

Multiple Perspectives on Assessing Student Team Dynamics Using CATME in a First-year Engineering Course

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Introduction

This complete evidence-based paper describes a novel method to assess student team dynamics. The importance of teamwork is undeniable in industries relating to new product development, and engineering professionals almost always collaborate in project teams composed of people from various, complementary engineering backgrounds [1-3]. As directed by the project managers or leaders, these project teams are responsible for completing various time-sensitive tasks and producing long lists of deliverables. Professionals from different engineering fields must therefore learn how to effectively collaborate on development projects to produce a product of the highest quality, with the highest efficiency, and ideally at the lowest cost. However, teaching engineering students (especially freshmen) team dynamics [4] and effective strategies for handling intra-group conflicts[5], is not always an easy task. The results of a given project are subject to the individual contributions within the overall team. Therefore, the teams that make the best use of each member's unique talents and knowledge in cooperative efforts would achieve a lot more than what would be achieved from an individual effort. It is therefore important to monitor and maximize team dynamics. The web-based program *Comprehensive Assessment of Team Member Effectiveness* (CATME), developed by Purdue University, allows for peer-to-peer evaluations and is therefore an effective tool to monitor team dynamics. Moreover, the instructor can intervene and promptly resolve any student issues.

At New York University, 600 students take first-year courses annually. It is time-consuming for instructors to analyze over 3000 peer ratings and comments. Given that the student teams would require fast response from the instructor, it is necessary to introduce a new framework: project mentorship, additional evaluation dimensions, and confidential statements to the instructors. One part of the framework is to introduce the assistant roles into the CATME evaluation process, i.e. the project mentor. The responsibilities of project mentors are to provide technical support as well as set benchmark requirements. The project mentors would be able to access the team performance together with the instructor and provide their perspectives on dealing with team issues. In this way, the mentors would speed up the instructor's workflow. The research question is: How to best assess student team dynamics incorporating the perspectives of all the shareholders?

It was found that additional evaluation dimensions allow the users to gain more insights into the team dynamics. The three new dimensions were psychological safety [6], team interdependence [7], and team satisfaction [8]. One dimension of psychological safety was applied in Peer Evaluation I. As it is the early and storming stage of team formation, it is critical to check if students feel comfortable within the team. Another dimension of team independence was applied in Peer Evaluation II to evaluate the team synergy, then the dimension of the team satisfaction was placed in Peer Evaluation III to analyze the overall teamwork experience. During the peer evaluations, some of the students prefer to directly message in fear of escalated interpersonal conflicts. CATME has a feature named confidential statements, which allows students to share additional thoughts or suggestions [9]. The instructor could have more insights into the team

issues such as potential cliques formed within the team. This new framework was implemented in the summer semester of 2023. The team peer ratings and evaluations will be compared with last year's data. It is worth noting that the student teams generally have more positive feedback on the teamwork experience after implementing the new framework.

Experimental Methods

Team projects

The project teams were first formed at the beginning of the semester. Each team has 2 to 4 students. The students were put into the teams via randomized assignment of team members with different demographic, racial and cultural backgrounds. The teams were given opportunities to generate project ideas for the first two weeks. A teamwork agreement was signed between the members to confirm the following expectations: detailed responsibilities of each member; ways of communication; meeting schedule and absence rules; difference in opinion; individual responsibilities and agreed workload for each team member.

There are three different types of projects: open-ended prototyping projects named Rapid Assembly and Design (RAD), Housing and Innovation in Revit (HIR), and Robot Design (VEX). Both HIR and VEX have pre-determined project scope and direction. On the other hand, due to the open-ended nature of RAD, project mentors have been assigned to RAD teams. A mentor is a senior student who has taken the class before and been very familiar with the requirements and standards of the student projects. Their main responsibilities are to guide the students through the completion of their RAD projects, participate in weekly meetings to assess and facilitate the team progress, set benchmarks for the students, advise and approve project purchases, and most importantly, act as an impartial negotiator to resolve conflict if needed.

