Strategies and Implications of Peer Assessment in Software Engineering Education

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***Abstract*—This Innovative Practice category full paper describes the strategy of peer evaluation approach. Effective team management is pivotal in the success of any collaborative project, particularly in the domain of learning Software Engineering or Professional Software Development courses. Peer evaluations are commonly used methods to motivate group-based learning. This paper addresses the significance of team management and peer evaluations in the context of two Computing Science (CS) courses offered: Professional Software Development (PSD) and Team Project (TP). The main contributions of this paper are to provide nuanced insights into the challenges and opportunities inherent in collaborative endeavors, emphasizing effective motivation, encouragement, and resolution strategies for tackling teamwork issues within group projects. This study scrutinizes the intricate dimensions of teamwork in Software Engineering education. A central aspect of the paper involves a comprehensive analysis of peer evaluation methodologies, intending to shed light on practical implications for educators and learners. The findings underscore the importance of leveraging these insights to cultivate a conducive learning environment, motivating students to actively participate in collaborative endeavors. The proposed peer evaluations approaches are presented as a combination of the existing quantitative assessment approach and newly qualitative feedback mechanisms. It incorporates these elements: weekly peer review, emotion rating & thoughts, release of feedback, and a centralized dashboard. In the study, 31 CS Sophomore students taking the CSC2101 – PSD and TP1 course participate to evaluation experiments, where positive results are obtained. The collective findings and evaluations contribute to the ongoing refinement of collaborative learning experiences within the dynamic landscape of Software Engineering education.**

Keywords—Peer evaluation, team project, group-based software development, software engineering education.

I. INTRODUCTION

Group-based learning in software engineering education gradually becomes a norm in Higher Education. Working in a group is one of the many skills professional bodies are looking for, especially in software industry [2][3]. As the digital landscape matures, the complexity of software projects escalates, necessitating a workforce adept not only in technical skills but also in managerial competencies. Such skills are important and crucial in equipping graduates to remain viable in the competitive job market. The capacity to work together towards a common goal is not just about achieving academic success, but more importantly, it is about preparing for the real-world scenarios where both technical capabilities and collaborative skills distinguish an individual [4].

Peer Assessment serves as a pedagogical tool, where students grade their peers' work with feedback sometimes [5]. There are benefits and challenges that come with peer assessment in group projects [6]. When done efficiently, peer assessment can enhance engagement, reinforce understanding, and foster a sense of ownership over the learning process [7]. Comprehensive Assessment of Team Member Effectiveness (CATME) is a well-known peer assessment tool, where there are 81 items with five categories in the full instrument for measuring the peer contributions [8]. It is a comprehensive method, but it is considered as comprehensive due to the high number of instrument items. The number of items in the instrument are reduced to be 33 [9]. A study compares the Engineering student in learning with CATME and Team+ software, where Team+ software consists of eight activities for four team development stages in providing team building [10]. The advantages and weaknesses of CATME and Team+ tools are discussed and compared in two Engineering courses.

While peer assessment is recognized as a valuable tool in fostering engagement and honing collaborative skills in software engineering education, its effectiveness may be highly variable and dependent on the implementation strategies. There is a lack of consensus on best practices for peer assessment in group projects of software engineering in Higher Education,

which may lead to inconsistencies in student experiences, education outcome and most importantly preparedness for the job market. This research aims to explore the strategy of peer assessments and understand the impact on learning in software engineering. The research questions of this paper include:

- RQ1: What are the primary challenges associated with implementing peer evaluation in group projects in software engineering education?
- RQ2: In what ways does the structure and design of peer evaluation impact motivation and engagement levels of students in software engineering?

Next, the discussions of related work in literature are delved in Section II. In Section III, the current peer evaluation method adopted in our university is described. Our methodology and proposed changes in the peer evaluation process are also presented. In Section IV, survey questionnaires are conducted with 31 participants in evaluating the proposed peer evaluation approach. The obtained results are discussed. The paper is concluded in Section V.

