Data-driven Strategy for Maintaining an Effective Team Collaboration in a First-year Engineering Course

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Data-driven Strategy for Maintaining Effective Team Collaboration in a First-year Engineering Design Course

Abstract

In this experience-based practice paper, peer-to-peer evaluation was used to improve students' team-based learning experience. For the future workforce, the ability to collaborate well in multidisciplinary teams is a highly valued professional skill. Many educational institutions have implemented project-based learning to develop students' teamwork skills. One of the top challenges is managing potential conflicts after team formation. Although constructive conflict may increase team productivity according to Tuckman, conflicts were viewed as negative and the primary cause of dysfunctional teams [1]. A critical first step for first-year students to achieve team success is to understand what types of negative conflicts could emerge, as well as train them to understand how to cope with and/or resolve the conflicts. In this experience-based practice paper, peer-to-peer evaluations were used to improve students' team-based learning experience. The research question of this study is: *How could course instructors utilize a content analysis of a peer feedback system to improve guidance for first-year students on resolving negative conflicts?*

At New York University, six hundred first-year engineering students participate in free-choice open-ended semester-long projects annually. The primary aim is to allow students to explore, prototype, and refine possible solutions to tackle real-world problems through project-based, collaborative learning. As the teams may have issues such as interpersonal relationships, mismatched schedules, task assignments, and leadership responsibilities, an effective tracking platform is required to manage more than 70 teams per semester. CATME (Comprehensive Assessment of Team Member Effectiveness) peer evaluations consist of two parts: quantitative rating as well as written confidential comments to the instructor and shared peer-to-peer comments.

CATME highlights potential conflicts based on self-adjustment factors. This study aims to categorize the conflicts by training a text classifier. Firstly, all the comments were filtered to identify negative comments by sentimental analysis. The negative comments were then categorized into major issues mentioned by the Lencioni Model [2]: lack of trust, fear of conflict, lack of commitment, avoidance of accountability; inattention to results. A detailed intervention guideline would also be provided in this study. A mixed-method analysis was used to evaluate the impact of instructors' interventions.

Introduction

There are three constructivist concepts as the foundation of the student-centered instruction method known as project-based learning (PBL) [3-6]: learners actively participate in the learning process, a specific context for learning, and the project objectives achieved via mutual interactions as well as sharing of technical knowledge and understanding [7]. PBL is regarded as a specific kind of inquiry-based learning[8, 9] where the context of learning is provided by real-

world actions and actual questions and challenges [10], which will lead to valuable learning experiences for students [11, 12].

Within a structured process of recording and commenting on learning, project-based learning can help students develop their own self-regulated learning[13] and can advance their conceptual knowledge [14]. Goal-setting, planning, and organization help students become self-directed[15, 16]; social learning helps them collaborate; and being encouraged to exercise some choice while studying at their own pace helps them become intrinsically motivated.[17]. PBL has been studied in a variety of settings and educational levels, from early childhood education through primary and secondary school and on to higher education[18-20].

Collaboration is a crucial educational method as well, particularly when it is combined with project- or problem-based learning (PBL). It has been suggested that collaborative PBL (CPBL) is a cutting-edge strategy for getting students involved in real projects or problems, letting them take charge of their own learning through inquiry, and getting them to collaborate on projects.[4, 17, 21]. CPBL is known to offer numerous advantages, including the improvement of critical and creative thinking, the development of collaborative skills, the ability to solve complicated problems, the transfer of learning, and positive task attitudes [22-25].

Researchers have investigated how collaboration could potentially improve learning outcomes. For example, how to learn in a group setting as well as learn how to collaborate. Therefore, collaboration could be interpreted as both a learning outcome and an instructional method [26]. Again, two critical components are learning to collaborate and collaborating to learn. Students may be more effectively guided in their information acquisition during their intragroup and intraindividual learning processes when they successfully learn how to work better together [27-29]. On the other hand, if they are unable to concentrate on the learning task due to poor collaboration and unresolved/unwanted intragroup conflicts, their learning processes may be hampered [30]. The knowledge base of how to improve cooperation as a learning result and how to aid learners in collaborative projects can therefore benefit from knowing the nature of collaboration.

