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From Exploration to Reflection: STEAM Assisted by Performance Assessment to Strengthen High School Students' Reflective Thinking in Biology Learning

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Abstract

The urgency of this research lies in the need to strengthen high school students' reflective thinking skills in biology learning through STEAM assisted by performance assessment. Reflective thinking is an essential competency in biology learning. However, preliminary findings indicated that this ability remained low among high school students, as students tended to rely on rote learning without critically interpreting their learning experiences, making it difficult for them to achieve a deep conceptual understanding. Therefore, a STEAM learning approach assisted by performance assessment, integrating five disciplines, was implemented. This study aimed to analyze the effect and contribution of the STEAM approach assisted by performance assessment on the reflective thinking skills of Grade X students in biology learning, particularly on the topic of ecosystem components and their interactions. Three classes were selected through cluster random sampling: X 5 (Study I, n = 33), X 7 (Study II, n = 34), and X 9 (Study III, n = 33). The instruments consisted of a reflective thinking essay test and a Reflective Thinking Scale questionnaire. The results showed a significant effect of the STEAM approach assisted by performance assessment on reflective thinking skills, as indicated by the Wilcoxon Signed-Rank Test ($p = 0.000 < 0.05$). The STEAM approach assisted by performance assessment also contributed to reflective thinking skills, as examined using Spearman's rank correlation and subsequently squared to obtain the coefficient of determination (R^2). The contribution was 58.2%, with a correlation coefficient of 0.763, while the remaining 41.8% was attributed to other factors. Thus, the STEAM approach assisted by performance assessment can serve as an effective learning alternative for strengthening students' reflective thinking skills.

Keywords: *Performance Assessment, Reflective Thinking, Ecosystems And Their Interactions, Steam Approach.*

Introduction

Reflective thinking skills are among the higher-order thinking skills that are important for students to master in the 21st century. These skills enable learners to critically evaluate their learning experiences, relate new knowledge to prior knowledge, and make decisions based on careful consideration. In the era of Society 5.0, technological developments such as Artificial Intelligence (AI) have fundamentally changed the way humans interact with the world. Technology no longer functions merely as a tool but has become an integral component of human life across various sectors, including health, the economy, and education. The integration of technology and social life is directed toward creating human-centered solutions so that technological advances can benefit all levels of society equitably (Aisyah et al., 2025).

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Society 5.0 is a concept of a future society that positions technology as a key instrument for addressing various social challenges. Unlike the previous era, which focused more heavily on industrial efficiency, Society 5.0 emphasizes the integration of technological advancement with human values. Thus, technology functions not only as a means of production but also as a practical solution to problems faced by society (Ferianto et al., 2024). In this era, individuals are expected to continuously update their knowledge and improve their competencies in response to rapid and dynamic technological development.

These demands have major implications for education. Educational systems need to transform in order to produce students who not only master subject content but also possess critical, collaborative, and reflective thinking skills to respond to change. In this context, the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach is relevant as a response to the demands of Society 5.0. By integrating these five disciplines, STEAM is designed to equip students with comprehensive competencies, encourage creative and innovative solutions to real-world problems, and prepare a generation capable of contributing to societal progress in an era of continually evolving technology (Wilson et al., 2021; Leavy et al., 2023)

The reflective thinking as a mental process involving observation, analysis, evaluation, and reconsideration of an experience or information in order to develop a more meaningful understanding (Mohamed et al., 2022). In biology learning, reflective thinking is particularly important because students encounter complex natural phenomena that require in-depth scientific analysis (Hayati et al., 2023). Biology learning therefore involves not only mastery of concepts but also the ability to understand relationships among living components, explain biological phenomena, and solve environmental problems. One topic that requires strong reflective thinking skills is ecosystems and their interactions.

Based on preliminary observations conducted at Al-Kautsar High School, Bandar Lampung, the reflective thinking skills of Grade X students in biology learning were still relatively low. This was evident in students' limited ability to explain biological phenomena logically, analyze ecological problems, and connect learning concepts with real situations in their surrounding environment. Students tended to rely on information delivered directly by teachers rather than exploring knowledge independently. Consequently, the learning process was not yet optimal for developing higher-order thinking skills (Portuna & Hasruddin, 2025).