II. Related Work

A. Groupwork Engagement Measure

Groupwork Engagement Measure (GEM) was introduced to rate the engagement of group members in a group project with 37-item model [11], where participants graded to each peer and the overall score determined the level of engagement of each member in the group project. A study is reported about if peer evaluation affects group work engagement in software engineering projects [12], where results were gathered at the mid-point (Week 5-6) and at the end (Week 12-13) in the duration of group projects. The peer evaluation results were released to students after the mid-point, where it was observed the increased group work engagement. It suggests that early disclosure of peer evaluation results prompts students to become more involved in group projects, minimizing potential impacts on their grades. Another study showed that using GEM can engage group members [13]. By providing the feedback results to group leaders anonymously, who can perform intervention work to engage the group members more effectively.

Despite GEM offering a concise feedback mechanism, it possesses certain limitations. Primarily, GEM was originally developed for social-work treatment, and not for peer evaluation in software engineering projects. To adapt GEM for peer evaluations in software engineering, it could remove some questions out of 37 items similar to that in the study of [12].

B. 360 Degree Feedback

Another peer evaluation method, multi-rater feedback encourages personal growth by evaluations with feedback from multiple perspectives [14]. The 360-degree feedback is a type of multi-rater feedback model where everyone is evaluated by all stakeholders or personnel who work with, including self-assessment, assessment from subordinates, from peers, and from customers, etc. [15][16]. The 360-degree feedback was utilized as a tool for student learning and satisfaction level analysis [17]. A study employed the 360-degree feedback to compared against established standards to identify competence gaps on the performance of software engineers [18]. The competence evaluation analysis can be then applied to pinpoint specific areas where teams might lack skills or knowledge, leading to decreased teamwork effectiveness. This in turn encouraged a culture of feedback and continuous improvement.

But this form of peer evaluation could tend to be subjective; thus, many factors, including personal biases and relationships with the ratee, can influence the leniency of the feedback provided by the rater. This ranged from how the rater is associated with the ratee, whether the rater is a peer, a superior, or a subordinate of the ratee, as well as the time spent with the ratee, as suggested in [19].

C. Using technology to aid peer evaluation

Peer evaluation can be implemented with or without technology, where the former allows applying more complex instructional designs, addressing larger audiences, and supporting multiple reviews [20]. Various technologies are introduced for the purpose of peer evaluation, including web-based peer evaluation system, Learning Management Systems (LMS), mobile applications, or social media, etc. [21]. Web-based systems are used in various domains, that come with some inherited benefits. For example, it could allow altering the study conditions according to the learning interests. There are benefits implementing peer evaluation in web-based applications, where it could reduce the administrative burdens on lecturers. Online peer evaluation system could also offer prompt feedback with scalability to large cohort [22]. Peer evaluation systems could be built into LMS such as Canvas or Moodle with favourable effectiveness [23][24]. It could facilitate for response recording, result analysis and peer feedback dissemination. A mobile application, Daily Smirk is reported to conduct daily peer evaluation provided in the form of emotional faces instead of text inputs for software engineering courses [25]. Gamification systems for peer evaluation incorporates key elements such as project-based learning, peer evaluation, and learning progress, to better motivate students in Software Engineering classes [26].

But there are potential limitations associated with technology-enabled peer evaluation. One notable concern is the possibility of errors during the submission of peer evaluation forms, including mis-clicking the wrong options. To mitigate such potential issues, the design of web-based applications should prioritize user-friendly interfaces and implement mechanisms to minimize errors in the peer evaluation process.

III. Our Methodology

This section presents the current peer evaluation pedagogy in group projects adopted by the Computing Science (CS) joint degree programme of Singapore Institute of Technology and the University of Glasgow (SIT-UoG) in teaching software engineering courses. We then aim to formulate learning methods to potentially improve the peer evaluation process in the software group projects.