CATME Evaluation

The CATME evaluation mainly comprises of three parts: peer evaluations, mentor feedback as well as confidential statement. **Figure 1** shows the proposed framework to utilize three parts to access the student team performance from different angles: peer angle, mentor angle and personal angle. This will determine the overall student performance for each student. This framework allows the instructors to identify and analyze the team situation in a timely manner. The peer evaluation was set to be visible to peers with their members' names, this encourages the students to leave positive comments to their peers and improve the team synergy. On the other hand, if the students prefer to leave private messages to the instructors, there is an option called "confidential comments" which are classified as "personal perspective" in this study.

Moreover, the mentor can leave comments to assigned student groups or email the instructors about the status of the student group. This provides a third perspective to the team performance as they can judge the project outcomes via observation during the regular team meetings and email communication. The mentor is serving as "the witness" of student behavior in the student projects.

At the beginning of the semester, the students were given instructions on how to perform peer rating as well as the evaluation flowchart. It is imperative to ensure the student knows the peer

evaluation is not a “peer grade” but provide a direct indication for instructors to know about the team performance. A small amount of course credits were given to the students who completed the consecutive milestone evaluations.

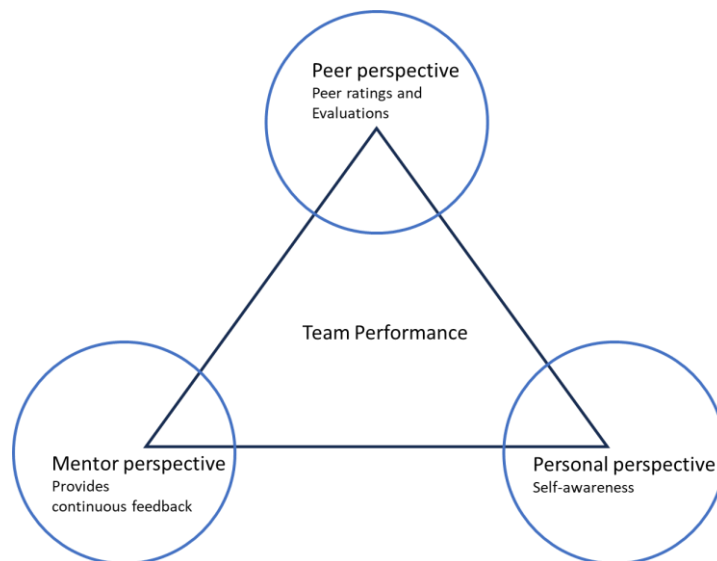


Figure 1. New framework describing the three perspectives: Peer, Mentor and Personal, which enables the instructor to evaluate the team situation from multiple angles.

In Fall 2023, the CATME survey was administered by 60 project teams overall. The data was collected from the 40 project teams on their Peer Evaluation 1, 2 and 3 (**Figure 2**). Peer Evaluation 1 happened one week after the team formation. The main content was the six dimensions of student teamwork effectiveness: contributing and psychological safety. The CATME Psychological Safety brochure concluded that the psychological safety questions could possibly explain the conflict and cohesion in teams [10]. Peer Evaluation 2 happened in the middle of the semester, the main content was five dimensions and team interdependence. Peer Evaluation 3 happened at the end of the semester, the main content was five dimensions and team satisfaction.

	Week 1 to Week 7	Week 8 to Week 10	Week 11 to Week 14
Peer Perspective	Peer Evaluation I	Peer Evaluation II	Peer Evaluation III
Mentor Perspective	Mentor Supervision		
Personal Perspective	Milestone 1	Milestone 2	Milestone 3

Figure 2. Schedule of the student Projects.

Table 1 shows the questions for psychological safety, team interdependence as well as team satisfactions, respectively. All the questions are from CATME website [11]. Psychological safety measures student feelings of being accepted, respected, and confident within a project team.

Team interdependence measures student interaction and dependency on other team members. Team satisfaction looks into the extent of satisfaction of a student within the current project group [12].

