals. They also connected the quality of work by checking each other’s work. However, faculty are still responsible for providing students with guidance on being prepared, setting goals, and evaluating team strengths and weaknesses.

Time Management: Students clearly understood what needed to be done to manage their time based on their responses. However, with several classes, extra-curricular activities, work and personal responsibilities, students struggled with prioritizing assignments and allocating sufficient time on projects. This is evident when the quality of the product is diminished during submittals due to procrastination. Students were required to submit periodic drafts during the semester to ensure that they were not trying to do all the work the days prior to the final submittal. This scaffolding approach provided students with feedback, helped students with time management and ensured a high-quality end-product. However, it was still difficult to ascertain who was doing the bulk of the work.

Communication Tools: Students have become quite adapted to the use of technology, as shown in the SLR. They were familiar and comfortable with using many different methods to work and communicate in a digital era. It was found; however, they do miss the personal interactions, but have found ways to work together via virtual applications.

Findings from the Confidential Peer Evaluation

Each individual completed a confidential peer evaluation on themselves and their team members. The results are averaged based on both their self- and peer-evaluation. The results are summarized in Table 2.

Table 2 – Average evaluation scores for team work assessment

Course Name	No. of Students *	Group Size	Leadership	Inclusive Environment	Goals	Deadline	Quality of Work	Responsibility
Construction Estimating	37	5 to 8	4.4	4.6	4.6	4.6	4.7	4.7
Water Resources	65	3 to 5 students	4.1	4.5	4.5	4.5	4.6	4.7

*Note: Each student was evaluated by each member of the team

Figure 2 provides the percent of students who scored within a specific area.

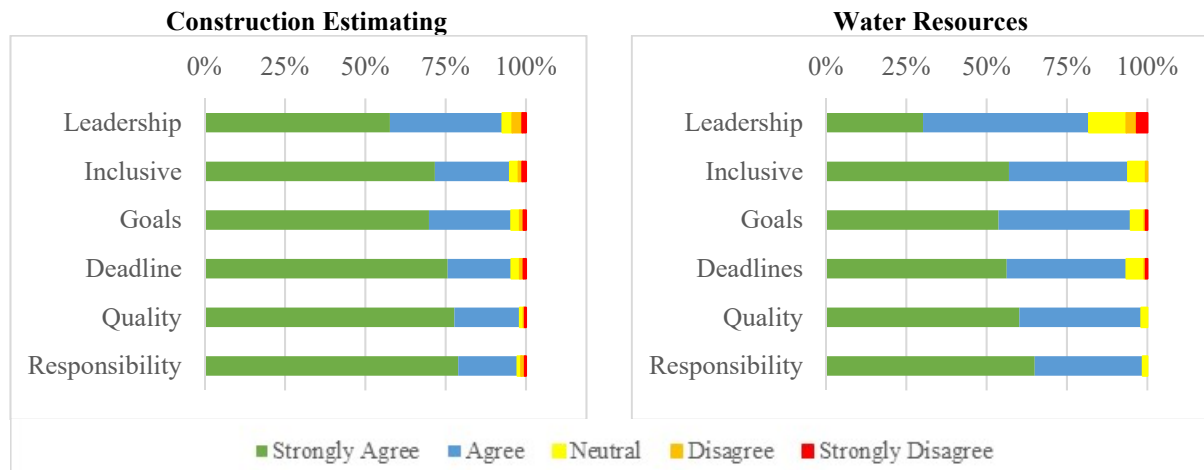


Figure 2 – Percentage of Students at each Likert scale from Peer Evaluation

Based on the overall results, students’ experience of working with teams during the fall 2020 semester was strong with average scores being above 4-points on the Likert scale (Agree to Strongly Agree). However, students were least satisfied with “Leadership”:

- 58% of the students in the Construction Estimating indicated they “Strongly Agree”; and
- 30% of the students in the Water Resources indicated they “Strongly agree.”

These results are also aligned with the SLR. That is, students identified “Leadership” with the role of a project manager and had difficulty seeing leadership as an action used by all members of the team.