A. Current Peer Evaluation Methods

In the context of the software engineering course CSC2101 – Professional Software Development & Team Project 1 (PSD & TP1), the existing peer evaluation method primarily involves

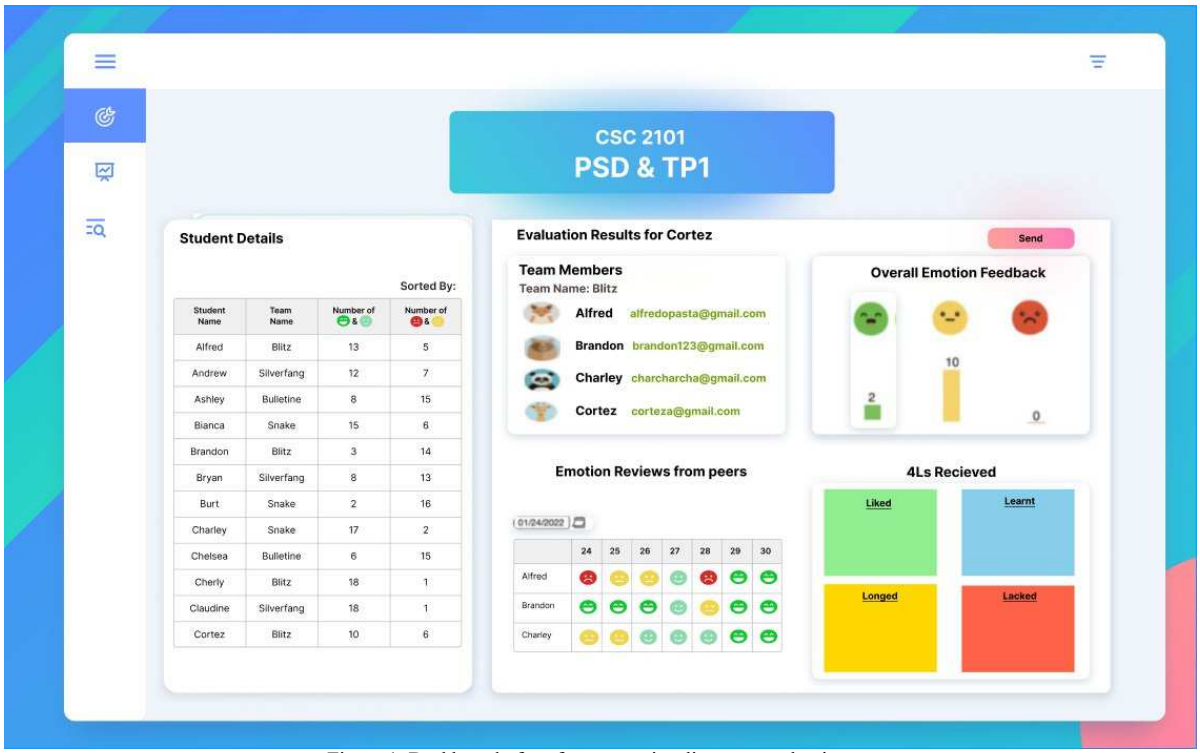

Figure 1. Dashboard of professors to visualise peer evaluation scores.

a post-sprint project assessment in the Scrum framework of software development life cycle (SDLC) where the group grades will be given by the project customers and academic supervisors first. Next, following the completion of a sprint in the SDLC where a monthly sprint of software development is conducted, each student does the peer assessments to all members in the same group based on their perceived contribution to the collaborative task. The peer assessment utilizes a numerical scale ranging from 1 to 10, with 10 representing the highest level of contribution. Students give peer scores to each team member. These peer ratings, in turn, are amalgamated to compute a mean peer score for group members. The mean score obtained from peer evaluations is multiplied with the group grade to derive the individual student grade. For instance, a member receiving a peer score of 9 would correspond to his/her individual grade to be 90% of the group grade of this group in the previous software development sprint.

