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Comparing teacher, peer, and self-assessment of students' contributions in an ecosystem model project

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ABSTRACT

Perceived unfairness in group work assessment often arises from unequal student participation, particularly when all group members receive the same grade based solely on the teacher's evaluation, regardless of their individual contributions. This study investigates differences in peer assessment, self-assessment, and teacher assessment when evaluating students' contributions to an ecosystem model project, and explores students' perceptions of these assessment approaches. Using a quantitative pre-experimental one-shot case study design, the study involved one tenth-grade class from a private senior high school in Bandung, Indonesia. Data were analyzed through descriptive and inferential statistics and were complemented by semi-structured interviews. The results reveal that self-assessment (SA) yielded the highest average contribution score, with a mean of 83, followed by peer assessment (PA) at 78, and teacher assessment (TA) at 67. The highest observed score was found in SA (100). Statistically significant differences were identified between teacher assessment and both peer and self-assessment, whereas no significant difference emerged between peer and self-assessment. Overall, students demonstrated high levels of contribution and expressed favorable perceptions toward the implementation of peer and self-assessment. These findings suggest that no single method fully captures student contributions, and a combined approach integrating teacher, peer, and self-assessments provides a more holistic and accurate evaluation.

INTRODUCTION

One of the learning models relevant to biology education is Problem-Based Learning (PBL). This model has been proven to improve learning outcomes (Xu et al., 2021), develop lateral thinking or the ability to think creatively from multiple perspectives (Mustofa & Hidayah, 2020), and encourage students to construct new knowledge by linking real-world problems to their prior understanding. PBL also contributes to enhanced long-term retention and the ability to apply concepts in new situations (Yew & Goh, 2016).

In the ecosystem topic, Problem-Based Learning (PBL) can be implemented by presenting students with real-world environmental problems that require analysis and solution development. For instance, students may be challenged to investigate issues such as ecosystem imbalance, pollution, or habitat destruction within a specific context. Through this process, they are encouraged to identify relevant biotic and abiotic components, analyze interactions among these components, and propose feasible solutions. As part of communicating their understanding, students may represent their solutions in visual forms, such as constructing an ecosystem model. Such an approach aligns with the Learning Outcomes of Phase E in the Kurikulum Merdeka, which emphasizes students' ability to create solutions for ecosystem interaction problems from local to global contexts (Badan Standar Kurikulum dan Asesmen Pendidikan, 2022). With its contextual and applicative characteristics, the ecosystem topic is highly suitable for integration within the PBL framework.

The construction of an ecosystem model is ideally conducted collaboratively. Students generally achieve better learning outcomes through group work (Alamoudi et al., 2021). The effectiveness of group-based ecosystem model projects within PBL is not solely determined by the final product but also by the extent to which each student contributes to the process. Individual contributions to both the task content and the social dynamics of the group are crucial factors influencing the success of science learning. Therefore, the implementation of PBL should consider group dynamics and ensure that each student provides meaningful contributions, rather than focusing only on the final product (Premo et al., 2022).

However, unequal contributions among group members remain a classic issue that leads to perceptions of unfairness, decreased motivation, and reduced quality of collaborative learning (Xu et al., 2021), as observed during the *Program Penguatan Profesional Kependidikan* (P3K). Such imbalances often result in certain students feeling overburdened with completing most of the tasks, while others participate minimally. This condition fosters a sense of unfairness among students who have contributed optimally. The emergence of this perception of unfairness is influenced by the assessment system applied during PBL. Typically, assessments are conducted solely by teachers; however, this approach may not fully capture individual contributions objectively, as much of the project work occurs outside the classroom and may not be directly observed by the teacher. Consequently, assigning the same final score to all group members without considering varying levels of contribution can lead to a sense of injustice, particularly among students who have worked diligently, and may ultimately reduce satisfaction and motivation to learn (Adawiyah, 2022).

In light of these issues, a more objective assessment intervention is required to ensure fair evaluation of students' contributions during PBL activities. A fair assessment system is believed to encourage active participation and enhance students' motivation to engage meaningfully in the learning process (Bahmanbijari et al., 2019). One promising strategy is the implementation of peer assessment and self-assessment.

