Applying Multiple Modes of Assessment to Evaluate the Team Work Competence*

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Engineers and technologists play an integral role in the global economy by responding to complex problems with innovative solutions. These roles are not acted on in isolation thus making teamwork an important competency. While the importance of mastering the competency concepts is known, assessing teamwork is not so straightforward. The purpose of this study was to gain a clearer understanding of student perceptions on teamwork. Researchers distributed, collected, and analyzed qualitative data from three different courses at a Midwestern University. Participants were enrolled in three different levels (engineering design – freshman (n = 26), Construction Management Technology – sophomores (n = 42), and Aviation and Transportation Technology – juniors (n = 30)). Specifically, researchers utilized the Comprehensive Assessment of Team Member Effectiveness (CATME) system and reflection prompts. A total of (n = 98) reflections were collected. After a thematic analysis using NVivo, results indicated students reflected differently upon teamwork depending on the project type, context, educational background, experience, and maturity of the team. The analysis yielded evidence towards the need to not only increase the opportunities for teamwork but to intentionally incorporate peer – and self-assessments. These assessments may be completed through evaluation and reflection.

Keywords: self-regulated learning; competency; proficiency CATME; reflection; active learning

1. Introduction

Engineers and technologists play an integral role in the global economy. Often, these workers are required to respond to complex problems through new designs and innovative solutions. This critical role is not done individually, but requires teamwork. Teamwork is a required learning outcome for ABET (formerly, the Accreditation Board for Engineering and Technology) accredited programs. Per ABET student learning outcome "d" – *an ability to function on multidisciplinary teams* [1]. Engineering and Engineering Technology programs require the development of leadership and team working skills through participation in team-based projects [2–4]. Unfortunately, many of these opportunities fail to assess and promote mastery of the teamwork competence accurately. In response, several researchers and organizations have developed quantitative-driven online tools to assist with the assessment and development of teamwork skills, including WebPA (Web Peer Assessment) [5], Team-Q [6], PEAR ((Peer Evaluation, Assessment and Review) [7], SPARK [8], SATT (Self-Assessment Teamwork Tool) [9], e-TAT (Electronic Teamwork Assessment Tool) [10], and CATME (Comprehensive Assessment of Team Member Effectiveness) [11]. Unfortunately, only one of these tools, CATME, is offered in a low-cost, easy to use, web-based portal. Other researchers have conducted teamwork assessments using offline mechanisms. However, many of these stu-dies focus on student and instructor satisfaction associated with team-based projects [12–15], providing limited focus on teamwork skill development. Given that the evaluation and development of teamwork skills and mastery of competence is particularly relevant for engineering and technologists, the purpose of this study is to showcase a triangulated approach to evaluating the teamwork competence which follows a qualitative data collection and analysis method. This unique, yet standardized approach, allows students to learn about teamwork and improve teamwork skills throughout the semester using the CATME system. Then, at the end of the semester, students complete a self-regulated learning reflection. This final assessment requires students to think and reflect upon the process starting from the very beginning. The prompts require students to consider why teamwork skill development and teamwork assessments matter for the real world, and how they might do things differently next time around, ultimately, bridging the gap between students' academic knowledge and industry's employment expectations.

Specifically, the research questions are as follows:

1. How can reflections improve self-regulated learning within the competence of teamwork for engineering and technology students?
2. What can be learned about teamwork skill development within various levels and types of engineering and technology courses?

2. Literature Review

2.1 Introduction to CATME

CATME is an acronym for Comprehensive Assessment of Team Member Effectiveness and promotes instructor-led best practices towards managing student team. This free tool is accessible online at (https://www.catme.org). CATME offers four modules: Team-Maker, Peer Evaluation, Rate Practice and Meeting Support. Team-Maker [16] provides ease in the creation of teams based on instructor selected criteria, some of which may include schedule, prerequisite courses, writing skills, fraternity/sorority involvement, and shop skills, to name a few. Peer Evaluation [17–19] allows team members to assess individual contributions to the team with respect to five default areas including (1) Contributing to the team's work, (2) Interacting with teammates, (3) Keeping the team on track, (4) Expecting quality, and (5) Having relevant KSAs (knowledge, skills, and abilities). Rater Practice [20] allows students to practice their rater calibration techniques using a fictional team to better understand how their ratings compare to the proposed ''correct'' ratings. This initial practice session better prepares students for more effectively and more accurately rating their real team. Meeting Support provides resources to promote productive team meetings. Example resources include templates for team charter, team-member preferences, meeting agendas, and meeting minutes. The literature offers several example applications of studies conducted using the CATME tools, yet, CATME Peer Evaluation appears to be the most commonly used module.