B. Reflections and Identified Limitations on Current Method

Having navigated through multiple team projects in CSC2101 - PSD & TP1 course, we found the numerical rating system for peer evaluation to be somewhat limiting in capturing the intricacies of effective teamwork. There were instances where the contribution of a teammate may go beyond the numerical score we could assign, e.g., their dedication to brainstorming sessions, their adeptness in problem-solving, or their ability to adapt to evolving project needs. Conversely, the rigid numerical scale failed to address nuances, leaving aspects like communication skills or adaptability unaccounted for in the evaluation process. It became evident that different team members excelled in different areas that were crucial for our projects success, yet these areas were not captured by the numerical assessment of the current peer evaluation system.

Despite its utilization, this current method of peer evaluation has certain limitations. The exclusive reliance on a numerical rating system to assess contribution might not comprehensively capture the diverse facets of teamwork, such as individual efforts, collaboration, communication, and problem-solving skills. Moreover, the singular of the current method focuses on quantifiable ratings but overlooks qualitative aspects which are crucial for effective teamwork assessment.

Using the current system, this can impose a high risk of subjectivity. Different students will have different perceptions of a '6' and '8' which can affect the fairness of the grading. The overall grade of the student can be severely impacted since this segment holds a high weightage. Additionally, since peer evaluations occur post-sprint of projects, students miss out on the chance to improve during the sprint of project development, leading to delayed feedback and limiting learning and growth. Peer evaluation can be seen as learning points for students, but these evaluations are not always released to them. Students may miss out on learning points and opportunities to improve.

C. Proposed Peer Evaluation Approach

Our proposed peer evaluation approach is a hybrid of the existing quantitative assessment methods and novel qualitative feedback mechanisms. The online web-application incorporates four high-level features: weekly peer evaluation, emotion rating & thoughts, release of peer feedback, and a centralized dashboard.

1) Weekly Peer Evaluation

Implementing a weekly peer evaluation feature will facilitate continuous feedback on both technical progress and communication skills in the group. Such a mechanism will

encourage regular engagements among team members, fostering a more iterative and developmental approach for evaluating individual contributions within the group. Through weekly evaluations, individuals can offer and receive constructive criticism, highlight strengths, and address areas needing improvement in a timely fashion.

2) Emotion Rating & Thoughts

Incorporating an emotion rating & thoughts feature like that of The Daily Smirk method in [25] will help supplement numerical evaluations. This feature will allow team members to express their emotional responses such as glad/sad/mad model similar to that of the sprint retrospective meetings in the Scrum framework [27], regarding their collaboration experience. Additionally, inviting 4L's (i.e., Liked, Longed, Learnt, and Lacked) thoughts similar to those of sprint retrospective meetings in the Scrum framework, on aspects of the progress of team members encourage qualitative insights into the team dynamics [28]. It will foster a deeper understanding of individual contributions and areas for growth of each member. By incorporating both emotional responses and the 4L's retrospectives, qualitative and quantitative feedback are given to peers. It provides balanced and comprehensive peer evaluation.

3) Release of Peer Feedback

For the release of feedback feature, the professors will adopt an anonymous approach for self-reflection purposes. However, to facilitate learning and growth, team members will have the option for automatic release of peer feedback. This flexibility aims to empower individuals to proactively engage with constructive feedback, while preserving their anonymity in self-reflecting on received assessments.

4) Centralized Dashboard

In the proposed centralized dashboard as an online web-application, student feedback will be meticulously archived, ensuring that professors have seamless access to a comprehensive record of individual peer evaluations on a weekly basis. This archival process not only streamlines the tracking of project progression but also enriches the oversight of collaborative dynamics within groups. Groups within the solution can be opened enrollment before the commencement of group projects and closed to new members once as projects begin. As a result, students do not have to continuously indicate the Student Unique Identifier or student number of their peers upon every peer evaluation submission. It simplifies the peer evaluation submission process and allows students to concentrate more fully on the collaborative learning experience in group projects.