Peer assessment allows students to evaluate their peers' contributions based on predetermined criteria and to provide constructive feedback (Zhan et al., 2023). Through this process, students can develop self-awareness regarding their roles within the group and foster a sense of responsibility for their learning (Adesina et al., 2023). In addition, peer assessment provides teachers with valuable information regarding individual performance within groups

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(Adawiyah, 2022). Nevertheless, Biesma et al. (2019) found that peer assessment still has limitations, such as potential bias due to friendships or students' lack of readiness to evaluate objectively. These limitations indicate the need to integrate self-assessment to achieve more accurate results.

Through self-assessment, students are encouraged to reflect on their own contributions, thereby developing responsibility, motivation, self-directed learning, and critical thinking skills (Yan et al., 2022). This process enables students to evaluate their strengths and weaknesses, recognize their roles within the group, and take ownership of their learning. In addition, self-assessment promotes metacognitive awareness, allowing students to monitor and regulate their learning processes more effectively. However, the accuracy of self-assessment is often difficult to verify, as students may overestimate or underestimate their own contributions due to limited self-awareness or social desirability bias. Therefore, the results of self-assessment should be interpreted cautiously and compared with other assessment sources, such as peer and teacher assessment, to obtain a more balanced and reliable evaluation (Brown & Harris, 2014).

Building on the need to integrate peer and self-assessment to address their respective limitations, the implementation of these approaches in collaborative learning contexts has been shown to provide several pedagogical benefits. Peer and self-assessment can help students reflect on the quality of their work and improve their participation (Kerr & Coleman, 2021). Similarly, Ion et al. (2024) reported that these assessment approaches enhance students' perceptions of fairness in the assessment process. In addition, they contribute to the development of analytical and evaluative skills, as well as students' sense of responsibility in collaborative learning (Dahal et al., 2022).

However, despite the potential of peer and self-assessment to address issues of unfairness in group work assessment, their implementation remains limited and often separate. Previous studies have highlighted both the strengths and limitations of each method; however, there is still a lack of empirical evidence on how the integration of peer and self-assessment can be used to more accurately evaluate individual contributions in group-based learning. This issue is particularly relevant in Problem-Based Learning (PBL) contexts, where students are required to collaborate to solve real-world problems. Therefore, further investigation is needed to examine how these assessment approaches can be combined and compared with teacher assessment to provide a fairer and more comprehensive evaluation of student contributions. Accordingly, this study is expected to provide insights into the potential of student involvement in contribution assessment and offer recommendations for teachers to implement fairer and more transparent group assessment practices.

METHODS

This study employed a quantitative approach using a pre-experimental one-shot case study design. The treatment consisted of the implementation of peer assessment and self-assessment, which had not previously been applied in the school, as an alternative assessment approach to evaluate students' individual contributions in group work. Data were collected through a single measurement conducted at the end of the learning process, in which students evaluated their own and their peers' contributions based on their engagement during the project. These results were then compared with the teacher's assessment to examine the consistency of contribution evaluations.

The participants of this study included tenth-grade students (Phase E), a biology teacher, and research observers from a private senior high school in Bandung, Indonesia during the 2024–2025 academic year. The student participants consisted of one intact class of 36 students selected through cluster random sampling, in which existing classes were treated as clusters and one class was randomly chosen, as students had been assigned to permanent class groups by the school. The biology teacher served as the learning facilitator and research collaborator, implementing the

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ecosystem learning activities and conducting teacher assessment. The students were organized into six heterogeneous groups of six members based on ability levels to support collaborative learning. In addition, two research partners assisted the researcher as observers in conducting teacher assessment. Prior to data collection, all assessors participated in a briefing and calibration session to establish a shared understanding of the contribution assessment indicators and to ensure consistency and objectivity in scoring. Learning activities were carried out over several sessions following the stages of PBL as the instructional context.

Within the context of PBL, students engaged in identifying ecosystem-related problems as the starting point of learning. The ecosystems selected by students included both natural and human-impacted environments. Students examined real-world issues, such as water pollution, deforestation, waste accumulation, and habitat degradation, which are commonly found in their surrounding environment. This process was followed by an analysis of ecosystem types, biotic and abiotic components, interactions among components, and the causes and impacts of the identified problems. The ecosystem model served as a project assignment that represented the outcomes of this identification and analysis process. Each student group independently selected a different ecosystem and translated their findings into a three-dimensional ecosystem model, which was required to display ecosystem components, illustrate interactions among components using arrows, and visually highlight the identified ecosystem problems. Proposed solutions were not directly displayed in the model but were provided through a QR code attached to each project. The QR code linked to a digital module containing a more comprehensive explanation of the ecosystem characteristics, the identified problems, their causes and impacts, and the proposed solutions. This integration allowed students to communicate both visual and conceptual aspects of their problem analysis and solution development.