One learning approach considered relevant to the demands of 21st-century education is Science, Technology, Engineering, Arts, and Mathematics (STEAM). STEAM is an extension of STEM that incorporates the arts to enhance students' creativity, innovation, and multidisciplinary thinking. This approach integrates five disciplines within contextual and problem-solving-oriented learning experiences. STEAM enables students to construct understanding actively through observation, experimentation, solution design, and evaluation of outcomes. Through this approach, students are encouraged to examine problems from multiple perspectives and develop solutions based on the integration of several disciplines (Cahyani, 2021).

In addition to the learning approach, assessment plays an important role in supporting the development of students' reflective thinking skills. One relevant form is performance assessment. Performance assessment evaluates students' abilities through their actual performance in completing tasks or learning activities. This form of assessment enables teachers to evaluate both the learning process and learning outcomes more authentically (Kusumawati et al., 2021). The previous studied state that the use of performance assessment

within a STEAM approach can help students demonstrate reflective thinking skills through activities such as observation, experimentation, presentation, discussion, and project completion (Kurniasih et al., 2020). Thus, assessment is not limited to measuring final learning outcomes but can also be used to evaluate students' thinking processes comprehensively.

Previous studies have shown that the STEAM approach can improve higher-order thinking skills. For example, reported that STEAM-based learning can enhance students' problem-solving skills, critical thinking, creativity, and collaboration (Azizah et al. 2023). However, research specifically examining the effect of a STEAM approach assisted by performance assessment on reflective thinking skills in biology learning, particularly on ecosystem topics, remains limited. Although substantial research has investigated STEAM and performance assessment separately, studies integrating a STEAM approach with performance assessment to develop Grade X students' reflective thinking skills in biology, particularly on ecosystem components and their interactions, are still scarce. Therefore, this study aimed to analyze the effect and contribution of the STEAM approach assisted by performance assessment on the reflective thinking skills of Grade X students in biology learning.

The novelty of this study lies in integrating STEAM learning with performance assessment to strengthen high school students' reflective thinking in biology learning. Unlike previous STEAM studies that mainly focus on creativity, problem-solving, and product development, this study emphasizes the transition from exploration to reflection by using performance assessment to capture both students' learning processes and outcomes. This integration provides a novel approach to developing students' ability to critically examine, evaluate, and learn from their experiences during authentic biology learning activities.

Method

This study employed a quantitative approach with a pre-experimental method to analyze the effect of the Science, Technology, Engineering, Arts, and Mathematics (STEAM) approach assisted by performance assessment on students' reflective thinking skills in biology. A quantitative approach was selected because the study focused on measuring the effect and contribution of the treatment through numerical data and statistical analysis. The study used a One-Group Pretest-Posttest Design, in which one sample group completed an initial test (pretest), received the treatment, and then completed a final test (posttest). This design enabled comparison of students' reflective thinking skills before and after implementation of the STEAM approach assisted by performance assessment. The study specifically examined Grade X students' reflective thinking skills in biology learning on the topic of ecosystem components and their interactions.

The study was conducted at Al-Kautsar High School, Bandar Lampung, during the second semester of the 2025/2026 academic year. The population comprised all Grade X students, totaling 424 students. Three classes were selected as samples using cluster random sampling, yielding a total of 100 students. All three selected classes served as research classes and received the same treatment. Cluster random sampling was used because the research subjects were organized in naturally occurring groups on a relatively large scale (Susanti, 2019). The research process consisted of three stages: the pre-research stage, the research stage, and the post-research stage. The sequence of research activities is presented in Figure 1.

