

## Work in Progress: First-time Use of CATME in a Design Course

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Goal: Make a difference in the world, through development and training of engineers to solve the most pressing problems facing the world today.

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## **WORK IN PROGRESS: First-Time Use of CATME in a Design Course**

### **ABSTRACT**

Being a member of a team is a common experience for many people, e.g., during athletic endeavors, as students in school, or as colleagues in the workplace. The idea, however, that any team will function at a high level (i.e., productively and constructively) without purposeful and well-informed effort is not true. The literature on forming teams supports the notion that teams thrive when team members feel psychologically safe, are engaged in setting goals, and are dependent on and are accountable to one another. It is unclear, however, what the appropriate conditions are in a given setting (e.g., athletics, school, workplace) that will encourage the formation of healthy teams and appropriately engaged team members. The goal of this study was to introduce, for the first time, CATME in Stanford University's mechanical engineering capstone design course (ME 170, Mechanical Engineering Design: Integrating Context with Engineering) so that it could facilitate the establishment of healthy team dynamics among student design teams. Specifically, we asked the following questions: (1) does the format of the course support healthy team practices? (2) do students find CATME sufficient/helpful for learning about their strengths and ways to improve? and (3) how healthy are the design teams? CATME was introduced in ME 170 as a tool to evaluate the extent to which teams were engaged in healthy team practices and to generate discussion within teams about healthy team dynamics. Following the end of the course, semi-structured interviews were conducted to learn about student CATME experiences. Based on the CATME scores from 13 design teams (51 students) and interviews of 2 students, we found that: (1) the structure of the course does support healthy team practices; (2) students may benefit from a team assessment tool, in addition to CATME, that requires structured, written feedback from everyone to be shared; (3) the student design teams were more healthy than not.

### **INTRODUCTION**

Being a member of a team is a common experience for many people, e.g., during athletic endeavors, as students in school, or as colleagues in the workplace. The idea, however, that any team will function at a high level (i.e., productively and constructively) without purposeful and well-informed effort is not true. The literature on forming teams supports the notion that teams thrive when team members feel psychologically safe, are engaged in setting goals, and are dependent on and are accountable to one another (Duhigg, 2016). It is unclear, however, what the appropriate conditions are in a given setting (e.g., athletics, school, workplace) that will encourage the formation of healthy teams and appropriately engaged team members. To this end, we considered various assessments that are used to evaluate team dynamics.

While there are many assessment tools for measuring, monitoring and managing team health (e.g., Rosenstein and Dickerson, 1996; Taggar and Brown, 2001; McGourty and De Meuse, 2001), the Comprehensive Assessment of Team-Member Effectiveness or CATME (Loughry et al., 2007; Ohland et al., 2013) appears to be a common one (Pung and Farris, 2001; Lucietto et al., 2017; Beigpourian et al., 2019) to evaluate the extent to which teams thrive. CATME is a

team-formation and team-evaluation tool rooted in management science, engineering education and psychology. CATME measures team health along five dimensions and each of which is considered on a 5-point Likert scale with a pre-defined description for each level. The literature is replete with examples of studies using CATME as a team evaluation tool. For example, Pung and Farris (2001) used CATME as a formative assessment to teach students how to “team” well. Luciette et al. (2017) described an effort among many institutions to standardize the way in which CATME is used to evaluate teamwork skills. Work by Beigpourian et al. (2019) was compelling in that they determined relationships among CATME responses that tend to be true for teams that were classified as dysfunctional. Despite the fact that there are many studies in the literature involving the use of CATME, we could not find guidance on the best way to implement CATME in a college design course. For example, from a course-design perspective, when should student teams be first introduced to CATME and how frequently should teams use CATME for feedback? Additionally, will CATME be well-accepted by new, college-age users and will they find the CATME framework sufficient and compelling to learn about their strengths and weaknesses during teamwork?

The goal of this study was to introduce, for the first time, CATME in Stanford University’s mechanical engineering (ME) capstone design course--ME 170, Mechanical Engineering Design: Integrating Context with Engineering--so that it could facilitate the establishment of healthy team dynamics among student design teams. The hope was that measurements of team health would provide student teams and the teaching team helpful information that could direct student and teaching team effort toward thriving student team experiences. Specifically, we asked the following questions: (1) does the format of the course support healthy team practices? (2) do students find CATME sufficient/helpful for learning about their strengths and ways to improve? and (3) how healthy are the design teams?