Data were collected using several non-test instruments, presented in Table 1. Contribution assessment sheets for peer, self, and teacher assessment were developed based on five indicators of contribution, namely participation and teamwork, information seeking and sharing, communication, critical and creative thinking, and social interaction, adapted from Khoirotin & Shofiyah (2024). These instruments employed a Guttman scale (Yes/No) to obtain clear responses (Forrester, 2016). In addition, the teacher used an ecosystem model assessment rubric to determine final project scores based on criteria such as completeness and consistency of ecosystem components, accuracy of interactions, clarity of the problem–solution presentation, and completeness of QR code information. To examine students' perceptions of the implementation of peer and self-assessment, a student response questionnaire was administered at the end of the project. The questionnaire used a four-point Likert scale ranging from Strongly Disagree (1) to Strongly Agree (4) and applied a forced-choice format without a neutral option to encourage respondents to express a clear position. The questionnaire indicators covered two aspects: students' perceptions of the relationship between peer and self-assessment and individual contributions within the group, and students' interest in applying these assessment approaches in PBL. The peer, self, and teacher assessment instruments were developed based on five key indicators of student contribution, adapted from Khoirotin & Shofiyah (2024). The detailed grid of these assessment instruments, along with sample items, is presented in Table 2, while the blueprint of the student perception questionnaire is presented in Table 3. This instrument is designed to examine students' responses following the implementation of peer and self-assessment.

RESULTS AND DISCUSSION

The findings presented in Table 4 and Table 5 reveal notable differences among the scores obtained from self-assessment, peer assessment, and teacher assessment in evaluating students' contributions to the ecosystem model project. Several students rated themselves substantially higher or lower than the evaluations given by their peers and the teacher.

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Table 1
Summary of research instruments.

	Instrument	Purpose	Scale	Respondent
1	Peer Assessment Sheet	To assess students' contributions from peers' perspectives	Yes or No	Student
2	Self-Assessment Sheets	To assess students' self-perceived contributions	Yes or No	Student
3	Teacher Assessment Sheets	To assess students' contributions based on teacher observation	Yes or No	Teacher
4	Ecosystem Model Assessment Rubric	To assess the quality of the final project	weighted scoring system with different maximum scores	Teacher
5	Student Response Questionnaire	Student Response Questionnaire	Likert 1-4	Student

Table 2
Grid of teacher, peer, and self-assessment instruments.

	Aspect	Indicator	Number of Items
1	Participation and Teamwork	Participating in all stages of the ecosystem model construction; completing tasks independently without relying on other group members; completing tasks on time; proactively preparing tools and materials	4
2	Information Seeking and Sharing	Contributing ideas, references, or solutions related to ecosystems; ensuring the accuracy of information; seeking answers to questions	4
3	Communication with Team Members	Listening to and respecting others' opinions; accepting feedback and suggestions for improvement; communicating effectively; initiating task distribution within the team	4
4	Critical and Creative Thinking	Elaborating information to develop problem solutions; identifying ecosystem-related problems; adjusting components and interactions according to the actual habitat	4
5	Social Interaction with Team Members	Avoiding conflicts in collaboration, appreciating each member's contribution, and dominating the model-making process. Response Questionnaire	4

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Table 3
Blueprint of the student response questionnaire instrument.

	Indicator	Number of Items
1	Students' responses to the relationship between assessment using peer and self-assessment, and students' contributions in groups	5
2	Students' interest in the assessment using peer and self-assessment	5
	Total Items	10

Table 4
Cases where self-assessment scores were lower than peer and teacher assessments.

Low Self-Assessment			
Student	**Peer Assessment**	**Self-Assessment**	**Teacher Assessment**
PX42	86	72	94
PX34	86	78	88
LX55	91	72	88
PX62	81	67	89

Table 5
Cases where self-assessment scores were higher than peer and teacher assessments.