Peer assessments are one method that has been empirically supported for holding engineering, science, marketing, and business students responsible for their team contributions, which has been applied in STEM and business education [31-35]. Peer reviews motivate individuals to demonstrate strong interpersonal skills and give their best effort to the team's goal-achieving efforts while also holding peers accountable [36, 37]. Individual accountability is the foundation of the effective use of team-based learning techniques [38]. Peer assessments make students aware of how their peers view them, which can increase self-awareness and enhance learning in addition to generating accountability [39]. Three tools are available in the CATME system, that educational institutions could use to prove they have met teamwork-related learning objectives. These include Rater Calibration, CATME Peer Evaluation, and Team-Maker [40, 41]. All were created with funding assistance from the National Science Foundation, and since their publication, they have all been available to use in higher education [42, 43].

However, Chowdhury et al.[44] highlight that it is unclear in engineering education how to employ an effective teamwork model, despite the fact that there are tools to use and measure cooperation in engineering classes. Additionally, many engineering instructors are now helping engineering students develop teamwork skills without support or generalized guidance. Lencioni

Model [2] has summarized the five dysfunctions of a team: lack of trust, fear of conflict, lack of commitment, avoidance of accountability; inattention to results. This model shows a hierarchy of the problems faced by teams in both industry and academics. Beginning from the foundation, if a team cannot trust one another, they are unable to participate in constructive conflict, unable to commit to an action plan, are not accountable to one another, and eventually their work does not provide the expected results.

On the other hand, there are some key elements or considerations when implementing peer assessment, such as avoiding potential issues of intending to manipulate the peer rating for better grades[37], or inappropriate timing when giving out the peer evaluations. In this paper, we propose a timed evaluation schedule together with an interventional strategy for the instructor to implement for project-based learning in the context of first-year engineering. The research question of this study is: How could course instructors utilize a text-based analysis of a peer feedback system to improve guidance for first-year students on resolving negative conflicts?

Experimental Method

Prediction model

Data Acquisition

The procedure was as follows: at the beginning of the semester, the instructor provided relevant CATME information to students, which included detailed instructions on how to write effective comments (**Figure 1**). Effective comments are based on five major elements: balanced, respectful, implementable, constructive, and specific. The students' teams will be shown examples of good and bad written comments during recitation. During Week 3 — 5, the rater practice was implemented to allow students to be familiar with the CATME interface. During Week 6 — 7, the students on Milestone I were involving an initial design of the prototype. Peer evaluation I allowed the instructor to have an insight into the team dynamics at the norming stage. During Week 8 — 10, the students were working on Milestone II involving an improved design of the prototype. Peer evaluation II allowed the instructor to keep track of the team dynamics at the performing stage. During Week 11 — 12, the students were working on Milestone III, in which the student needed to deliver finalized prototypes.

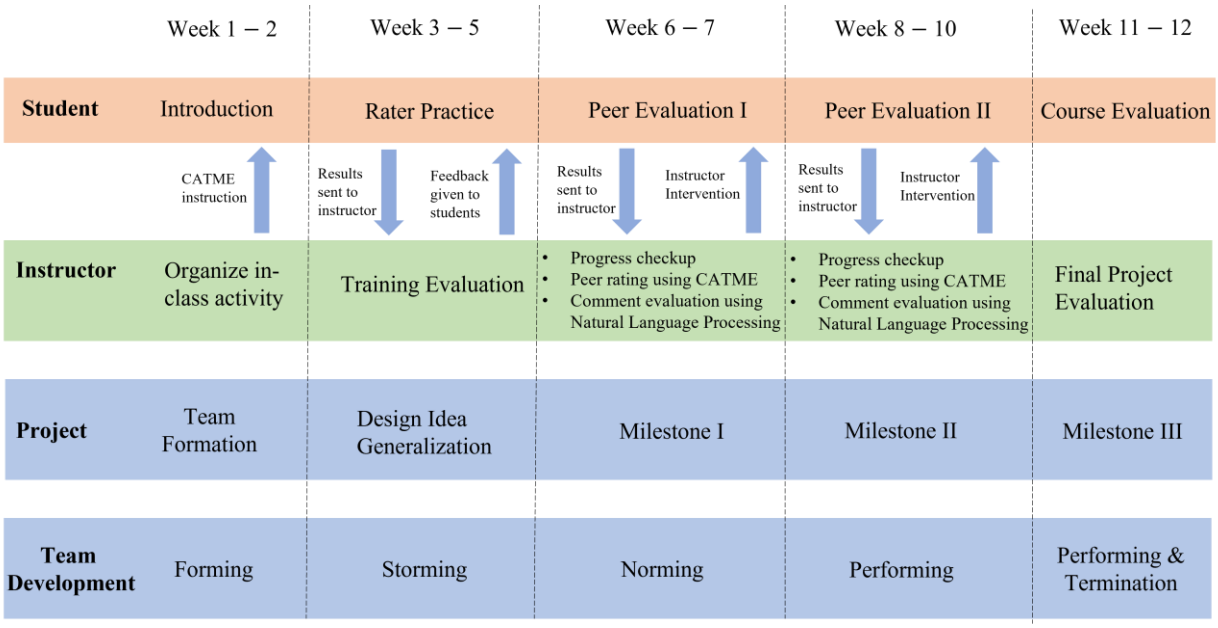

Figure 1: Implemented workflow of project-based peer evaluation for one semester.