The area where students were most satisfied is associated with “Responsibility.” This can partially be attributed to the course instructors who provided detailed instructions through a transparent assignment [18], allowing for the team to divide work evenly. The assignment also clearly outlined the expectations of the project and the order in which to complete tasks. The instructions made the projects manageable, and students were overwhelming satisfied with the performance of their team.

With an overall favorable evaluation of teamwork in both Construction Estimation and Water Resources, the questionnaire asked students to identify which types of teamwork activities they participated in within the course (see Figure 3.)

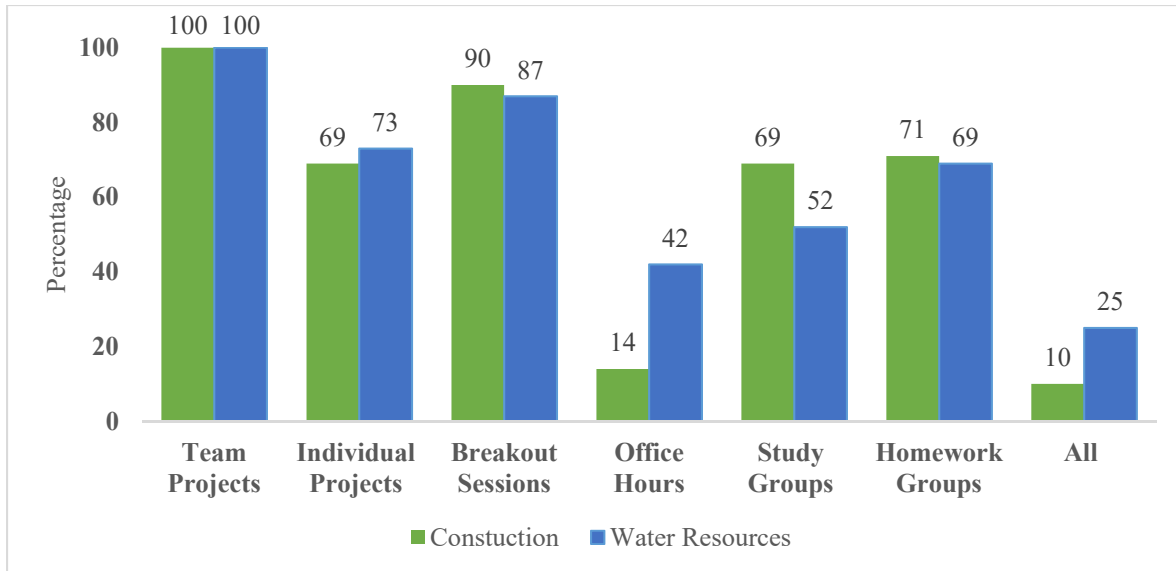


Figure 3 – Types of Teamwork Engagement during Fall 2020

The results indicate that students participated in a variety of activities that engaged their learning in team environments, with the most common being Team Projects and Zoom Breakout Sessions. Both were controlled by the course instructors. These are valuable to help students work together. However, the benefits of students developing study groups and working on assignments more regularly together has shown to have significant impact on success [14], [19], [20]. There needs to be intentional intervention to encourage this level of collaboration.

Findings from the Team Effectiveness Evaluation

Students provided an assessment of team effectiveness using the psychological safety questionnaire adapted from Amy Edmonds [10], [11]. Table 3 summarizes the results.

Table 3 – Overall Evaluation regarding a Student’s Experience

Survey Questionnaire	Frequency (Total: 102)				
	Never	Rarely	Often	Every Time	No Response
In this team when someone makes a mistake, it is often held against him or her;	73	17	8	0	4
In this team it is easy to discuss difficult issues and problems;	12	6	22	57	5
In this team people are sometimes rejected for being different;	98	3	0	0	1
In this team it is not safe to take a risk;	71	18	4	3	6
In this team it is difficult to ask other members for help; and	77	15	5	3	2
In this team each students’ contributions are not valued and respected.	89	8	3	1	1

Most students felt that they were able to take risks and showed that they could be vulnerable in front of each other. The results from these questions are directly aligned to the criterion on inclusion and collaboration from the SLR, which indicated that students' perception is aligned to the performance captured by the peer evaluation:

- 96% of students did not feel rejected for being different
- 87% of students valued and respected their team members' contributions.