High Self-Assessment			
Student	**Peer Assessment**	**Self-Assessment**	**Teacher Assessment**
PX15	70	100	83
PX11	58	78	33
LX25	59	89	44
LX45	67	94	83

In-depth interviews with students and the teacher reinforced these findings. Students who gave themselves high self-assessment scores generally felt they had contributed fully to the project, even though their peers and the teacher evaluated them differently. One student, identified as LX25, stated, "*I feel that I have contributed to the group, so my self-assessment score is already fair*." Conversely, the student's teammates mentioned that this student only became active after being repeatedly invited to discussions and that their participation in completing the worksheets and constructing the model was inconsistent. The supervising teacher also emphasized that the student's engagement was still developing, adding, "*Some students think the score affects their final grade, so they give themselves high marks right away*." This indicates a positive bias driven by the motivation to achieve higher grades. As noted by Brown & Harris (2014), self-assessment results are often unrealistic because they are influenced by students' optimism toward their own abilities.

In contrast, some students gave themselves lower scores than their peers and the teacher did. These students reported low self-confidence regarding their contributions. For example, student LX55 mentioned, "*I feel my contribution in the group is average*." Similarly, student PX42 stated, "*I'm not confident in assessing myself. I'm afraid my score will differ from my peers', so I prefer the teacher and friends to assess me*." However, according to the observer's notes, these students actually played an important role in the project planning phase. These findings highlight that self-assessment should not be used as the sole basis for evaluating students' contributions in PBL, particularly in ecosystem model construction tasks that represent students' identification,

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analysis, and proposed solutions to ecosystem-related problems. Instead, it should serve as a reflective instrument to help teachers understand students' self-perceptions of their contributions. As González-Betancor et al. (2019) point out, self-assessment remains susceptible to bias stemming from factors such as gender and academic ability, even when supported by tools like rubrics. Descriptive analyses of central tendency and data dispersion were conducted to provide a comprehensive overview of the score patterns for each assessment type and to examine their consistency in representing students' participation in the ecosystem model project (Table 6).

Table 6
Cases where self-assessment scores were higher than peer and teacher assessments.

Assessment	Max	Min	Mean	Median	Mode	Distribution
Peer Assessment	92	52	78	81	86	11
Self-Assessment	100	67	83	89	89	18
Teacher Assessment	94	33	67	83	89	31

The results presented in Table 6 indicate that self-assessment (SA) yielded the highest average contribution score, with a mean of 83, followed by peer assessment (PA) at 78, and teacher assessment (TA) at 67. The highest observed score was found in SA (100), indicating that some students awarded themselves a perfect score. Conversely, the lowest score was observed in TA (33.33), indicating that students' engagement was considered very low according to the teacher's evaluation.These differences in mean scores reflect variations in perception between students and teachers regarding individual contributions during the project. This finding is consistent with De Grez et al. (2012), who reported that teacher assessments tend to yield lower scores compared to peer and self-assessments.

Teachers generally provide more critical evaluations based on direct classroom observation and experience in assessing group dynamics and individual participation. Furthermore, certain project activities took place outside the classroom, limiting the teacher's ability to observe all aspects of the students' engagement. While teachers could evaluate students during the project-planning stage in class, the actual construction of the ecosystem model took place two to six days later, outside regular class hours. Consequently, students who were active outside the classroom could still receive lower scores in teacher assessment. This situation underscores the need for peer assessment as a complementary measure, providing additional information from peers who directly observe and participate in the group work process. This finding aligns with Cheng & Warren (2000), who emphasize the significance of peer assessment in considering individual contributions within collaborative learning. Therefore, a combination of teacher and peer assessments represents an ideal strategy for achieving fairer and more representative evaluations of students' actual contributions.

Beyond the mean, the median also provides insight into the distribution of contribution scores. The median for SA was 89, followed by TA at 83 and PA at 81. Although the mean of TA was lower, its median remained relatively high, indicating that most students received good scores from the teacher, while a few extremely low scores pulled down the overall mean. These low scores were generally assigned to students who showed minimal engagement during classroom activities, consistent with Ali et al. (2019), who reported that extremely low scores can significantly affect the average teacher-assigned evaluation. The mode across the three assessment methods demonstrated a similar trend, showing dominance of high contribution scores. Both SA and TA had a mode of 89, whereas PA was slightly lower at 86. This indicates that the majority of students were frequently evaluated as having high levels of contribution, as reflected by the clustering of scores near the upper end of the scale across all assessment methods. This pattern suggests that students tend to evaluate their own contributions more positively, while teacher evaluations are comparatively more critical.