Figure 2 shows the model used to classify the text. Overall, 200 peer comments were used from 60 project teams for this study from Peer Evaluation I. 50 % of the data was for data training and 50 % of the data was for testing. F1 score is a metric being used in the field of machine learning to justify the output accuracy of a model. It consists of both the precision and recall scores of that particular model [45]. The F1 score could be calculated using Equations (1) — (3):

$$F1\ score = 2 \times \frac{Precision \times Recall}{Precision + Recall} \tag{1}$$

$$Precision = \frac{t_p}{t_p + f_p} \tag{2}$$

$$Recall = \frac{t_p}{t_p + f_n} \tag{3}$$

In the Equation (1), the t_p is the number of cases that have true positive results, i.e., the correct classification of peer comments by the model. f_p is the number of cases that have false positive results, i.e., the model wrongly classifies the positive comments as negative ones. f_n is the number of cases in which the model fails to output a prediction for negative comments.

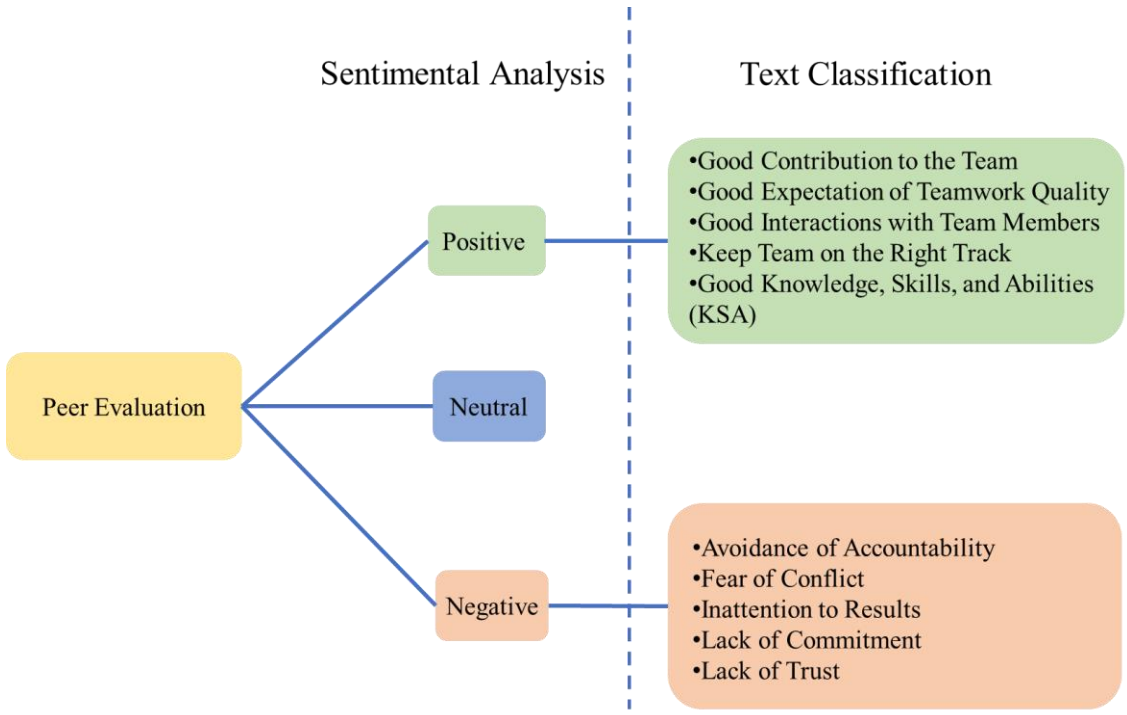

Figure 2. Classification model for analyzing peer comments

Model Construction

To train students in providing constructive feedback, a rater practice was assigned in the CATME system. First-year faculty also provided in-class instruction to students on how to write effective feedback.