Table 1. Questions covered in psychological safety, team interdependence as well as team satisfactions.

Psychological Safety	
Scale: 1 = Very Inaccurate, 2 = Inaccurate, 3 = Slightly Inaccurate, 4 = Uncertain, 5 = Slightly Accurate, 6 = Accurate, 7 = Very Accurate	
Q1	If you make a mistake on this team, it is often held against you. <i>[scale reversed]</i>
Q2	Members of this team are able to bring up problems and tough issues.
Q3	People on this team sometimes reject others for being different. <i>[scale reversed]</i>
Q4	It is safe to take a risk on this team.
Q5	It is difficult to ask other members of this team for help. <i>[scale reversed]</i>
Q6	No one on this team would deliberately act in a way that undermines my efforts.
Q7	Working with members of this team, my unique skills and talents are valued and utilized
Team Interdependence	
Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree Nor Disagree, 4 = Agree, 5 = Strongly Agree	
Q1	My teammates and I have to obtain information and advice from one another in order to complete our work
Q2	I depend on my teammates for the completion of my work
Q3	I have a one-person job; I rarely have to check or work with others <i>[scale reversed]</i>
Q4	I have to work closely with my teammates to do my work properly
Q5	In order to complete our work, my teammates and I have to collaborate extensively
Team Satisfaction	
Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree Nor Disagree, 4 = Agree, 5 = Strongly Agree	
Q1	I am satisfied with my present teammates
Q2	I am pleased with the way my teammates and I work together
Q3	I am very satisfied with working in this team

At the beginning of the semester, the students were given instruction on how to perform peer evaluations. The instructor suggested that the student should activate the account and work on rater practice in the third week of semester.

The project mentors were able to monitor the project progress via reviewing the peer evaluation as well as hosting team meetings. The detailed responsibilities of the mentors are guide students through the completion of their RAD project, hold weekly meetings to assess and facilitate progress, complete weekly progress reports, set benchmarks that are challenging but achievable, provide updates and information to the group as needed, advise and approve purchase requests, act as an impartial negotiator to resolve conflicts if needed. The weekly meeting with the students is mandatory, it is supposed to last at least 30 minutes per week. The first meeting will start before the first project Milestone.

The project mentors were trained over summertime to deal with different team situations. Most

With the help of final project completion status, the following equation was introduced. This enables the instructor to evaluate the team performance from a peer perspective.

$$\text{Peer Perspective} = \text{Adjustment factor Without Self} \times 100 \quad (1)$$

Along with the framework in Figure 1, the Equation (4) is able to determine a numerical value for the team performance within the range of 0 — 7 with 7 is the highest performing score a project team could achieve. The Overall Perspective (OP) can be assessed using **Table 2**.

Table 2. Grading Policy

Peer Perspective		
Need major improvement	Needs minor improvement	Satisfied
<90	<100	100-105
Mentor Perspective		
Need major improvement	Needs minor improvement	Satisfied
Two warning messages	One warning message	No warning message
Personal Perspective		
Need interventions from the instructor	Needs minor interventions from the instructor	Satisfied
<4.5	<5	5-7

Results

Value of Personal Perspective

The personal perspective has three main components: psychological safety, team interdependence, and team satisfaction. The psychological safety survey was administered during Peer Evaluation 1. **Table 3** shows two examples of the student ratings on the psychological safety of their teams. According to the CATME guideline, the students who receive peer rating of **less than 4.71**, would need faculty's attention. A common approach is to set up a one-on-one meeting with the student, allow the students to explain the situation in detail, and make

appropriate suggestions to the students. For example, for Student B, choose “Slightly Inaccurate” in “People on this team reject others for being different” and “Uncertain” in “It is safe to take a risk in this team”. The instructor would approach Student B and encourage the student to communicate with other members with confidence and express their concerns. The problem would eventually be resolved via more effective team communication. The communication barrier would likely happen between first-year students as they came from different backgrounds and were still new to the college learning environment. Many of them may not have group project experience.