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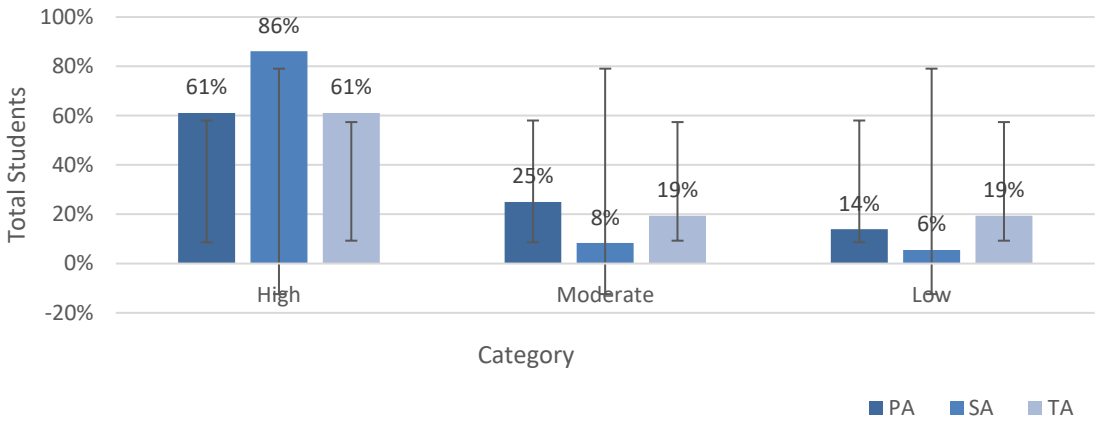
Regarding score dispersion, TA exhibited the highest standard deviation (SD = 31), indicating considerable variability in teacher evaluations of student contributions. According to McCoach et al. (2024), high score dispersion can reflect the genuine diversity of students' contributions observed by teachers in the classroom. SA also showed substantial variability (SD = 18), reflecting differences in how students assessed their own contributions. In contrast, PA demonstrated the lowest variability (SD = 11), indicating higher consistency among peers' evaluations. This is expected, as peer assessments were conducted within the same group context, allowing students to directly observe similar behaviors and contributions of their group members, which in turn resulted in more consistent scoring. Overall, these results suggest that the differences among self, peer, and teacher assessments not only reflect variations in scoring but also reveal dimensions of perception, engagement, and observation within collaborative learning contexts. The integration of all three assessment methods can create a more comprehensive evaluation system that accurately reflects authentic student contributions in PBL projects.

Figure 1
Categorization of the three assessment methods.



The categorization of students' contributions based on the three assessment methods, as shown in Figure 1, indicates that the majority of students were classified in the high contribution category. The highest percentage was observed in self-assessment (86%), followed by peer assessment (61%) and teacher assessment (61%), suggesting that all three methods tended to classify most students as high contributors according to their respective criteria. The moderate contribution category accounted for a smaller proportion, particularly in self-assessment (8%), compared to peer assessment (25%) and teacher assessment (19%). This finding indicates that students tended to rate themselves higher, whereas teachers and peers provided more moderate evaluations, reflecting the teachers' objective observation of contributions that were not yet optimal. The low contribution category showed the smallest proportion, with 6% in self-assessment, 14% in peer assessment, and 19% in teacher assessment. This trend suggests that students rarely rated themselves as low contributors, even though teacher and peer evaluations indicated otherwise. These findings are consistent with Baiduri (2022), who reported that self-assessment tends to produce higher scores compared to peer assessment, as well as with Thawabieh (2017), who found that students tend to rate themselves higher than teachers do.