## **METHODS**

### ***CATME***

CATME was introduced in ME 170 to supplement the team formation process, influenced by student interests and student self-assessments of skills/traits, and to evaluate team dynamics. In the course, 51 students were divided into 13 teams of 3-4 students, and followed the engineering design process through verification and validation of a working prototype that addressed a client-inspired need. The main challenges of the course for the students are to integrate multiple engineering themes within the ME curriculum as well as to grow to demonstrate a command of professional skills that facilitate healthy team dynamics. Such skills include, communication, organization, time management and decision-making.

During the initial weeks of the first quarter of the course and before CATME was introduced to the student teams, they had the opportunity to participate in learning activities intended to prepare them to work constructively as teammates. For example, such activities centered around how to demonstrate good and productive behavior, and conflict resolution. Near the end of the first quarter, students were also asked to watch standard CATME videos on “how to take a peer evaluation for students” and “rater practice demonstration for students.” Following preparation for CATME, team members were given the opportunity to provide self- and

peer-feedback at the end of the first and second quarters of the course. In general, CATME measures team health along the following five dimensions: (1) contribution to team’s work, (2) interacting with team members, (3) keeping the team on track, (4) expecting quality and (5) team satisfaction. Each dimension is considered on a 5-point Likert scale with a pre-defined description for each level. For example, the descriptions for each level of dimension #1 (contribution to team’s work) are listed here:

**Table 1:** Five-Point Likert Scale Descriptions for CATME Dimension #1: Contribution to Team’s Work

5	<ul style="list-style-type: none"> <li>● Does more or higher-quality work than expected</li> <li>● Makes important contributions that improve the team's work</li> <li>● Helps teammates who are having difficulty completing their work</li> </ul>
4	<ul style="list-style-type: none"> <li>● Demonstrates behavior between 5 and 3</li> </ul>
3	<ul style="list-style-type: none"> <li>● Completes a fair share of the team's work with acceptable quality</li> <li>● Keeps commitments and completes assignments on time</li> <li>● Helps teammates who are having difficulty when it is easy or important</li> </ul>
2	<ul style="list-style-type: none"> <li>● Demonstrates behavior between 3 and 1</li> </ul>
1	<ul style="list-style-type: none"> <li>● Does not do a fair share of the team's work and/or delivers sloppy or incomplete work</li> <li>● Misses deadlines and/or is late, unprepared, or absent for team meetings</li> <li>● Does not assist teammates and/or quits if the work becomes difficult</li> </ul>

In addition to providing numeric CATME feedback, students provided written feedback on team member strengths and areas in which team members could improve using another assessment tool, called “I like, I wish” (ILIW) (Calleja, 2020). Students were given the following prompt:

“Think about interactions with your teammates, and reflect on your team charter. How are things going? What's working well, and what do you wish might improve? Reflect on each team member, what are 1-2 behaviors that you like, 1-2 behaviors you wish they would take on. Reflect on your own behaviors. Are they consistent with your team values? Is there something that you believe you could improve? Communicate honestly, generously, and clearly, reflecting on tools discussed in class. What will you commit to going forward.”

Following CATME and ILIW evaluations during the first quarter of the ME 170, student teams met to discuss feedback, committed to changes in behavior based on the feedback, and agreed on team values. Paired t-tests ( $\alpha < 0.05$ ), conducted using MATLAB (Mathworks; Nantucket,

MA), were used to compare CATME scores from the first session to the second session on class-wide and team bases.

### ***Interviews***

Following the end of the ME 170, semi-structured interviews were conducted to learn about student CATME experiences. Each interview was, at most, 30-minutes long, recorded, and consisted of six questions. The questions were formulated to normalize student CATME experiences; to explore the relationship between course learning goals and CATME, as perceived by the students; and to understand how students responded to CATME peer feedback. Follow-up questions were asked where appropriate. The following are the six questions:

1. Had you used CATME in another class?
2. By the end of the course, student will be able to: (1) deliver a finished engineering system addressing a real-world problem; (2) work as part of a team to design and develop an engineering system; (3) assess the impact of engineering solutions on the world; and (4) learn and apply professional communication skills, including oral presentations, written deliverables, and critical listening and feedback. Do you think CATME helped you to achieve any of the goals? If so, which one(s)? How?
3. How useful was the feedback you received?
4. How did you use the feedback, if at all?
5. How accurate did you believe the feedback to be?
6. Would you recommend the use of CATME in other teamwork settings?