Table 3. Two examples of student ratings on the psychological safety of their project teams

Project Team 1											
Student Name	Student ID	Team ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Mean	Standard Deviation
Student A	0	RAD30	2	6	2	6	2	6	6	6.00	0.00
Student B	0	RAD30	6	6	3	4	4	6	5	4.57	1.40
Student C	0	RAD30	2	6	2	6	2	6	6	6.00	0.00
Project Team 2											
Student Name	Student ID	Team ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Mean	Standard Deviation
Student D	0	D2LAZ	2	6	1	5	1	7	6	6.29	0.76
Student E	0	D2LAZ	1	6	1	6	1	7	7	6.71	0.49
Student F	0	D2LAZ	5	6	4	7	1	1	6	4.86	2.27
Student G	0	D2LAZ	1	7	1	7	1	7	7	7.00	0.00

Moreover, the confidential statement enables the students to share private messages which they want to be confidential to other team members. This allows the instructor to set up individual meetings with the students who have specific concerns.

Value of Peer Perspective

Table 4 shows some examples of confidential statements in comparison with the peer evaluation. In Project Group 1, the adjustment factor is 0.78 for Student A, hence the peer perspective for Student A is 78, which is within the range “needs minor improvement”. The instructor would call for an individual meeting with Student A and guided Student A to work on team communication. On the other hand, in Project Group 2, the adjustment factor is 1.04 for Student D. This means the peer perspective is 104, which is within the range “satisfied”. So the instructor does not need to apply any interventions.

Table 4. Confidential statements and peer evaluations provided by individual team members.

Project Group 1							
Confidential Statements				Peer Evaluations			
Student A, “ <i>I wish Student B included me more in the project. I don’t feel as if I’m contributing enough but that is also because I am assigned the bare minimum.</i> ”				Student B to Student A, “ <i>She does the work that is assigned to her, however I wish she started on it earlier so we had time to account for outside errors. She communicates well with the rest of the team.</i> ”			
				Student C to Student A, “ <i>Communicates with the team and helps the team with electrical plans. Something she needs to work on is being more efficient in completing her tasks and managing her time more.</i> ”			
Peer Ratings of Project Group 1							
	Contrib. to Team	Interact w/ Team	Keeping on Track	Expect Quality	Having KSAs	Adj Factor (w/ Self)	Adj Factor (w/o Self)
Student A	2.7	3.3	3	3	2.7	0.8	0.78
Student B	4	4	3.7	3.7	4	1.05	1.05
Student C	4	4.3	4.3	4	4.3	1.05	1.05
Project Group 2							
Confidential Statements				Peer Evaluations			
Student D, “ <i>Great work great team and everyone collaborates. But during the process, Student B zones out sometimes. Like he is here physically but not mentally.</i> ”				Student D to Student E, “ <i>Pulls up to meetings, great work, replies to messages.</i> ”			
				Student F to Student E, “ <i>Edison has demonstrated the ability to learn new skills for this project. He makes sure to get his work done, and shows up to most meetings.</i> ”			
				Student E self-comment, “ <i>Find ways to fix the wiring as well as codes. Help teammates to build the greenhouse</i> ”			
Peer Ratings of Project Group 2							
	Contrib. to Team	Interact w/ Team	Keeping on Track	Expect Quality	Having KSAs	Adj Factor (w/ Self)	Adj Factor (w/o Self)
Student D	4	3.5	3.8	4.2	3.8	1.02	1.04
Student E	4.2	3.2	3	3.5	4.5	1	1
Student F	4	3.2	3.5	4	4	1	1.01

Value of Mentor Perspective

Table 5 shows one example on how the students is using CATME to evaluate each other's performance in one project group. It seems the group is on the right track by just reviewing the peer rating and comments. However, the mentor is able to point out a potential problem which the student could improve on the meeting attendance. Since there is one warning message from the mentor, it is important for the instructor to follow up with Student A on meeting attendance.