As shown in Figure 2, score percentages varied across indicators and assessment methods. For participation and teamwork, self-assessment was highest (81%), followed by peer (72%) and teacher (66%) assessment, suggesting students perceived themselves as more active than their evaluators did. Teachers based their judgments on direct classroom observation, while peers also

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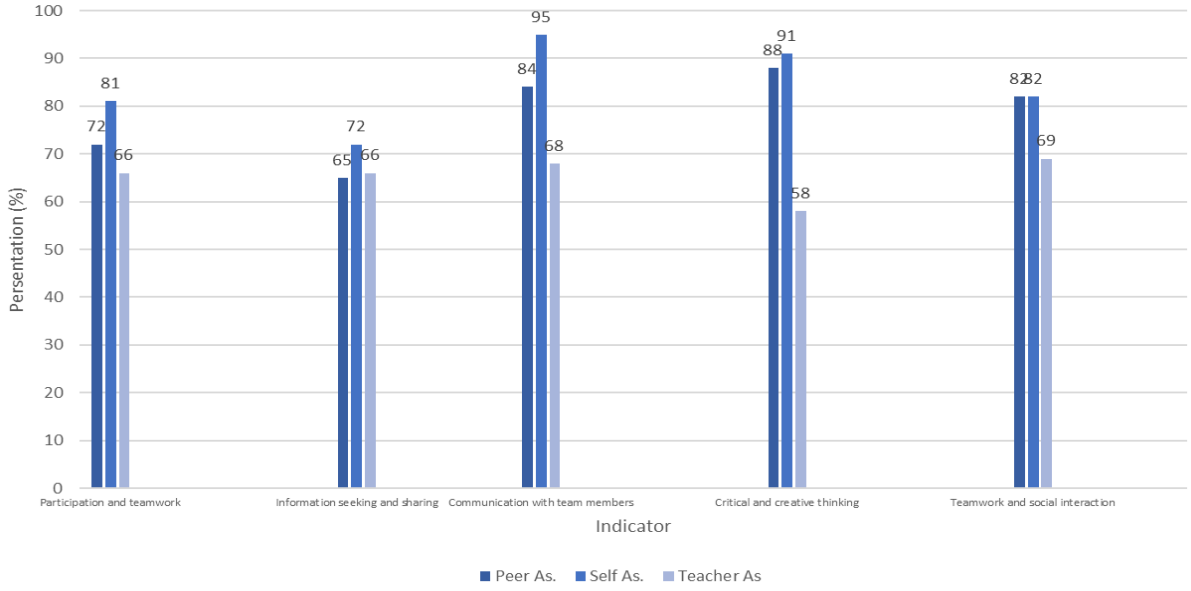
considered out-of-class contributions such as bringing materials, attending extra meetings, and showing initiative.

Figure 2

Percentage of peer, self-, and teacher assessment based on assessment indicators.



For information seeking and sharing, self-assessment (72%) was slightly higher than peer (65%) and teacher (66%) assessment. This indicator covers contributing relevant ideas, providing references, verifying information, and seeking answers during learning. Teachers identified some students as passive, completing assigned tasks without engaging in discussion—a pattern closely matched by peer assessment, indicating similar evaluations from both. For communication with team members, differences were more pronounced: self-assessment reached 95%, peer 84%, and teacher only 68%. Although students perceived their communication as highly effective, teachers observed limited involvement from some, particularly in initiating task distribution. Allocation was often dominated by a few active members, while others remained passive in group discussions. For critical and creative thinking, self-assessment (91%) and peer assessment (88%) were substantially higher than teacher assessment (58%). While students perceived themselves as engaging in analytical and creative processes, teachers observed that only a few members in several groups actively contributed ideas, with others following more dominant peers. This pattern reflects limited independent critical engagement, evident in difficulties identifying ecosystem components and the need for further guidance. For teamwork and social interaction, self-assessment and peer assessment were consistent (both 82%), while teacher assessment was lower (69%). Although students viewed their social interactions positively, teachers noted that passive members created an imbalance, with some students dominating group activities—likely contributing to the lower teacher scores. Following these descriptive analyses, a Wilcoxon signed-rank test was conducted to examine the significance of differences across assessment methods, strengthening the quantitative findings. The results are presented in Table 7.