The CATME peer reviews were first exported as a CSV spreadsheet. Commercial software named MonkeyLearn, as well as an independently developed algorithm, was used to analyze the written feedback and provide two major outputs. The first output is the sentimental analysis which indicates if the comments are positive, neutral, or negative. The second output was classification. The positive comments were classified in terms of the CATME's five team dimensions: contributing to the team's work, interacting with teammates, keeping the team on track, expecting quality, and having relevant KSA（knowledge, skills, and abilities). The negative comments were classified in terms of the Lencioni model [2]: lack of trust, fear of conflict, lack of commitment, avoidance of accountability, and inattention to results.

Modeling Training

The training data were randomly selected from CATME peer comments from 45 students. The rest of the raw data was used for testing.

Intervention Strategy

After the students' feedback was categorized, an intervention strategy was developed for the instructor to intervene if necessary. Table 1 shows possible intervention strategies for the categorized negative peer comments.

Table 1. Strategy for Different Team Issues

Categorized Conflicts	Suggested Intervention Format	Meeting Details	Action Items
Avoidance of Accountability	One-on-one in-person appointment, then a group meeting	Firstly, talk with the student who has been rated or commented poorly by the peers, and ask the following questions: 1. What are your incentives for working on this group project? 2. What is your role in the team? Can you still commit to the role? 3. Can you commit to the minimum number of hours required by the group project each week? Then talk with the group and inform the instructor's decision.	Apply temporary penalties to the individual students after Peer Evaluation I. See if the peer rating has been improved in Peer Evaluation II. If not, the penalty stays permanent for the final course grade.
Fear of Conflict		Firstly, talk with the student who has been rated or commented poorly by the peers, and ask the following questions: 1. What are your major concerns in the team project? 2. Who else on the team do you think I can talk with to relieve some of your concerns? Then communicate with the rest of the group and ensure the students understand each other's clearly defined roles.	No Individual penalty will be applied in this case. But follow up with the student after Peer Evaluation I and ensure the student clearly about the individual team role and help the student to build up self-confidence.
Inattention to Results		Firstly, talk with the student who has been rated or commented poorly by the peers, and ask the following questions: 1. What are your plans for this project?	Apply temporary penalties to the individual students after Peer Evaluation I. See if the peer rating has been improved in Peer Evaluation II. If not,

		2. What are the expected outcomes you have in mind?	the penalty stays permanent for the final course grade.
Lack of Commitment		Firstly, talk with the student who has been rated or commented poorly by the peers, and ask the following questions: 1. What is your current team role? 2. Do you need to make any adjustments to the current role? 3. Do you have any concerns regarding other team members or the project itself?	Apply temporary penalties to the individual students after Peer Evaluation I. See if the peer rating has been improved in Peer Evaluation II. If not, the penalty stays permanent for the final course grade.
Lack of Trust		Firstly, talk with the student who has been rated or commented poorly by the peers, and ask the following questions: 1. What issues result in your mistrust of the team members? 2. Have you thought about ways to improve the mutual trust among the team members?	No Individual penalty will be applied in this case. But follow up with the student after Peer Evaluation I and ensure the student is able to regain the trust of the team member. In most cases, this is due to a lack of communication.

Interventional Effectiveness

The interventional effectiveness was evaluated based on two major criteria: variations in peer ratings as well as classification of peer comments. The overall interventional effectiveness was assessed by the improvement of peer ratings. The peer comments were first classified by the model mentioned in Section 2.1.2 during Peer Evaluation 1 (Figure 1) and teams involving negative conflicts were identified. The interventional strategy was applied to each team (Table 1) and the team performance was closely monitored by the instructors. Out of the 60 teams, four case studies were used for demonstrating the effectiveness of the interventional strategy.

Results

Prediction Model Accuracy

The F1 score for our self-developed software was 0.8. In comparison, the F1 score for the commercialized software was 0.9. Sample test results are shown in Table 2. The highlighted ones are the inconsistent predictions from the self-developed algorithm and commercial software.