Braender and Naples [21] have worked on using student activity logs from Learning Management systems and CATME Peer Evaluation tools for evaluation of team performance. The authors found that the results from the two tools correlated with the student grades. In addition, the tools were useful for monitoring student experiences and improved conflict resolution skills through an examination of Task Conflict measures in CATME. Alford and authors [22] have worked on the investigation of student perceptions towards teamwork in a first-year project-based design course. The data was collected before the team project began, after a small-scale design and after completion of a larger scale design and was evaluated using a variety of teaching methods including CATME peer evaluation. The advantage was that the threat of providing lower scaling factors to students who do not contribute well to a team decreases the number of unsupportive members in the team. After the second team project, the authors found that dividing work evenly and fairly, communication and personal relationships had a posi-tive impact towards being successful in the team activity. Students felt that procrastination and lack of motivation could hurt team performance. The authors have recommended that the project chosen must have enough breadth but also provide potential learning as this influences the success of the project activity. Maneeratana and Sripakagorn [23] have worked on using the CATME peer evaluation assessment in a mechanical engineering project course to assess team contributions. Students assessed themselves and their peers through comparison of behaviors. The authors found that the students were comfortable with the user interface and in evaluating their peers. The significant challenges observed were the difficulty of understanding the instructions presented in English and low levels of confidence in the effectiveness of the ability to assess teamwork and personal performances.

2.2 Reflection-Based Teamwork Assessments

The literature is filled with many examples of how reflection has been integrated into teamwork assessments. Autrey and others [24] have proposed a framework for implementation of a Learning Statement as a method for learning through reflections and using that for assessment in a Mechanical Engineering Design coursework. Through the mining of the themes obtained from student reflections, the authors found that students focused on principles associated with team formation, team management, prototype construction and testing. Mayne [25] worked on a course design that embeds teamwork-based projects into an undergraduate biotechnology degree and used student reflections to assess student perceptions and learning outcomes. The author found that superficial depth of metacognition and weaknesses in self-insight possess serious challenges for leadership and successful team outcomes. McNaughton [26] described a case study investigating first-year non-clinical students' reflections about teamwork and collaborations with the purpose of understanding major factors influencing team function and success. The results show individual characteristics, team dynamics, team structure and external factors are the four factors that influence *team functionality*; and time management, communication, cooperation and leadership were the most important factors to ensure *successful operation*. Volkov and Volkov [27] conducted a study to identify best practices for teamwork student reflection assessments. The results highlight that teamwork activities must be connected to real-life practices to optimize student learning related to collaboration, team unity, and cultural diversity. Thus, connecting the reflection assessments to students' future professional career proved to be the most beneficial. Koh and colleagues [28] worked on

Table 1. Summary of Participants and Assessments

Course	Typical Level of Students	Type of Team Project	Majors (Quantity)	Assessment
Design Thinking in Technology	Freshmen	Engineering Design	Engineering Technology (n = 26)	CATME-Focused Teamwork Reflection
Intermediate Construction Management	Sophomores	Site Assessment Report	Construction Management Technology (n = 42)	Standard Teamwork Reflection
Advanced Transport Flight Operations	Juniors	Report Writing	Aviation and Transportation Technology (n = 30)	Standard Teamwork Reflection

a teamwork assessment that makes use of information and communication technologies tool among student teams. The sessions consisted of a collaborative activity using the computer, followed up by a feedback and reflection activity. The researchers found that team emotional support and team commitment were the most evident teamwork dimensions experienced by students.