The comparison between peer and teacher assessments yielded a significance value of 0.046 ($p < 0.05$), indicating a statistically significant difference between the two methods. This finding is consistent with Power & Tanner (2023), who reported that students tend to assign higher scores than expert evaluators. The discrepancy reflects differing perspectives between teachers and students: teachers rely on more structured, objective criteria, whereas students' evaluations may be influenced by their direct social interactions within the group. Similarly, the Wilcoxon test

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between self- and teacher assessments showed a significant difference (Asymp. Sig. = 0.005, $p < 0.05$). This result suggests that self-assessment alone may not fully capture students' actual contributions. Previous studies have highlighted that self-assessment scores often diverge from teacher evaluations (Power & Tanner, 2023), largely due to students' limited experience in conducting reflective evaluation. These findings suggest that peer and self-assessment capture students' perspectives through group interaction and personal reflection; however, both remain susceptible to bias, particularly when students are not yet accustomed to evaluating based on clear and consistent criteria (Biesma et al., 2019; Brown & Harris, 2014; Topping, 2017).

Table 7
Wilcoxon test between assessment methods.

Assessment Comparison	Test Statistic	Asymp. Sig.	Interpretation
PA x TA	Wilcoxon	0,046	Significantly Different
SA x TA	Wilcoxon	0,005	Significantly Different
PA x SA	Wilcoxon	0.126	Not Significantly Different

Note: PA = Peer Assessment, TA = Teacher Assessment, SA = Self-Assessment

Findings from teacher interviews further support this interpretation, revealing that students were not yet accustomed to self-assessment, leading to less objective reflection. This reinforces the notion that self-assessment requires external validation to ensure its reliability (Brown & Harris, 2014). In line with this, Oren (2018) found that self- and peer-assessment demonstrate an adequate level of agreement with teacher assessment, indicating that both can serve as viable alternatives for evaluating student performance. Therefore, integrating self-, peer-, and teacher assessment is essential for obtaining a more balanced and comprehensive understanding of students' contributions, particularly in problem-based group work that culminates in a model product. In contrast, the comparison between peer and self-assessments showed no statistically significant difference (Asymp. Sig. (2-tailed) = 0.126, $p > 0.05$), indicating relative consistency between the two methods. This similarity may stem from the shared experiential basis of the two assessments, as students evaluate contributions within the same collaborative context, including both the planning and implementation phases of the project. However, consistency between peer and self-assessment does not necessarily imply accuracy. Both methods remain susceptible to bias, particularly when students are influenced by social relationships or hesitate to provide critical evaluations (Biesma et al., 2019). Consequently, teacher guidance plays a crucial role in ensuring that assessments are based on clear criteria and honest reflection. The findings indicate that while peer and self-assessments are relatively consistent, both differ significantly from teacher assessment and may lack objectivity; therefore, combining all three methods with proper guidance is essential to achieve a more accurate and comprehensive evaluation of students' contributions (Li et al., 2016; Mumpuni et al., 2022).

Table 8
Students' responses toward the use of peer and self-assessment.

Questionnaire Indicator	Assessment Method	Response	
		Positive	Negative
Relevance of assessment to students' contribution	Peer Assessment	86%	14%
	Self-Assessment	90%	10%
Students' interest in the assessment methods	Peer Assessment	87%	13%
	Self-Assessment	92%	8%