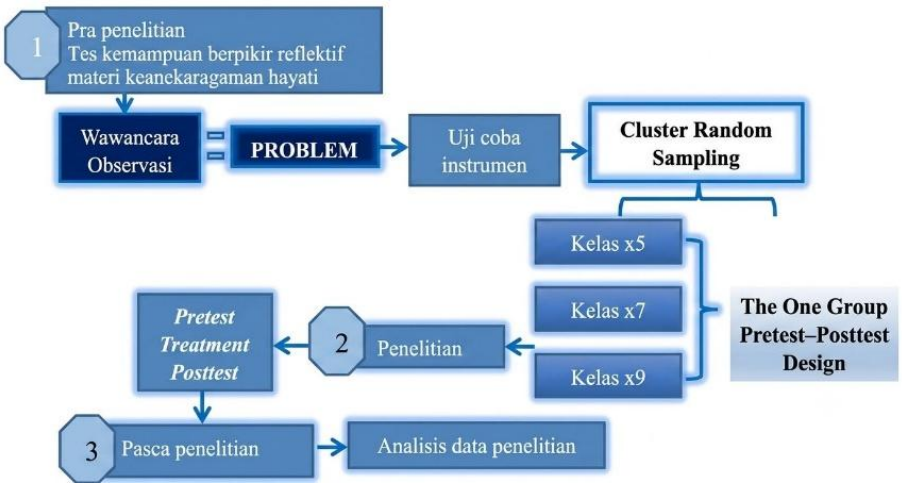

Figure 1. *Research Flow*

The independent variable in this study was the STEAM approach assisted by performance assessment, while the dependent variable was students' reflective thinking skills. The STEAM approach integrates Science, Technology, Engineering, Arts, and Mathematics within a series of student-centered learning activities. Through this approach, students participated in observation, problem identification, solution design, product creation, and presentation of learning outcomes. Performance assessment was used to evaluate students' learning processes and outcomes authentically based on activities performed during learning (Tanfiziyah et al., 2022). The combination of STEAM and performance assessment was expected to encourage students to think more critically and reflectively and to connect learning concepts with real-life problems.

Data were collected using a reflective thinking essay test, a Reflective Thinking Scale questionnaire, and performance-assessment rubric data from students' practical activities. The reflective thinking essay test was administered before and after the treatment to identify changes in students' abilities. Likewise, the questionnaire was administered before and after the treatment. Performance assessment was used to evaluate students' performance during a mini-terrarium practicum as a direct learning activity on ecosystem topics involving thinking skills, problem solving, and presentation of work results.

Table 1. *Reflective Thinking Ability Essay Test Grid*

No.	Indicator	Maximum Score	Item Number
1	Habitual Action	4	1.6
2	Understanding	4	5, 7, 10
3	Reflection	4	4, 8, 9
4	Critical Reflection	4	2, 3

As shown in Table 1, the reflective thinking essay test was developed based on four indicators: habitual action, understanding, reflection, and critical reflection. Each indicator had a maximum score of 4, with item allocation adjusted to the corresponding indicator so that the instrument could measure students' reflective thinking skills systematically.

Table 2. *Reflective Thinking Ability Essay Test Grid*

Indicator	Statement Type				Statement Number		Number of Statements
	Positive (+)	Value	Negative (-)	Value	Positive (+)	Negative (-)	
Habitual Action	SS	4	SS	1	2, 7, 15.16, 28	11, 13, 18, 29, 38,	10
	S	3	S	2			
	TS	2	TS	3			
	STS	1	STS	4			

Indicator	Statement Type				Statement Number		Number of Statements
	Positive (+)	Value	Negative (-)	Value	Positive (+)	Negative (-)	
Understanding	SS	4	SS	1	1, 12, 17, 23, 35	10, 19, 27, 33, 36,	10
	S	3	S	2			
	TS	2	TS	3			
	STS	1	STS	4			
Reflection	SS	4	SS	1	4, 9, 30, 32, 37,	3, 5, 22, 25, 31,	10
	S	3	S	2			
	TS	2	TS	3			
	STS	1	STS	4			
Critical Reflection	SS	4	SS	1	20, 21 26, 34, 40,	6, 8, 14, 24, 39,	10
	S	3	S	2			
	TS	2	TS	3			
	STS	1	STS	4			

Before being used in the study, the research instruments underwent expert validation to ensure the suitability of their content, indicators, and measurement objectives. Validation was conducted to ensure that the instruments appropriately measured the research variables and produced reliable data. The validity test results indicated that all essay-test items were valid. For the Reflective Thinking Scale, 12 statements were found to be invalid; therefore, only 28 statements were used. The scale was adapted from (Fu & Hali, 2025).