The grading system is activated at the end of each SDLC sprint of group projects, or anywhere in between depending on the arrangement of professors. The individual grade of each member can be calculated based on a combination of customers grading, professors grading, student peer reviews, individual contributions, and emotional ratings. It ensures that every aspect of the participation of a team member is quantified and recognized. The algorithm of the grading system will be made known to everyone. Its criteria and weighting will be informed to all team members. It ensures that expectations are set, and assessments are understood to be objective. It provides transparency as well as the enforcement that team projects are not only looking for technical competencies, but also the collaborative and soft skills in individuals. Such a grading system promotes a culture of accountability and continuous personal growth, as students will be more incentivized to contribute positively to team dynamics, knowing that their actions will be fairly evaluated and reflected in their academic progress and group projects.

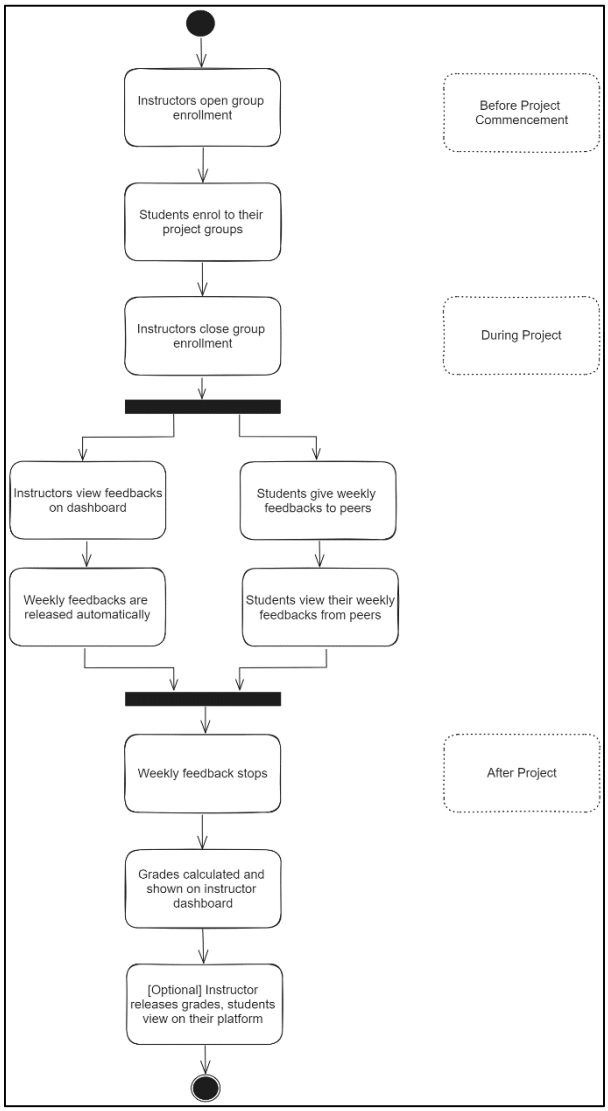

Figure 2. UML activity diagram of the proposed peer evaluation approach.

Our proposed peer evaluation approach seeks to optimize the strengths of prior works in literature, while mitigating their respective weaknesses. By combining structured quantitative metrics with nuanced qualitative insights, our proposed approach aims to offer a more comprehensive and fair evaluation of peer contributions. This hybrid approach strives to maintain objectivity and measurability, while enriching the peer evaluation process with a deeper understanding of individual performances. In doing so, it aspires to create a robust peer evaluation system that accommodates diverse learning styles and project dynamics, fostering a more constructive and insightful peer feedback environment.

The activity diagram of unified modeling language (UML) shown in Fig. 2 depicts the proposed peer evaluation approach. It goes through three stages of a group project: Before Project Commencement, During Project Sprints, and After Project Sprints.

In the first stage, professors opens the enrollment to all groups, such that students can enroll themselves into the corresponding groups. In the second stage at each sprint of the SDLC project development, there are two parallel paths of activities. Students conduct the weekly peer evaluations and feedback to each peer in the same group. Students are also able to view their own received weekly peer evaluations. Professors can view the weekly peer evaluation of each student on the centralized dashboard. The weekly peer evaluations will be released to all students. In the third stage after each project sprint, the individual combined grades of students will be calculated based on the grading system. Professors can view combined grades of in the past sprint to all students. There is an option for professors to release the combined grades to students.