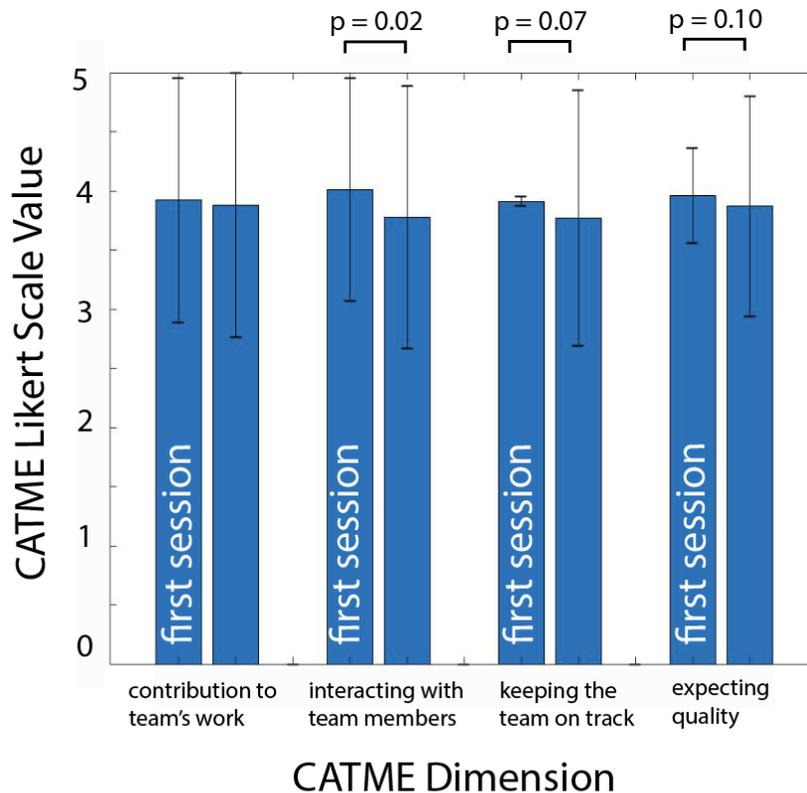
The interview responses were manually reviewed to identify common themes or anecdotes and to identify key quotes among the participants. In this study, we employed a triangulation design mixed-methods approach (Creswell, 2003) where we aimed to address the study questions using data sets from both CATME and the interview sessions.

## **RESULTS**

### ***CATME***

One hundred percent of the class (51 students) completed the CATME evaluation at the end of the first quarter while 86% of the class (44 of 51 students) did so at the end of the second quarter. The class-wide mean and standard deviation scores along CATME dimensions #1-4 at the end of the first quarter were 3.92 (1.03), 4.01 (0.94), 3.91 (0.04), 3.96 (0.4); and at the end of the second quarter, 3.88 (1.12), 3.78 (1.11), 3.77 (1.08), 3.87 (0.93) (Fig. 1). After comparing the first and second quarters' CATME data, there was a class-wide, significant decrease ( $p=0.02$ ) of 0.23 in the second score, i.e., "interacting with teammates." See Fig. 1.

## Class-Wide CATME Dimension Scores at the End of the First and Second Sessions



**Figure 1: CATME Scores Bar Graphs.** Mean scores and their standard deviations are presented for four CATME dimensions at two time points, the end of each quarter of class. On average, teams had significantly less team member interactions ( $p=0.02$ ) at the end of the second quarter compared to the first quarter.

Table 2 lists CATME pre-defined descriptions for dimensions in which teams on average demonstrated a behavioural shift (“interacting with teammates”) from the first and to the second quarter of the course (Loughry et al., 2007). Mean scores can be used to infer behaviors based on the tables. For example, considering dimension #2 (“interacting with teammates”) during the first quarter of the course, members of a given team, on average, listened to each other, while occasionally inviting the opportunity to hear from one another. Members of that team also showed respect for each other’s contributions.