Table 5. One example on mentor perspective

Project Team Peer ratings					
	Contribution to Team	Interaction with Team	Keeping on Track	Expect Quality	Having KSAs
Student A	3.6	3.6	3.4	4.0	3.6
Student B	3.8	4.0	3.8	4.2	3.8
Student C	4.2	4.4	4.2	4.2	3.8
Student D	4.6	4.4	4.4	4.2	4.2
Project Team Peer Comments					
"I think that I need to. Learn to bring more ideas to the table. But overall, the structure of our project looks very stable, and I think that we are on the correct path." "Student A is on time with the tasks and communicates with the team. He is working on the coding and does not hesitate to research more to do a better job." "I commend you for doing a great job learning the necessary software and language in such a short time."					
Mentor Comments (to the instructor)					
"This RAD team was able to work very well collaboratively. There weren't many major issues that had arise other than purchasing, which was an issue with the Amazon deliveries, and the logo approval, which had difficulty sending it to Proto on the correct format which was an issue for many groups. The only thing that came up was Student A missing 2 meetings and he didn't respond to his team members or me about his whereabouts after multiple reach outs. They were all able to work efficiently and met all early benchmarks."					
Mentor Comments (to the students)					
To Student A: <i>"I am glad to see that you were able to use the new software with the guidance and reassurance from William. It is good to see you persevere against new things you aren't used to and out of your comfort zone, and you were still able to come up with great results. For future reference, it is important to communicate with your team members when you can't show up for whatever reason. Make sure to respond when they reach out, and be honest."</i> To Student B: <i>"Amazing job being a team player and recognizing your talents and where they are needed. I was happy to hear how you were going to design a webpage advertisement for the extra credit and pushing yourself to design more. I am glad and appreciative that you were communicative to me and looped me in when the solder</i>					

Discussion

Students are allowed to do the rater practice before the actual ratings. However, most of the first-year students are not able to accurately evaluate peer performance due to lack of experience, especially group-working experience. That is why multiple perspectives such as mentor perspective can investigate the issue to deeper level from the surface. Especially in the case of a two-student team, the peer rating could play less important role as it is difficult for them to stay anonymous. Therefore, the mentor and personal perspective would greatly help to evaluate the team dynamics.

Having peer evaluations is beneficial for students to self-evaluate their own project performance. Students are more likely to leave positive or neutral comments to each other for multiple reasons: 1. They want to keep the team integrity and are trying to avoid conflicts due to negative comments; 2. They would like to encourage team members to put more effort into the projects. From the data in Fall 2023, over 90% of peer comments are positive or neutral. The introduction of mentor comments could potentially bring more constructive opinions into the team.

The introduction of confidential statements allows the instructor to gain more insights into the situation. For example, in Table 5, Student B and C asked for more productivity from Student A in the peer comments while Student A hoped to be more involved in the project. Therefore, the reality is that Student B and C will need to see Student A could complete easier tasks with higher efficiency before they could assign more challenging tasks to Student A. Hence, the instructor could have a private discussion with Student A regarding the task assignment.

This study is heavily based on the raw data collected from CATME system. The student comments were manually screened and selected. Ideally, an automatic screening algorithm would increase the efficiency of reviewing student comments and reduce human errors.

Conclusion

A new framework of tracking team performance was proposed. It is recommended that the instructor would allow the mentors to give comments to their student team at project milestones. The instructor could also encourage students to utilize the feature of confidential statements. Moreover, a quantitative team assessment is suggested using three different perspectives: personal, peer and mentor. The personal perspective can be quantitatively evaluated via three different surveys being administered at different milestones of the project: psychological safety, team interdependence, and team satisfaction, all developed by CATME. The peer perspective can be quantitatively evaluated via the Equation (1) with adjustment factor without self. The mentor's perspective would be directly assessed via written feedback. Through this multi-perspective approach, the first-year instructors could apply more specific instructions or intervention to ensure student projects are completed on time.

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