IV. Findings Analysis and Discussions

To gather feedback of students on the current peer evaluation method and the proposed evaluation approach, a questionnaire was created using Microsoft Forms and was sent to 31 Sophomores students taking the CSC2101 – PSD and TP1 course in the Computing Science of our university. The survey responses reflected a consensus of the current peer evaluation method, with participants expressing dissatisfaction primarily due to limitations in feedback capabilities, transparency, accuracy, and engagement levels. These insights underscore our evaluations of the perceived weaknesses in the existing method, as reported by respondents who found the current method lacking in providing comprehensive and effective feedback.

Firstly, participants were asked how satisfied they were with the current peer review method using Microsoft Form. '1' denotes "strongly unsatisfied", and '5' denotes "strongly satisfied".

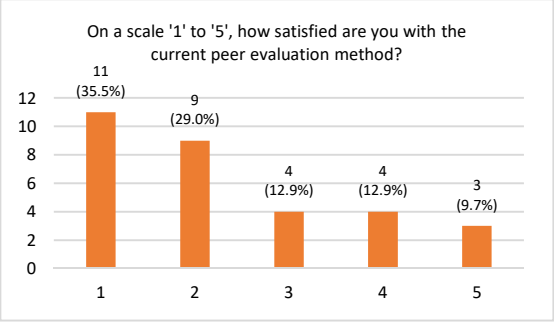

Figure 3. Results on how satisfied with the current peer evaluation method.

The responses gathered in Fig. 3 shows about 64.5% of the participants were not satisfied by giving a rating of '1' or '2'. The average rating is about 2.32 out of 5. Since a high percentage of participants were not satisfied with the current peer evaluation method, they were followed up by asking what weaknesses of the current method are. The participants could choose multiple options in this survey question, unlike the remaining questions to select a single option.

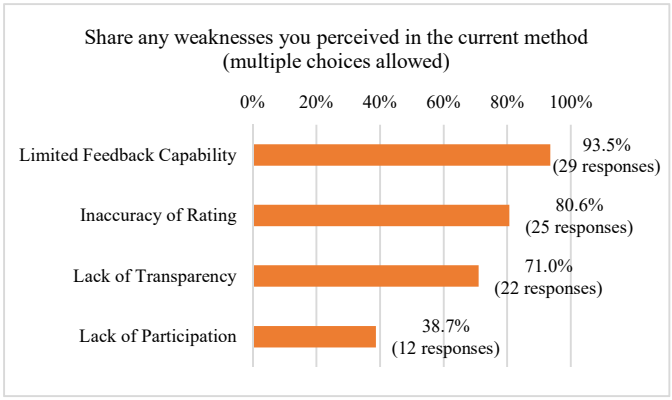

Figure 4. Results on weakness participants perceived in the current method.

The responses were shown in Fig. 4. Amongst these options, "Limited Feedback Capabilities" was chosen 29 times, i.e., about 93.5%; "Inaccuracy of Rating" was chosen 25 times at about 80.6%; and "Lack of Transparency" was chosen 22 times with about 71.0%. This provides us with the reasoning of why participants dislike the current peer evaluation method.

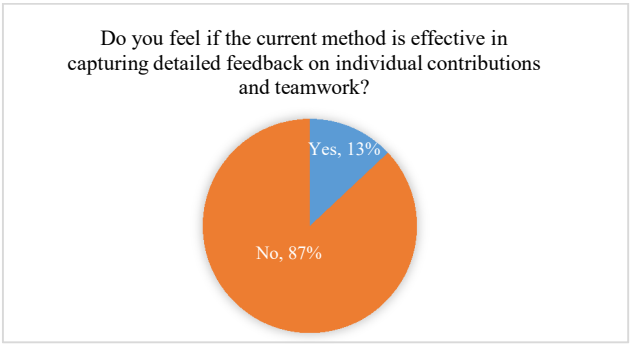

Figure 5. Results on if it is effective in capturing detailed feedback currently.