Table 2. Side-by-side Comparison Results

Sample Peer-to-Peer Comments	Self-developed Software	Commercial Software
Student I add tremendously to the project so far because she is very organized and helps keep the group meetings on track and is good at delegating individual tasks to help meet deadlines and push the project along. She helped divide up all the work in a way that was fair to everyone and keeps in contact almost daily regarding updates on the project and new things we need to get done. She is also very good at creating time for the group to meet and collaborate on things that require all of our attention like the PDI and the engineering notebook.	Positive. Keep the team on the right track	Good contribution to the team: Positive
Overall I've been really active in participating whenever my group is having discussions regarding the progress of our project. I contribute new ideas that could help us get a better grade and bring up possible early submission opportunities that will help our grades for the project. My understanding of all the project requirements for milestone one have helped us make sure that everything we need is included.	Positive. Good contribution to Team's work	Good contribution to the team: Positive
Student J is really good at stopping during meetings to help any member who might be confused with their part of the project and breaking down points of confusion so we can continue working seamlessly together. she has a really good understanding of important components needed for our submissions like Microsoft project and is willing to help other members who might not know it as well. She is also very good at using outside material to research and enhance our project. She reaches out to many different sources of information to	Positive. Good interaction with teammates	Positive: Good contribution to the team

make sure our project is always accurate. Overall, the group probably wouldn't have gotten as much done in the time frame that we have without her help.		
Did a great job in brainstorming the company name and product name. Explained pretty well in the background information and project objective. Completed the full tasks.	Positive: Good contribution to the team	Positive: Good contribution to the team: Have good KSA
I did the 3D model for the design project and completed the slide of the Technical design description and the cost estimate in Milestone 1. I also went through the slides before submitting them, checking for any problems that might appear in the slide.	Positive. Having relevant KSA	Have good KSA: Positive
Student K intends to do her work sometimes. I feel that sometimes communication can be a hassle because sometimes she takes a while to respond to things, which can be annoying at times. She also has not done much work in her role, which might be fine for now (as we are still figuring out the circuitry layout for the headphone and where to pit things), but I feel like she could be more responsive and take on more work.	Negative. Avoidance of accountability	Positive: Good contribution to the team

Interventional Effectiveness

The improvement of the student team performance is based on their peer ratings as well as peer comments. Figure 3 shows an average rating variation per group for one class of 15 students after applying the intervention for five dimensions: contributing to the team's work, interacting with teammates, keeping the team on track, expecting quality, and having relevant knowledge, skills, and abilities. Group 5 is a control group where no intervention is applied between Peer Evaluation I and II. However, After Peer Evaluation II, the instructor intervention has applied to improve team performance.

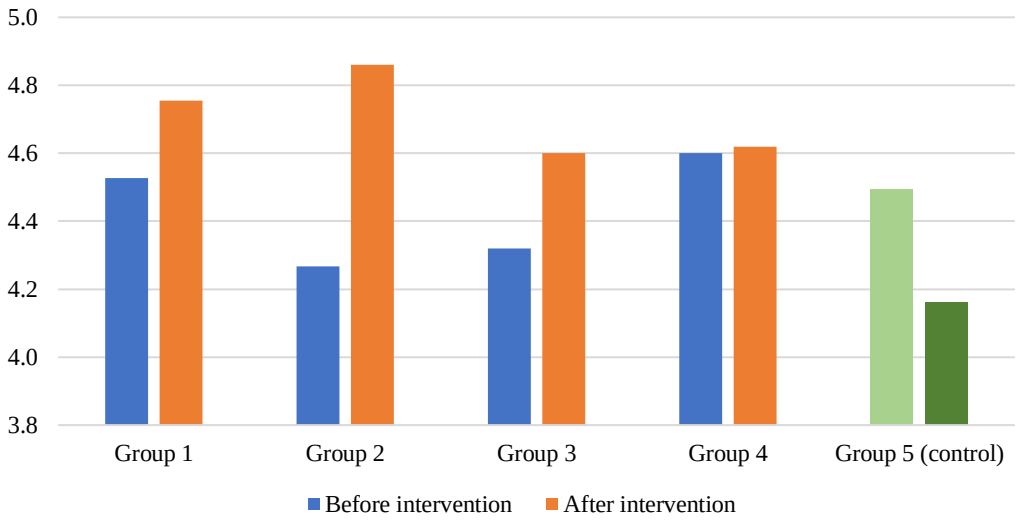

Figure 3. Rating variations across one class section of 15 students.

Case Study 1- Avoidance of Accountability

In the first case study, Student C commented, "Student A adequately completed his part of the presentation, however, our group had to seek him out when there was an issue with our group chat that made him unable to see our messages for the first couple weeks. After the issue was solved, Student A had to miss a meeting because he was sick, however, he did do all his work remotely so there were no issues related to that." The case was determined as "Avoidance of Accountability" and the instructor applied the corresponding intervention according to **Table 3**.

Table 3. The Peer Ratings for Case Study 1.