**Table 2:** Five-Point Likert Scale Descriptions for CATME Dimension #2: Interacting with Teammates

5	<ul style="list-style-type: none"> <li>● Asks for and shows an interest in teammates' ideas and contributions</li> <li>● Makes sure teammates stay informed and understand each other</li> <li>● Provides encouragement or enthusiasm to the team</li> <li>● Asks teammates for feedback and uses their suggestions to improve</li> </ul>
4	<ul style="list-style-type: none"> <li>● Demonstrates behavior between 5 and 3</li> </ul>
3	<ul style="list-style-type: none"> <li>● Listens to teammates and respects their contributions</li> <li>● Communicates clearly and shares information with teammates</li> <li>● Participates fully in team activities</li> <li>● Respects and responds to feedback from teammates</li> </ul>
2	<ul style="list-style-type: none"> <li>● Demonstrates behavior between 3 and 1</li> </ul>
1	<ul style="list-style-type: none"> <li>● Interrupts, ignores, bosses, or makes fun of teammates</li> <li>● Takes actions that affect teammates without their input. Does not share information</li> <li>● Complains, makes excuses, or does not interact with teammates</li> <li>● Is defensive. Will not accept help or advice from teammates.</li> </ul>

A team-by-team analysis shows that 6/13 teams experienced a significant decrease ( $p < 0.05$ ) in one or more CATME scores and 2/13 teams experienced a significant increase ( $p < 0.05$ ) in one CATME score from the first to the second quarter of the course (see Table 3). Team 5 experienced the greatest change, i.e., 1.37 with respect to the second CATME dimension (see boxed cell in Table 3).

**Table 3:** Significant Changes in CATME Scores Along Each Dimension by Team

Team	CATME Dimension			
	1 - Contribution to Team's Work	2 - Interacting with Team Members	3 - Keeping the Team on Track	4 - Expecting Quality
1				4.33 to 3.33 (-1.00)
2				
3				
4	3.75 to 3.12 (-0.63)	4.50 to 3.62 (-0.88)		
5		3.81 to 2.44 (-1.37)	3.88 to 2.75 (-1.13)	4.00 to 3.44 (-0.56)
6			4.67 to 3.89 (-0.78)	
7				3.75 to 4.25 (+0.50)
8				
9			3.50 to 4.33 (+0.83)	
10				4.19 to 3.50 (-0.69)
11				
12				
13	4.67 to 4.25 (-0.42)	4.67 to 4.33 (-0.34)		

To add context to the changes in Table 3, Tables 4 and 5 (and Tables 1 and 2 above) list CATME pre-defined descriptions for dimensions in which individual teams on average demonstrated behavioural shifts (Loughry et al., 2007). Mean scores can be used to infer behaviors based on the tables.

**Table 4:** Five-Point Likert Scale Descriptions for CATME Dimension #3: Keeping the Team on Track

5	<ul style="list-style-type: none"> <li>• Watches conditions affecting the team and monitors the team's progress</li> <li>• Makes sure that teammates are making appropriate progress</li> <li>• Gives teammates specific, timely, and constructive feedback</li> </ul>
4	<ul style="list-style-type: none"> <li>• Demonstrates behavior between 5 and 3</li> </ul>
3	<ul style="list-style-type: none"> <li>• Notices changes that influence the team's success</li> <li>• Knows what everyone on the team should be doing and notices problems</li> <li>• Alerts teammates or suggests solutions when the team's success is threatened</li> </ul>

**Table 5:** Five-Point Likert Scale Descriptions for CATME Dimension #4: Expecting Quality

5	<ul style="list-style-type: none"> <li>● Motivates the team to do excellent work</li> <li>● Cares that the team does outstanding work, even if there is no additional reward</li> <li>● Believes that the team can do excellent work</li> </ul>
4	<ul style="list-style-type: none"> <li>● Demonstrates behavior between 5 and 3</li> </ul>
3	<ul style="list-style-type: none"> <li>● Encourages the team to do good work that meets all requirements</li> <li>● Wants the team to perform well enough to earn all available rewards</li> <li>● Believes that the team can fully meet its responsibilities</li> </ul>

Finally, concerning the fifth CATME score, “team satisfaction”, there was no change between scores during the first (mean = 4.04, STD = 1.03) and second (mean = 3.68, STD = 1.21) quarters of the course.

### ***Interviews***

Two of 51 students, representing 2 of 13 teams, participated in interviews. In addition to the six planned interview questions, 6 follow-up questions were asked of subject 1 and two of subject 2. From those interviews, the following anecdotes/commonalities emerged:

1. Their first experience with CATME was in this course
2. CATME enabled accomplishment of 2 of the 4 course learning goals (LG)
  - a. Students will be able to work as part of a team to design and develop an engineering system (LG #2)
  - b. Students will learn and apply professional communication skills, including oral presentations, written deliverables, and critical listening and feedback (LG #4)
3. ILIW comments were more useful than the average numerical CATME rating along each dimension
4. CATME auto-generated rating-based feedback was ignored, if noticed at all
5. Anonymous nature of CATME scoring feedback facilitated honest and critical feedback for the one giving the feedback
6. Anonymous nature of CATME scoring feedback made the feedback credible for the one receiving the feedback
7. CATME is recommended for other team-based settings

### *Key quote*

“ ‘I like, I wish’ provided a helpful norm for honest face-to-face conversation and this was more important than solving problems.”