2.3 Summary of Knowledge Contribution to this Study

Given the assessment and development of teamwork skills and mastery of competence is particularly relevant for engineering and technologists, the purpose of this study is to showcase a triangulated approach to evaluating the teamwork competence which utilizes a qualitative approach, respectively, with the CATME system and self-regulated learning reflections.

3. Methods

3.1 Participants

Participants included undergraduate students enrolled at a Midwest U.S.A. research-intensive university's college of technology, which offers 18 ABET-accredited bachelor's degrees. Students enrolled in three different courses were asked to participate. The classes and course descriptions are as follows:

- Design Thinking in Technology (100 level course): Student will engage in critical analysis of real-world problems and global challenges, and demonstrate the ability to recognize opportunity and to take initiative in developing solutions applying the principles of human-centered design. Students will be able to communicate effectively and work well on teams. Problems and solutions will be examined from societal, cultural, and ethical perspectives.
- Intermediate Construction Management (200 level course): A project course covering intermediate level commercial, residential, heavy/civil, and industrial construction projects. Stu-

dents will expand their understanding of construction materials and methods, layout, documentation, site planning, site supervision, cost control, and MEP systems.
- Advanced Transport Flight Operations (300 level course): This course addresses advanced aviation topics to include high-speed aerodynamics, automated cockpit instrumentation, domestic/international flight operations, and global navigation.

3.2 Study Design

All participants were required to complete a teamwork-focused self-regulated learning reflection. However, only participants in the engineering design course were required to complete the CATME peer evaluations. This allowed researchers to discover if the CATME peer evaluations might have an impact on student perceptions reflecting upon the teamwork concepts. The study assessment instruments were approved by university Institutional Review Board (IRB) #1808020877 as Exempt Category (1). As a result, students were notified that the class assignment would be used for research purposes. A summary of participants is provided in Table 1.

3.3 Measures and Data Collection

Throughout the semester, all participants engaged in group project work. Two different research instruments, provided in Fig.1, were used to collect data including (1) CATME-focused teamwork reflection prompts and (2) standard teamwork reflection prompts. Participants enrolled in the Design Thinking in Technology course used the CATME system six times throughout the semester, then completed CATME-focused teamwork reflection prompts at the end of the semester. Participants enrolled in the Intermediate Construction Management and Advanced Transport Flight Operations submitted a response to the standard teamwork reflection prompts.

3.4 Analysis

This study followed a qualitative approach using thematic analysis. According to Braun and Clark

Introduction: It's one thing to join a team, but quite another to perform effectively as a team member. To put it simply, teams don't work without teamwork. Teamwork can be likened to two compounds, almost essential to modern life. It's the glue which keeps a team together, a bond which promotes strength, unity, reliability, and support. Teamwork is also the oil that makes the teamwork. It can enable smoother movement towards targets, can prolong forward momentum, and can help teams to overcome obstacles. Teamwork has the potential to underpin so much of what is valuable in work. The purpose of this assignment is to reflect on your experience developing your ability to work effectively in teams this past semester.

1. Pre-Assessment: Think back to when the semester first started, and identify your strengths and weaknesses with respect to your perceived ability to work effectively in teams. Provide evidence and justification to support the initially identified strengths and weaknesses.

2. Mid-Assessment: Throughout the semester, while working in a group environment on team-based projects, state observations you noticed that support or hinder your initial assessment of your strengths and weaknesses with respect to your perceived ability to work effectively in teams.

2. Mid-Assessment (CATME-Focus): Throughout the semester, while working in a team environment and utilizing the CATME tools, state observations you noticed that support or hinder your strengths and weaknesses (identified in prompt 1) with respect to your perceived ability to work effectively in teams.

3. Post-Assessment: It's now the end of the semester. With respect to your perceived ability to work effectively in teams, identify what you learned and insights you gained. Explain how your initial assessment of your strengths and weaknesses changed. How might you approach teamwork differently next time?

4. Why this Matters: Identify what type of job or career you might like to have in the future. Why is your ability to work effectively in teams important for this type of job? How does working on team-based projects as an undergraduate assist in preparing you for entering the workforce? What might be missing from the undergraduate experience with respect to developing your ability to work effectively in teams in the real world?