(a) Peer ratings before instructor intervention						
Team ID	**Section**	**Contrib. to Team**	**Interact w/ Team**	**Keeping on Track**	**Expect Quality**	**Having KASs**
2533-HIR	A1	3.7	4.3	4.0	4.7	4.7
2533-HIR	A1	4.3	4.7	4.3	4.7	4.7
2533-HIR	A1	5.0	4.7	4.7	4.7	4.7
(b) Peer ratings after instructor intervention						
2533-HIR	A1	4.3	5.0	4.7	4.3	4.3
2533-HIR	A1	5.0	5.0	4.7	5.0	5.0
2533-HIR	A1	4.7	5.0	4.7	4.7	4.7

Student C realized that his team performance really depends on individual contributions, and he would try his best effort to play the role, which was thought to be insignificant by himself. In Peer Evaluation II, Student C commented, "Student A worked mainly on the presentation while offering support for the Revit. He also created a few of the classrooms in the design." Student C also left a confidential comment to the instructor, "Everything has been going smoothly and everyone is helping out using their specific skills to advance the project."

Table 4. Peer Comments for Case Study 1

(a) Peer comments before instructor intervention
"Was absent from a stomachache but tried to fulfill."
"Student A adequately completed his part of the presentation, however, our group had to seek him out when there was an issue with our group chat that made him unable to see our messages for the first couple of weeks. After the issue was solved, Student A had to miss a meeting because he was sick, however, he did do all his work remotely so there were no issues related to that."
"He is always ready to help and learn new things. He reminds the team about what tasks need to be done."
(b) Peer comments after instructor intervention
"Because I have a weakness for the Revit, I was trying to help as most as possible on presentation and the logo or engineer notebook."
"Student A worked mainly on the presentation while offering support for the Revit. He also created a few classrooms in the design"
"He was willing to work but might be a little limited by his skills with Revit. However, he made sure the team milestone presentations get done in a timely manner and in relatively high quality.'

Case Study 2 - Fear of Conflicts

Four students formed two non-collaborating sub-groups, i.e., "cliques". Student E was rated significantly lower than the other three team members (**Table 5**).

Table 5. The Peer Ratings for Case Study 2

(a) Peer ratings before instructor intervention							
Team ID	**Section**	**Contrib. to Team**	**Interact w/ Team**	**Keeping on Track**	**Expect Quality**	**Having KASs**	**Note**
2594-RAD62	G2	4.5	4.5	4.5	4.5	4.5	Cliq
2594-RAD62	G2	1.8	3.2	2.5	4.0	2.5	Cliq
2594-RAD62	G2	4.5	4.5	4.2	4.2	4.5	Cliq
2594-RAD62	G2	3.8	4.5	3.8	4.2	3.8	Cliq
(b) Peer ratings after instructor intervention							
2594-RAD62	G2	4.3	4.7	4.7	4.7	4.0	
2594-RAD62	G2	4.0	4.7	3.3	4.0	3.3	
2594-RAD62	G2	4.3	4.3	4.3	3.7	4.0	
2594-RAD62	G2	4.0	4.3	3.7	4.0	4.0	

The case was determined as "Fear of Conflicts" as Student D communicated with the instructor that she was trying her best to avoid potential team issues by making many compromises during team decisions. After the instructor's intervention, Student D realized that the best solution was to be more involved in team discussions and share her own ideas on important team decisions.

Table 6. Peer Comments for Case Study 2

(a) Peer comments before instructor intervention
"Recently, you have shown a lot more dedication to this project which I really appreciate. I also appreciate how you try to get ahead of the project and you ask a lot of questions which shows that you care. I gave you these ratings based on your behavior from the beginning of this project, as much as you showed promise and intent, it would have been better if your promise could've turned into actions towards the project. It would be a little more helpful if you had shown up to all of our meetings, so you were aware of the changes to the project and the new course we were on. For example, it can be a bit frustrating when we call over a TA for help and the information you are relaying to them about our project isn't necessarily accurate information. However, I really appreciate the changes you made this last weekend by showing up and contributing."
"Compared to when we first started, you show a lot more effort and dedication now. However, it would be better if you could try to contribute and understand the project more in detail. If you're ever confused about the project or miss any meetings feel free to ask us questions. Such as the ideas that were discussed in meetings you didn't attend, so that when we discuss it with other people you will know specifically what the idea was on. Also, I think you should try to minimize the lengths of your breaks so that you can spend more time working on the project with us. During our meetings, I hope that you can show up on time and put more work in."
"Could make a greater effort to show up to team meetings; Please plan around scheduled team meetings, not on top of them."
(b) Peer comments after instructor intervention
"You have been doing so much better with showing up to meetings, making your input known, and putting in more work into the project which is amazing. I think you have so many good ideas during our meetings, and your work on the cost tables and finding background information for our glove has been very helpful."
"I think you're doing a good job of keeping up with the updates of the project. You're able to effectively manage your time with the project and project tasks."
"Thank you for attending the recent meetings and making an effort to contribute more to the team."