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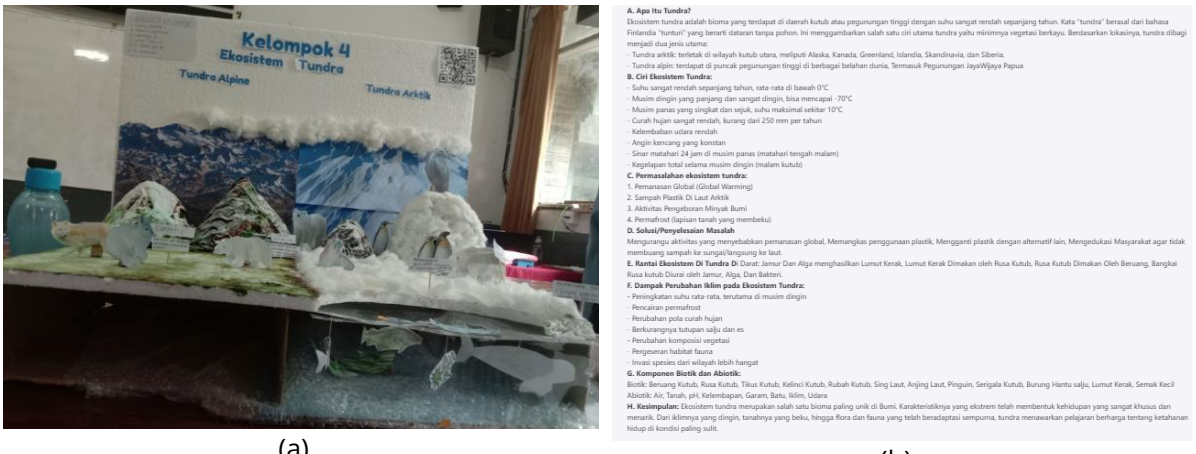
The survey analysis revealed that the majority of students expressed positive responses regarding the use of peer and self-assessment in evaluating their contributions to the ecosystem model project. Specifically, 86% of students agreed that peer assessment is relevant for assessing individual contributions within the group, while 90% shared the same view regarding self-assessment. Students perceived that both assessment types helped them recognize the importance of individual roles and responsibilities in group success. For instance, student PX13 commented, "*The assessment was fun and made us more aware*," while PX53 stated that it made them "*more reflective of the roles I had performed.*" These findings align with Ndoye (2017) and Adesina et al. (2023), who suggested that peer and self-assessment foster responsibility and ownership in collaborative tasks. Students also noted that these methods facilitate the assessment process by making it more objective and transparent. Student PX33 remarked, "*It's easier to evaluate our group now*," and LX55 added that they assessed peers and themselves "*based on the tasks that had been agreed upon*." Nonetheless, some students acknowledged potential errors or biases in self-assessment, indicating the need for practice and training to improve accuracy (Li et al., 2016; Sinaga et al., 2024). Incorporating a justification or rationale for each score was recommended to deepen student reflection.

Furthermore, students perceived that peer and self-assessment enhanced fairness compared to teacher-only evaluation, as group members better understood each other's contributions. PX42 stated, "*Peer assessment helps, so you can point out if someone isn't contributing*," while PX33 added that the method allowed them to provide evaluation without direct confrontation. This supports findings by Ion et al. (2024), who reported that these methods increase the perception of fairness in group work.

Interest in applying these assessment methods was also high, with 87% of students showing interest in peer assessment and 92% in self-assessment. Most students indicated that these methods made group work more meaningful, enjoyable, and collaborative. LX55 commented, "It's very fun, we help each other and share ideas," and LX24 added, "*It's very enjoyable to work together effectively*." Awareness that their contributions would be evaluated encouraged students to be more active and responsible for their tasks. PX22 emphasized, "*The group could cooperate and strive to complete the project as a team*." These findings support Ndoye (2017), who found that student engagement in group work increases when the benefits and fairness of peer and self-assessment are clearly understood.

Figure 3

Example of a student-created ecosystem model (a) and a screenshot of the QR-code-linked digital module (b), which contains explanations of ecosystem characteristics, identified problems, causes, impacts, and proposed solutions.



(a) (b)

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Figure 3 presents an example of a student-created ecosystem model representing a tundra ecosystem, including both alpine tundra and Arctic tundra. The model illustrates biotic components such as penguins, polar bears, and seals. As well as abiotic components, including snow, rocks, and low temperatures. Interactions among ecosystem components are indicated by arrows, accompanied by brief explanations to clarify their nature. An environmental issue, namely global warming, is also represented in the model; however, its visual depiction is relatively small compared to other components. A QR code is attached to the model and can be scanned to access a digital module. The module provides a more comprehensive explanation of ecosystem characteristics, component interactions, and environmental problems, including their causes, impacts, and proposed solutions. This integration enables the model to represent both visual and conceptual aspects of students' understanding.

CONCLUSION

This study found notable differences in how students and teachers perceived contributions to the ecosystem model project. Self-assessment produced the highest scores, followed by peer assessment, with teacher assessment the lowest, indicating that students tend to rate themselves and their peers more generously than teachers do. Interviews revealed that self-assessments were shaped by positive bias and self-confidence, while teacher assessments reflected objective observation. Peer assessment captured contributions occurring outside the teacher's view, offering a complementary perspective. These findings suggest that no single method fully captures student contributions. A combined approach integrating teacher, peer, and self-assessments provides a more holistic and accurate evaluation. To be effective, students require training in objective criteria, reflective justification, and honest evaluation. Beyond enriching teachers' data, peer and self-assessment also strengthen students' social, reflective, and collaborative skills in project-based learning. Their implementation is therefore recommended, supported by training and habituation to ensure that student evaluations become increasingly accurate and meaningful.

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