There were, however, some areas where some students did not feel as safe:

- 18% of students found it difficult to discuss issues and problems within the team
- 8% of students felt that mistakes were held against them
- 8% of students did not feel comfortable taking risks
- 8% of students found it difficult to ask for help within the team.

These results suggest that our students need to become more self-aware of their interactions within teams so that they can improve the overall well-being of the team.

Conclusion

This pilot project developed a preliminary approach to evaluate teamwork and leadership within the Civil Engineering, and Construction Engineering and Management curriculum using an SLR, peer-evaluation, and psychological safety (PS) survey. Through the project we evaluated the students' ability to effectively perform within a group on a few team assignments. They each provided artifacts directly aligned to SO 5: provided leadership, created a collaborative and inclusive environment, established goals, planned tasks, and met objectives.

Based on the SLR and the peer-evaluation, students' notion of leadership was closely tied to the role of a leader. In Construction Engineering 58% of student strongly agreed that the members within the team provided leadership, whereas 30% of students in Water Resource Engineering strongly agreed that team members provided leadership. All members of the team can and should be a leader. However, a leader is someone who helps the team beyond just completing assigned tasks. Students were clearly able to define inclusivity and collaboration in the SLR, and the results were supported by the peer-evaluation and PS survey. That is, results from the peer-evaluation revealed that approximately 95% of all students in both courses agreed or strongly agreed that the working environment was inclusive and collaborative. In addition, the PS survey revealed that not only did 96% of students did not feel rejected for being different, but 87% of students valued and respected their team members' contributions. These findings suggest that students respected each other's diverse viewpoints and made sure everyone had an opportunity to be heard. Furthermore, students' responses on the SLR and peer-evaluation regarding meeting the project goals, submitting a quality product and completing assignment on time were similar, with the majority of students stating they either agreed or strongly agreed (93% to 98%). This can be attributed to the instructors transparent assignment and project templates. This ensured that students understood the overall assignment and what's needed to be submitted. In addition, the instructors developed a scaffolded approach to the project by requiring teams to submit a draft report. The draft assignment revealed that students struggled with prioritizing assignments and allocating sufficient time on projects, which made evident there was still room for growth.

This need for growth was made more evident on the day of submittal when several teams attended office hours to better understand comments provided on their draft reports. Ultimately, we were pleasantly surprised to see that students participated in a wide variety of activities that engaged their learning in team environments. There can be more intentional instruction to have students work together to improve their sense of belonging. Finally, our students need to become more self-aware of their interactions within teams so that they can improve the overall well-being of the team.

Through the creation of intentional learning modules, students can be asked to perform a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis on their team to identify ways to become more self-aware. There also needs to be more intentional engagement to guide students in creating these working communities outside of the classroom. The results will increase student success and provide students with a sense of belonging.

Next Steps/Continuous Improvement Plan

Based on the results the we engaged in a collaborative process to develop strategies for continuous improvement.

1. During future sessions, team members should be placed in teams based on their Belbin team roles. Belbin states that highly functioning teams have members that exhibit all the team roles. To accomplish this, students will need to take the Belbin team roles assessment and faculty will need to evaluate the results to place students in teams covering each of the team roles [21]. At the end of the semester the team performance can be evaluated based on the team assignments made at the beginning of the semester.
2. Develop a discussion post or survey to identify the level of contribution that each team member makes on the assignments and projects.
3. Provide teamwork training and resources to student teams. One example could be to have the students complete a team SWOT analysis to become more self-aware and learn to work as a highly effective team. Offer case studies on teamwork and have students reflect on positive and negative behaviors.
4. Intentionally have students work in study groups and/or work on assignments together. One strategy could be that over the course of the semester make 3 homework assignments group assignments. The results will increase student success and provide students with a sense of belonging.
5. Work with the College of Engineering Leadership team to develop modules that can be imbedded into various courses to help build students' abilities to function effectively within teams. The modules should focus on:
 - decouple connection students have with a project manager and a leader;
 - instruction on setting goals for the projects;
 - create case studies for students to reflect on positive and negative teamworking behavior;
 - develop a plan to evaluate team strengths and weaknesses;
 - come prepared to team meetings so that one's time is being used efficiently; and
 - getting student testimonials on their experience participating in the Leadership series

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