Case Study 3 - Inattention to Results

Table 7 shows the group members rate each other low (3.5) on team contribution. After the instructor's intervention, two of the students' peer ratings has been improved and increased to 5.0.

Table 7. The Peer Ratings for Case Study 3.

(a) Peer ratings before instructor intervention						
Team ID	**Section**	**Contrib. to Team**	**Interact w/ Team**	**Keeping on Track**	**Expect Quality**	**Having KASs**
2555-HIR	G2	3.5	4.0	4.0	4.5	5.0
2555-HIR	G2	3.5	5.0	4.0	4.5	5.0
2555-HIR	G2	3.5	4.0	4.0	4.5	5.0

(b) Peer ratings after instructor intervention						
2555-HIR	G2	3.0	5.0	5.0	5.0	5.0
2555-HIR	G2	5.0	5.0	5.0	5.0	5.0
2555-HIR	G2	5.0	5.0	5.0	5.0	5.0

Student E commented to Student F, "I think you're a good group member. I like how you try to consistently contribute to the share of the work, and I really value the ideas you bring to the table. I think it would be helpful for our entire group to be more organized and work on things ahead of time collectively. The instructor also noticed that students E and F missed some project due dates. Therefore, the intervention was applied to ensure they are on the right track. Students E and F understood that it was critical to plan things ahead and communicate with each other on the next steps.

Table 8. Peer Comments for Case Study 3

(a) Peer comments before instructor intervention
"I think you're a good group member. I like how you try to consistently contribute to the share of the work and I really value the ideas you bring to the table. I think it would be helpful for our entire group to be more organized and work on things ahead of time collectively."
(b) Peer comments after instructor intervention
"I think you are a good partner."

Case Study 4 - Lack of Commitments

Table 9 shows the group members rated 3.5 on the dimension of keeping the team on track and 3.8 on the dimension of interactions with the team. After the instructor's intervention, the overall students' ratings have been improved. It is noticeable that one of the team members is being highlighted as "under-confident" by CATME software as his or her self-rating is lower than the peer's average rating. This could possibly be due to a lack of communication between the team members. After the instructor's intervention, the situation was resolved.

Table 9. The Peer Ratings for Case Study 4

(a) Peer ratings before instructor intervention							
Team ID	**Section**	**Contrib. to Team**	**Interact w/ Team**	**Keeping on Track**	**Expect Quality**	**Having KASs**	**Note**
2588-RAD34	G2	4.0	3.8	3.5	3.8	4.0	
2594-RAD62	G2	4.2	4.2	4.0	3.8	4.0	
2594-RAD62	G2	3.8	3.8	3.5	3.8	4.0	Under
2594-RAD62	G2	4.2	4.2	3.8	4.0	4.0	
(b) Peer ratings after instructor intervention							
2594-RAD62	G2	3.8	4.0	4.0	3.8	4.0	
2594-RAD62	G2	4.2	4.0	4.0	3.8	4.0	
2594-RAD62	G2	4.0	4.0	4.0	3.8	4.0	
2594-RAD62	G2	4.0	4.0	4.5	3.8	3.8	

In this case, Student G commented to Student H, “Thanks for designing the logo! I think we should all communicate ***more*** on when deadlines need to be met.” The student also left a confidential comment to the instructor, “Student H and Student I seem to do the work last minute which can stress me out. However, we are just beginning the project and I think all our communication could use some work, so I am not too worried.” The case was determined as “Lack of Commitments”. After the instructor’s intervention, student F was able to distribute more time on the project and participate in the group activities. In Peer Evaluation II, Student G commented to Student H, “Good work with the 3D logo! I also feel like you add good ideas to discussions and are always eager to help.” The temporary individual penalty was then removed.