Thirdly, we would like to find out if the current method is effective in capturing detailed feedback on individual contributions and teamwork. It was observed in Fig. 5 that about 87% of participants chose "No". From the findings of three survey question responses, overall dissatisfaction among the participants is noticed. It indicates a need for substantial improvement in the current peer evaluation process.

Next, participants were asked for their feedback on the proposed peer evaluation approach. Conversely, participants demonstrated considerable enthusiasm and support for the proposed changes in the peer evaluation process.

The participants responded to their thoughts on the proposed weekly peer evaluation feature shown in Fig. 6, where scale '1' denotes "Strongly Disagree" and '5' denotes "Strongly Agree". It was seen that the introduction of a weekly peer evaluation feature to facilitate continuous feedback garnered significant positive feedback, with about 71.0% participants voting "Strongly Agree". It shows this feature is very useful.

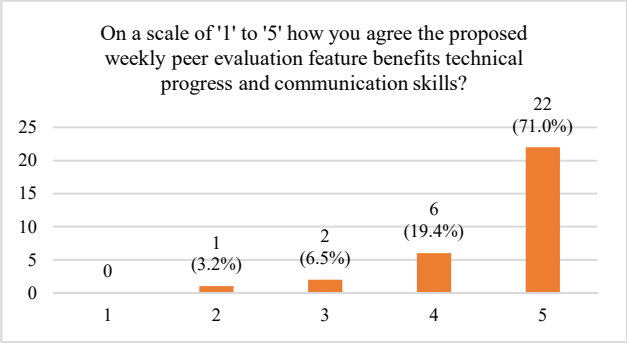

Figure 6. Results on the proposed weekly peer evaluation feature.

Next, the survey questionnaire asked how participants were comfortable with the idea of integrating an emotion rating & thoughts feature for peer evaluation similar to the glad/sad/mad and 4L's retrospective models on the scale of '1' (Strong Disagree) to '5' (Strong Agree). Seen in Fig. 7, it was met with high approval having about 71.0% voted "Strong Agree". The average rating was obtained at 4.68 out of 5 for its usefulness.

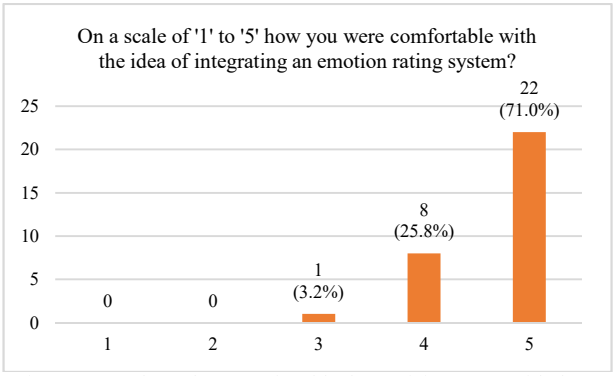

Figure 7. Results on how comfortable the participants are with the introduction of emotional ratings & thoughts.

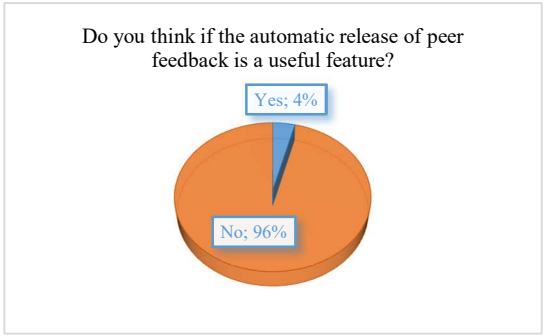

Figure 8. Results on the automatic release of feedback and its usefulness.

Furthermore, our proposed feature of automatic release of peer feedback received very positive responses from the participants shown in Fig. 8, where about 96% participants agreed that it is a useful feature.