4. Why this Matters (CATME-Focus): Identify what type of job or career you might like to have in the future. Why is your ability to work effectively in teams important for this type of job? How does utilizing the CATME tools assist in preparing you for entering the workforce?

5. Lifelong Learning: In the future, how might you extend your knowledge related to working effectively in teams? Be specific in identifying a minimum of 5 resources (e.g., people, books, movies, government agencies, MOOCs, magazines, websites, educational institutions, courses, museums, conferences, etc. . .)

Fig. 1. Reflection Prompts Completed by All Participants.

[29], a thematic analysis is a foundational qualitative method for discovering patterns within the data. It should be conducted using a step by step process. The first two authors took the lead on the data analysis; both have extensive experience conducting qualitative data analysis and have numerous educational research publications. These two researchers first become thoroughly familiar with the data to generate initial codes. The NVivo 12 qualitative analysis software was used to code the reflections. The two lead researchers reviewed and analyzed the documents several times. Upon the completion of coding, themes were generated. As a final step, the two lead researchers revised the themes and wrote the report. Due to the qualitative nature of the research, the goal of the analysis was to explore potential themes within the data. The two lead researchers debated the strengths and weaknesses between strictly conceptualizing themes without quotes and heavily using quotes to provide readers with evidence. It was decided to merge the two philosophies and meet in the middle. Quotes were drawn from the data to allow readers to make their own judgements on credibility, accuracy, and fairness [30].

In summary, themes were identified related to the CATME participation and completion of reflections. First, with respect to the impacts of participating in the CATME, in general, the Design Thinking in Technology students noted positive takeaways from participating in the CATME system throughout the semester. Second, with respect to completing the reflections, several themes were present. In general, the pre-, mid-, and post-assessments resulted in similar responses across the three different courses. However, the section on *why this matters* produced different themes across the three different courses likely due to the different discipline contexts. Finally, lifelong learning responses were different across the three different classes possible due to the diverse experience and maturity levels of students. Details are provided next, within the Results and Discussion section.

4. Results and Discussion

The purpose of this study is to respond to the following research questions:

1. How can reflections improve self-regulated learning within the competence of teamwork for engineering and technology students?
2. What can be learned about teamwork skill

development within various levels and types of engineering and technology courses?

The first research question will be addressed in sections 4.1 and 4.2, which respectively provide results on the impacts of the CATME peer evaluation system and use of reflections to improve self-regulated learning. The second research question will be addressed in section 4.3, which aims to summarize implications based on the three different courses (which each targeting different levels of students across various disciplines within engineering and technology courses). The bolded content is intended to show stronger relationships within individual responses based on the analyses.

4.1 Impacts of CATME

In general, Design Thinking in Technology students noted positive takeaways from participating in the CATME system throughout the semester. Example quotes are provided here:

- "CATME allowed me to realize that my strength and weakness are related and also that it has a root cause. My strength was to organize task and my weakness was the inability to motivate people. **The results of CATME showed that I do all or more than the work that I am expected to do, but it also showed me that I did not show much interest as individuals.** I did all the academic tasks, but I did not become close to the team member on a personal level. That meant that I organized the tasks well, but I did not assign the correct tasks to the individuals, which was why not motivated students did not do the task."
- "I believe that under the hood **CATME does well matching members based on their personal profiles** that they filled out."
- "Due to the feedback of CATME, I found out about my tendency to push my ideas onto the group. I saw that I had an overall positive team score but my score in areas related to being aggressive with my ideas was much lower. I re-evaluated myself during the next class brainstorming session. And tried to fix my mistakes. I **decided to support the idea of another group member instead of my own for the final iteration and it has been coming along very smoothly. Ultimately, CATME helped me fix one huge flaw I had working with groups**."
- "After looking at some of the CATME requirements to be an adequate group member, **I changed some of the ways I acted in my group, like allowing others to have an opinion too.** Doing this, I believe gave me a better CATME score which made me feel better about my group."
- "I feel like my teammates have given me positive feedback in ways that have helped me. **Some of my weaknesses were that I was not very good at scheduling out work with my team, setting team goals and making a schedule as to when we were going to have assignments completed by.** Now, especially since project 3 I feel like I have made big strides in setting mile stone goals throughout this project."
- "CATME tools help students understand their strengths and weaknesses in order to be able to work on them. Once made aware of your weaknesses, **it is much easier to be active and work on them rather than not knowing about them**."
- "I can understand the use of CATME tools and the activities themselves, since they do make sure people are doing their work and learning. I also noticed how **CATME kept me cognizant of my shortcomings, which allowed me to curb my weaknesses** when working in teams."
- "**I like the anonymity of the CATME. Because I don't like conflict, I find that this is a good way for me to express some of the thoughts I might not have the courage to tell someone outright.** I want to become better at resolving conflicts, but right now, the CATME allows me to configure my thoughts before putting them out in the open."