Table 10. Peer Comments for Case Study 4

(a) Peer comments before instructor intervention
“Completes all tasks on time with high quality. Keeps track of deadlines and update team members about my work frequently. Shares my ideas openly and communicate with fellow team members. Listens and respects everyone. Always attends team meetings on time.”
“Completed all of the designated benchmark tasks on time and helped with group assignments. Communicated with members regarding assignments and attended weekly meetings. Spent a lot of time outside of class on the 3D printed logo and successfully completed it before Benchmark A.”
“Completed tasks well and even got ahead by 3D printing the logo, attended meetings, good communication.”
“Thanks for designing the logo! I think we should all communicate more on when deadlines need to be met.”
(b) Peer comments after instructor intervention
“Completes all tasks on time with high quality. Keeps track of deadlines. Shares ideas openly and communicates frequently with fellow team members. Listens to everyone. Always attends team meetings.”
“Finished 3D logo early, and got it approved and printed. Good communication and team meeting participation. Completed all assigned benchmark tasks.”
“On time to all meetings, good communication got logo approved and printed early, worked on engineering notebook.”
“Good work with the 3D logo! I also feel like you add good ideas to discussions and are always eager to help.”

Discussion

The accuracy of the test

This study aims to remove the heavy workload of instructors who have to review peer comments line by line by developing an effective analysis tool. The incentive for developing our own algorithm is that it could be later customized for specific research needs. Compared to commercial software, our self-developed software is mainly based on manually defined rules. For example, if the word *efficient* appeared in the written comments, our self-developed algorithm will automatically match the word *efficient* with pre-defined lexical units connected with one specific dimension of CATME, in this case, which will be “Positive. Good contribution

to Team's work". The initial trials show the instructor can provide more effective intervention to students and respond more promptly to any team issues, together with the peer rating.

Interventional Strategy

The instructor's intervention proposed in **Table 1** was based on the instructors' experience in dealing with students' team issues. Some of the pioneering work was done by other educational institutions [46, 47]. The intervention has only been tested on four major team issues (four case studies): fear of conflict, lack of commitment, avoidance of accountability; inattention to results. The peer evaluation after the intervention has shown evidence of the effectiveness of the interventional strategy. However, the intervention strategy for "lack of trust" will need further validation as it is challenging to determine by the current five-team dimensions. It is possible to add one more dimension named "Team Trust" in CATME for evaluating the mutual trust among the team members. CATME has been used for this study as it is an effective tool for analyzing team performance, however, the intervention strategy mentioned in this paper could also be applicable while other team evaluation software such as Qualtrics® being used, which could be applied to most of the team issue cases in student group projects.

The use of confidential statements

The students were allowed to leave instructors confidential statements while working on peer evaluations. This could potentially provide a different perspective on peer evaluation as some of the students felt more comfortable having a private communication channel.

A student group has Student C commented to the instructor privately, "So far, we have had some issues communicating with Student A, and I do feel like it is easier to work with Student B than with him. Nevertheless, we have continued to include him as normal. So far, he has completed the work he said he would and offered to do bonus work when he had to miss a meeting. I hope that the communication gets smoother as we solidify our group dynamic." The case has been determined as "Avoidance of Accountability" and a corresponding intervention has been implemented. In Peer Evaluation II, Student C commented to the instructor privately, "Everything has been going smoothly and everyone is helping out using their specific skills to advance the project."

Limitations

Our self-developed algorithm still has some limitations. It could not perform multiple text classifications. For example, In Table 2, "Student J is good at stopping during meetings to help any member who might be confused with their part of the project and breaking down points of confusion so we can continue working seamlessly together. She has a good understanding of important components needed for our submissions like the Microsoft project and is willing to help other members who might not know it as well. She is also very good at using outside material to research and enhance our project. She reaches out to many different sources of information to make sure our project is always accurate. Overall, the group probably wouldn't have gotten as much done in the time frame that we have without her help." The correct classification should indicate that Student J has positive comments on the aspects of good interaction, good contribution as well as good relevant knowledge, skills, and abilities.

Also, the students' written comments could be more balanced and constructive. It has been found over 20% of the peer comments are just one simple sentence or phrase, which created an

additional barrier for the instructor to evaluate the team's performance. Another potential area we could improve is to investigate more complex situations such as multiple cases involved. For example, “Inattention to Results” and “Lack of Commitment” for one team. A procedure for applying intervention strategies needs to be developed in those cases.

Conclusion and Future Work

A proprietary platform for text analysis was developed for team peer evaluation along with a proposed time schedule and intervention strategy. So far, the accuracy was comparable to the commercial software. However, there are some difficulties when analyzing longer student responses. The purpose of this study is to identify potential negative team issues with the help of text analytics and explore the use of instructor-led interventional strategy to resolve the team issues. Future work would focus on improving the accuracy of the self-developed algorithm, providing students with more training on how to write effective written comments, and incorporating confidential statements into the model.

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