When participants were asked how they agreed on the ability of the proposed peer evaluation approach to mitigate anticipated issues such as personal biases, about 58.1% participants expressed Strong Agree, shown in Fig. 9. The average score is about 4.42 out of 5. The regular releases of peer evaluation scores and 4L's retrospectives discussions to all members on the centralized dashboard could improve peer assessment transparency and group communications. Fair peer assessment with less personal biases could become possible in the peer evaluations at the monthly sprint of software development in SDLC.

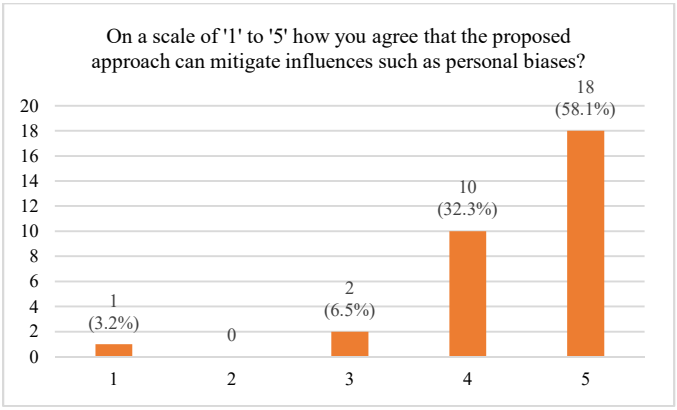

Figure 1. Results on how the proposed approach mitigates influences such as personal bias.

Overall, it was observed that the reception of our proposed changes in the peer evaluation process has been quite positive. Shifting from the use of sporadic feedback in the current method to a more frequent and interactive approach holds promise for fostering better communication, understanding, and collaboration among team members. Furthermore, the incorporation of emotion ratings & thoughts alongside traditional numerical evaluations could offer a multifaceted understanding of individual experiences and team dynamics. This combination may lead to a more holistic assessment of performance and contributions within the team context. Lastly, an anonymous feedback release feature, coupled with the option for automatic feedback release seeks to provide a balanced environment for learning and growth. This initiative encourages candid peer feedback while offering students the autonomy to control the pace of learning and self-reflections.

V. CONCLUSION

The multifaceted landscape of peer evaluation within group-based learning in software engineering courses was explored to answer the two research questions. Challenges in implementing peer evaluation mechanisms were discussed in group projects of SDLC in RQ1. It provides insights into how structured and comprehensive peer evaluation can significantly enhance group work engagement and individual accountability (RQ2). Through the analysis of our methodologies, it is evident that timely peer evaluation and feedback can serve as a catalyst for increased engagement and motivation of students.

Based off the literature review and by weighing the pros and cons of the methods researched, we have distilled the peer evaluation methods for software engineering into several features to implement in our proposed peer evaluation method.

Our proposed peer evaluation approach for software engineering education merges the existing quantitative assessment model with innovative qualitative feedback mechanisms. Its four key features include (1) weekly peer evaluation to foster continuous feedback on technical progress and communication skills, promoting iterative development within teams; (2) incorporation of the emotion rating & thoughts, which enhances numerical evaluations by capturing emotional responses and soliciting qualitative insights through the glad/sad/mad and 4L's (Liked, Longed, Learnt, and Lacked) models; (3) the feedback release mechanism offers flexibility, allowing individuals to choose anonymous self-reflection or automatic feedback release for proactive engagement; (4) the centralized dashboard ensures meticulous archiving of feedback, providing professors with seamless access to comprehensive records and enriching oversight of collaborative dynamics. This holistic approach aims to enhance the peer evaluation process, encouraging continuous improvement, open communication, and a more nuanced assessment of individual contributions within group projects. Positive feedback and responses are observed from the participants in their survey questionaries.

As a future work, we plan to further improve the proposed approach by implementing pre and post development surveys that provide professors with feedback on how peer evaluation scores of students change in the software engineering course. Another future implementation could be enhancing the features of customization of the peer evaluation system to cater to different educational contexts in other courses besides software engineering education. For example, allowing evaluation criteria and feedback mechanisms to be configurable for different courses, based on specific course requirements and learning objectives. It could give more system flexibility.

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