4.2 Impacts of Reflections

The teamwork reflection prompts have three core sections: (1) pre-, mid-, and post-assessments, (2) why this matters, and (3) lifelong learning. In general, the *pre-, mid-, and post-assessments* resulted in similar responses across the three different courses. However, the section on *why this matters* produced different themes across the three different courses likely due to the different discipline contexts. Finally, *lifelong learning* responses were different across the three different classes possible due to the diverse experience and maturity levels of students.

Pre-, Mid-, and Post-Assessments

Responses to the pre-, mid-, and post-assessments were similar across the three groups of participants. In general, participants were very perceptive and open about sharing their strengths, weaknesses, lessons learned, and plans for doing things differently moving forward. An example from each participant group is provided here:

- Engineering Technology Student: "I learned that sometimes it is difficult for me to be a leader, especially in a group that does not respond and communicate well. I do not need to be a leader in every group I am in, but I tend to sit back and be lazy when I do not have some sort of leadership role in a group. I have noticed many areas that I can improve on, however. One of the biggest

areas is contributing even when I do not have a leadership role. When I am in groups **in the future, I need to find an area I can lead in, even if it isn't the main group leader**. I need to know that sometimes it is fine to not be the leader."

- Construction Management Technology Student: "Now that the semester is over I would say that my strengths are my creativity and my ability to present my ideas in a persuasive way. I know how to tell people what I am thinking and make it believable for others who might not understand the concept yet. My **weakness is my intuition on basic knowledge with construction-based concepts**. I feel like a lot of people know more about construction than I do at this stage in the game but as I practice and learn more and more about the industry and the information within it I will be able to contribute my ideas way more effectively."

- Aviation and Transportation Technology Student: My only weakness was procrastination. I could never really motivate myself to get my parts of the project done until the last minute, which could have possibly held the team back. In the end, we finished everything on time with good quality, but **if we had gotten it done sooner, we would have had more time to review the project and improve it more**.

Interestingly, the three groups of students did not hesitate to admit their weaknesses in the pre-, mid-, and post-assessments. Students largely responded that they identified areas for future improvement that will help them become better contributors to project teams. The trends were consistent across groups with little variance across the type of assessment type deployed (i.e., CATME and teamwork reflections). These results are surprising, as students participating in self-regulated learning were equally critical of their shortcomings, as were their counterparts who provided anonymized peer evaluation and feedback during the CATME process. Moreover, attributing the potential for future success to leadership, cooperation, and time management all key components for increasing team functionality.

Response to "Why this Matters"

In responding to "Why this Matters," a consistent theme of the Engineering Technology students (who worked together on design thinking projects) was related to the ability to work creatively to brainstorm ideas and optimize on value propositions as a key outcome of good teamwork. Essentially, this group of students highlighted the benefits of teamwork with respect to creating good, high-quality ideas and solutions. This is not entirely surprising, as it is common for engineers to do design-related tasks

when they work in industry. Example quotes from Engineering Technology students are as follows:

- "I am planning to become a data engineer. Better teamwork within and between teams would improve the **quality** of the database significantly."
- "A job I would love to have is something in the biomedical field. Being able to trust people in these teams will allow for **better products and solutions** to problems to be made."
- "I would like to be a project manager after my mechanical engineering job. This way the company can make money selling the **product they promised to the market** and we get paid for making such product."
- "My dream job would be to work as an engineer at Give Kids the World, a completely free resort for kids with life threatening illnesses who make a wish to go to Disney World or other parks in Florida. The amount of teamwork I would come across in this line of work is huge. I'd love to be a part of their engineering team and work on **building wheelchair accessible amusement park rides**."
- "My future goal is to secure a mechanical Engineering Technology job with Bastian Engineering. I hope to work for their problem solution team. This team works in the field at different warehouses and assembly plants **identifying problems they face and developing solutions**."
- "In the future, I hope to work as a mechanical engineer on assembly lines in a factory. As a mechanical engineer, designing products is a very important skill. It is important for a mechanical engineer to be **innovative and creative**."
- "I would like to work as an engineer after college. Most jobs now have to deal with teamwork in the engineering field. People have to work in team setting to **make products or designing**."
- "I would like to work for multinational companies like Google, Amazon, Nike, Adidas, or Microsoft. The motivation comes from the feeling of **innovating different ideas on solutions** that can make the world more technologically –, environmentally –, and medically-focused."

In responding to "Why this Matters," a consistent theme for the Construction Management Technology students (who worked together on site assessment reports) was related to the ability to work with various stakeholders to get a job done on time. Thus, these students noted productivity and efficiency in working with various types of stakeholders (e.g., homeowners, architects, engineers, subcontractors, employees, etc. . .) as a key benefit of teamwork. This is not entirely surprising, as it is common for Construction Management Technol-

ogy students to work as project managers when they work in industry. Example quotes from Construction Management Technology are as follows:

- "I would like to be a Construction Manager and run a job site. If we do not work as a team, **no work will get done on time**."
- "I the future I would like to work in the construction industry, either in commercial or heavy civil construction. In construction it is just one big team that is all striving towards the same goal. It will be important to be able to work in teams so that **everyone is staying busy and working hard**."
- "Once I graduate college, I will be a project manager. Building structures, roads, or pipe work takes a team of people to communicate, work together efficiently, and **get the job done within the time frame**."
- "I am planning on being a construction manager and working effectively in teams is key. Everything about a construction project is teamwork, from pre-planning, to construction, to post-construction. Teamwork will be essential for me **getting all of the work done** that I will be responsible for."
- "I see myself in the construction industry being a project manager. And working in teams is key since it will make the **process complete faster** and make more money at the end of the day."
- "In the future I hope to be a project manager for a construction company. In construction it is key to **be on time and get things done right** and without good teamwork that is when accidents occur."
- "For these careers it is important to work in teams effectively because I will be dealing with a **large number of people at one time** and I will be working with them to **complete a project**."
- "In the future I hope to be a Project Manager for a large commercial contractor. The project moving forward is very important in the real world because that is **time and money that is being lost**."

In responding to "Why this Matters," a consistent theme for the Aviation and Transportation Technology students (who worked together on written reports) was related to the importance of teamwork with respect to safety. Students stressed the need to work effectively by following communication protocols as consequences can be life or death. This is not entirely surprising, as it is common for Aviation and Transportation Technology students to work in jobs which directly impacts the safety and wellbeing of millions of people. Example quotes from Aviation and Transportation Technology students are as follows:

- "The career I plan to have in my future is a career as an airline pilot. The ability to work in teams in this industry is absolutely vital. If a crew can't work together properly, **people die**."
- "As a future airline pilot, teamwork is paramount as at some point, it will be my team's **mission to safely transport** over 150 souls for over 500 miles at 40,000 feet. Flying the most complex aircraft man has designed up to date, it is gargantuan to know how to follow the leader, be the leader, and work effectively as a team dividing up tasks, following a plan of action, and mitigating all risks and obstacles together."
- "In the future, I would like to work as a corporate jet pilot. Competency of my duty as a pilot is critical as the **aviation industry is hazardous by nature**. However, it will be my role as a pilot to mitigate these risks in order to provide the safest flight possible."
- "In the future I hope to have a job as a professional pilot. The **safety of the flight** as well as efficiency and customer satisfaction are heavily impacted by the teamwork and professionalism of the flight crew.
- "In the near future, I want to be an airline pilot. If some safety accident happens, you're costing the company fortunes. Future employers are **trusting you that no accidents will occur**.
- "Ideally, I would like to work as an airline pilot. Working as a team is essential to the **safety of any flight**, as pilots and controllers are constantly working together. However, teamwork is even more important in the crew environment of an airline where pilots are not only responsible for their own safety, but also **responsible for the safety of their company's airplane and all the passengers on board**.
- "I would like to work for a Major Airline (ex. Southwest, Delta, American), and these skills of teamwork and communication are very essential components to working in a multi person crew environment and in order to **get the plane from point a to point b safely** and on time.
- "The job I would like to have in the future is a commercial pilot. Teamwork is important for this job because the **safety of the flight** and the satisfaction of the passengers hinges on how well I can operate with my copilot. I need to be able to efficiently communicate and operate with my co-pilot so we get where we are going as fast and **as safe as possible**.

In summary, consistent themes arose corresponding to each of the individual student groups. Considering the Engineering Technology students, a core theme was related to the ability to work creatively to brainstorm ideas and optimize on value propositions as a key outcome of good teamwork. With respect to Construction Management Technology

students, the core theme was related to the ability to work with various stakeholders to get a job done on time. As for the Aviation and Transportation Technology students, a noticeable theme was related to the importance of teamwork with respect to safety. Yet, it is also important to note coherent threads between the three individual student groups. In general, students from all three groups mentioned teamwork was an inherent part of the job (regardless of the type of job or industry they planned to enter). As a result, in general, students from all three groups suggested the importance of teamwork, going into details of how it will impact their particular type of future job.

Responses to Lifelong Learning

Response to the lifelong learning prompts were very different across the three groups of participants. The younger level of students (freshman) demonstrated a lack of intuition and vague knowledge about available resources to extend their knowledge related to teamwork skills. The older students (sophomores and juniors) on the other hand, revealed a more adept understanding of campus, community, online, and industry-specific resources. Example quotes from each participant group are provided here:

- Engineering Technology Student (Freshman): "So I think moving forward really getting used to utilizing resources like educational text from university libraries, learning the difference between credible and non-credible online sources, analyzing the history of what problem it is at hand through extended research, possibly attending convocations/speakers who are more knowledgeable in such subjects, as well as being aware of what problems are at hand through news sources will help in the end."
- Construction Management Technology Student (Sophomore): "When I enter into my career it will be important to continue my learning process of team settings. The **first resource is the book** The Seventeen Indisputable Laws of Teamwork, written by John C. Maxwell. This book gives a detailed list about the benefits of being involved with a motivated team that can bring positive skills from each member. . . . The **fourth resource is the movie** Remember the Titans. This movie is an inspirational film that was created to teach people to recognize what a great team can accomplish. The lessons that were portrayed in this movie were hard work, accountability, motivation, and care for each of your team members. I feel that these are all great ways to act in a team setting. The final resource is The Secrets of Great Teamwork, which is an **article posted on the Harvard**

Business review, written by Martine Haas. This article goes into great detail about the many ways to build a successful and motivated team based off how each of the members are treated. It explains that if each team member is treated equally and with respect they are more willing to share all of their ideas.
- Aviation and Transportation Technology Student (Junior): "In the future, teamwork is a topic I would really enjoy delving deeper into. Teamwork is an essential life skill, especially in my anticipated career path of being an airline pilot. The aviation industry is rich in history, and older aviators can truly help educate and prepare a student such as myself about the industry and how to deal with various team-centric situations that will likely arise during the course of my career. Personally, I would like to extend my knowledge by studying history in two specific ways. The first is by **learning from NTSB accident reports**. By analyzing where teamwork broke down and led to accidents in the past, I am better equipped to be able to identify these potential breakdowns in my own cockpit and fix them before they become detrimental to safety. Next, there are **two pilots who stand out in my mind** who I would like to learn more from. The first is **Captain Richard de Crespigny**, the Qantas 32 pilot who saved his crippled Airbus A380 after an engine had an **uncontained failure in flight**. The way that he used teamwork to deal with such a harrowing situation and yet get every passenger to safety should be much more of a model of crew success than it is. In addition to Captain de Crespigny, **Captain Chesley Sullenberger** is another person I would like to know more about. I would hope that by **reading his book Highest Duty** I could learn a great deal about how to work with and lead a team of aviation professionals.