## **DISCUSSION**

This work summarizes a first effort to incorporate an assessment tool (CATME) in a Stanford’s ME capstone design course to evaluate the extent to which teams were engaged in healthy team practices. In this pilot study, we asked the following questions: (1) does the format of the course support healthy team practices? (2) do students find CATME sufficient/helpful for learning about their own strengths and ways to improve? and (3) how healthy are the design teams?

*The structure of the course was supportive of healthy team practices.* On average, the CATME scores for teams along the dimensions considered were approximately 4’s (out of 5) following the first and second quarters of the course (Fig. 1). While we do not know the preparedness of the students prior to the course for working in teams, this course is the first one in the ME curriculum that aims to equip students to work in teams in a structured way. As such, it is reasonable to believe that the CATME-related learning exercises, and targeted interactions with and weekly guidance from members of the teaching team had positive effects on the student teams and, therefore, contributed to the overall high CATME scores in both quarters. The fact that 8 of 13 teams experienced statistically significant shifts in CATME scores along one or more dimensions is practically unimportant as the magnitudes of those shifts were relatively small (most were less than 1). Teams 1 and 5 were the only teams that experienced a decrease in CATME scores that were greater than or equal to 1 along one or more CATME dimensions. The fact that Team 1’s CATME score along dimension #4 at the end of the second quarter was greater than 3 (i.e., 3.33) is less alarming than Team 5’s second-quarter scores that are less than 3 relating to “interacting with team members” (2.44) and “keeping the team on track” (2.75). It appears that Team 5 was not representative of the class as a whole, but perhaps the team had a level of dysfunction worth addressing.

*Students may benefit from an additional team assessment tool that requires structured, written feedback from everyone to be shared.* Two anecdotes emerged from the student interviews: (1) teammate ILIW comments were more useful than the average numerical CATME rating along each dimension; and (2) CATME auto-generated rating-based feedback was ignored, if noticed at all. Taken together, these data indicate that students placed more value on shared, written feedback from their teammates. When asked if they would recommend CATME to use in other teamwork-based settings, the students answered “yes.” The students also emphatically recommended ILIW as an assessment tool that should accompany CATME numerical feedback.

The students interviewed appeared to appreciate the structured and targeted nature of the feedback, and the opportunity to share, despite the awkwardness, one stated. One student commented, “ ‘I like, I wish’ provided a helpful norm for honest, face-to-face conversation and

this was more important than solving problems.” It seems that CATME plus ILIW is more instructive than either one alone for generating constructive feedback in areas important for teamwork. Given that students placed more value on shared, written feedback, teaching students how to give constructive and actionable feedback to each other (Gehring, 2017) would be a helpful addition to the course.

It is not surprising that the students interviewed had a positive experience with the ILIW activity. In some ways, ILIW can be viewed as formative feedback among teammates and therefore ILIW shares the benefits of formative feedback (“9 Benefits of...”, 2021). ILIW creates the opportunity for thoughtful and actionable feedback during the developmental phases of a team. Those phases are: (1) forming, (2) storming, (3) norming, (4) performing; and (5) adjourning (Mosel and Shamp, 1993). A benefit of ILIW is that teammate feedback is presented in a low-stakes way, i.e., in a way where there is little penalty for a team member to buy-in and where teammates are available to help. This process is supportive of collaborative success toward a target. While the students, who were interviewed, were emphatic about their aforementioned thoughts, they only represent 2 of the 51 students in the course.

*The student design teams were more healthy than not.* As stated earlier, the class-wide scores were approximately 4 along the CATME dimensions considered. Further, students, in some cases, made favorable comments about their experiences on their teams and in the course.

In summary, the results of this pilot study suggest that CATME was integrated into the structure of ME 170 in a way that supported healthy team practices. Students may benefit from a team assessment tool (e.g., ILIW), in addition to CATME, that requires structured, written feedback from everyone to be shared. CATME feedback, alone, could be sufficient if participants are required to give thoughtful and actionable written feedback within CATME.

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