Although responses to the lifelong learning prompts were different across the three groups of participants, in that the younger level of students (freshman) offered limited specific resources to extend their knowledge related to teamwork skills and the older students (sophomores and juniors) revealed more adept understanding of specific resources, a similarity between the groups should be noted. In general, students from all three groups identified that resources did indeed exist. Even though the freshman students were not specific, they at least were able to identify sources of information. This finding is positive because the freshman students acknowledge the resources exist. Over time, as they take more discipline specific courses, it is anticipated they will learn more about specific resources (as indicated by the Sophomore and Junior groups).

4.3 Summary

Students reflected differently upon teamwork depending on the project type, context and educational background of the team, and experience and maturity of the team. Here, it is important to highlight two key takeaways. First, for ABET-accredited programs, which tend to limit teamwork assessment to the final senior capstone design project, faculty should reconsider approaches to allow for teamwork skill development and assessment throughout the undergraduate learning experience. In these cases, teamwork skill development should go beyond exposure and practice to intentionally incorporate peer- and self-assessment through evaluation and reflection. Specifically, faculty should consider longitudinal and scaffold approaches to teamwork assessment, which would require students to compare and contrast individual teamwork competency as students transform from a foundational skillset through to, hopefully, a proficient skillset. This would allow students the ability to understand growth and skill development in team-based projects over time. In particular, it would enable students to note specific changes in experiences when working on different projects, with people from similar and varied educational backgrounds, and with people at different maturity levels. Second, lifelong learning is an essential mission of many institutions of higher education. Given the many different paradigms, including language and frameworks, used throughout academic disciplines, it is sometimes difficult for students to transfer learning in one course to the next. Thus, engineering and technology instructors should be intentional about discussing practical and real-world implications for completing assignments. Also, starting with first-year students, instructors should be explicit about provide recommendations for different resources available for students to extend knowledge beyond the classroom.

5. Conclusions

5.1 Contributions

The purpose of this study is to respond to the following research questions:

1. How can reflections improve self-regulated learning within the competence of teamwork for engineering and technology students?

2. What can be learned about teamwork skill development within various levels and types of engineering and technology courses?

This paper makes several contributions. First, it provides an example of how teamwork can be assessed using a triangulated approach including both the CATME system and reflection prompts. In addition, this approach provides evidence of self-perceived student learning and student satisfaction with the process. Second, it shows how practical implications (*why this matters*) of teamwork vary depending on the discipline and context, and how the ability to identify ways to further one's skills in teamwork (*lifelong learning*) varies depending on the maturity and experience of the group. Third, it justifies actively engaging in and practicing teamwork (including the assessment of teamwork) throughout the undergraduate learning journey. To that end, just providing opportunities for students to work in teams and naturally improve teamwork skills is a starting point, but being intentional towards teamwork skill development and assessment provides substantial student benefit. The CATME system and reflection prompts offer free and easy to implement approaches to guiding students down a path of self-regulated learning and skill development within the teamwork competence.

5.2 Future Research

The study was qualitative in nature, which provided a more in-depth and richer understanding of the phenomena. Future research would benefit from a mixed methods approach integrating qualitative, explanatory analysis to explain the phenomena better. Also, future research would benefit from access to more extensive and more diverse engineering and technology classrooms. Also, although the focus of the study was on assessing the teamwork competence for engineering and technology classrooms, the researchers are confident that the CATME system and reflection prompts would be successful outside of engineering and technology. Thus, future research should consider the CATME and reflection-based prompts for assessing teamwork with natural science students, social science students, and humanities students, to name a few other disciplines.

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