Data were analyzed using IBM SPSS Statistics version 26. The analysis began with a normality test using the Kolmogorov-Smirnov test to determine whether the data were normally distributed. Because the normality test indicated that the data were not normally distributed, N-Gain analysis was subsequently conducted to determine the level of improvement in students' reflective thinking skills after learning through the STEAM approach assisted by performance assessment. Hypothesis testing was conducted using the One-Sample Wilcoxon Signed-Rank Test as a non-parametric test to determine the significance of the treatment effect on students' reflective thinking skills. In addition, Spearman's rank correlation was used to determine the contribution of the STEAM approach assisted by performance assessment to students' reflective thinking skills, expressed through the coefficient of determination (R^2) as a percentage. The use of Spearman's rank correlation was based on the non-normal distribution of the data. The decision criterion was based on the significance value: if Sig. < 0.05, H_0 was rejected and H_1 was accepted, indicating a significant effect of the STEAM approach assisted by performance assessment on students' reflective thinking skills.

Results

This study involved three research classes: X 5 as Research Class I, X 7 as Research Class II, and X 9 as Research Class III. All three classes received learning through the STEAM approach assisted by performance assessment to foster students' reflective thinking skills. Performance assessment functioned as an authentic evaluation tool that directly measured students' abilities through demonstrated learning processes and outcomes, enabling a comprehensive description of the development of students' reflective thinking during learning. The indicators of reflective thinking were habitual action, understanding, reflection, and critical reflection. The STEAM approach adopted the five learning: observation, new idea, innovation, creativity, and society. The learning activities are presented in Table 3.

Table 3. *Learning Activity Process*

STEAM Stages	Learning Activities	The Relationship of STEAM with Reflective Thinking (Kember)
Observation 	Teachers direct students to read literacy and literacy before entering learning activities. Teachers present visual stimuli in the form of visualizations of ecosystems (rice fields, forests, lakes, seas) and their biotic-abiotic components, videos of interaction phenomena between ecosystem components (symbiosis, competition, predation), and infographics on Energy Pyramids and Food Chains. Students observe, identify patterns of relationships between components, predict the impact of changes in abiotic variables, and analyze the efficiency of energy flow between trophic levels through real-world case discussions in the surrounding environment.	Activities of observing various visual stimuli (ecosystem visualization, interaction videos, energy pyramid infographics) and literacy activities at the beginning of learning to practice Habitual Action and Understanding, students build habits of processing information regularly while constructing a new conceptual understanding of the components, interactions, and energy flows of the ecosystem from each stimulus presented..
New Idea 	The teacher presented a video of making a mini terrarium to facilitate smartphone-based information search, asked hypothetical questions related to changes in ecosystem conditions, and presented the case of the Aceh-Sumatra flood disaster as an example of ecosystem imbalance. Students collaboratively synthesize information, reinterpret concepts using their own language, map food chains in terrariums, and formulate ideas for preventing damage to micro-macro-scale ecosystems	Activities of exploring information collaboratively, reexplaining concepts using their own language, responding to hypothetical questions about changing ecosystem conditions, and analyzing real disaster cases practicing Understanding and Reflection, students not only verify conceptual understanding, but also begin to consider the interconnectedness between components, evaluate the consequences of change, and connect scientific knowledge with real-life contexts..
Innovation (Assessment of Discussion Dynamics (LDPD)) 	Teachers give LDPD tasks ecosystem components. Students discuss in groups, exchange arguments, and estimate the proportion of terrariums, then present the results of the analysis in a plenary session to get critical responses between groups. The observer assesses the performance of the discussion using the assessment rubric that has been determined.	Group discussions through LDPD and plenary presentations train students to evaluate arguments, consider different points of view, and integrate critical perspectives from other groups. Solving problems related to the proportions of terrarium materials and responding to the critical responses of fellow groups encourages Critical Reflection, where learners test assumptions, identify design weaknesses, and build solutions based on stronger scientific arguments.
Creativity (Practicum Performance Assessment (LKPD)) 	The teacher gave the LKPD task of interaction between ecosystem components as a practicum guide for making mini terrariums. Students design sketches, construct the terrarium gradually from the drainage layer to specimen planting, and discuss LKPD questions while monitoring the product. The observer assesses the performance of the practicum using the assessment rubric.	Construction of the terrarium gradually while discussing the LKPD questions practicing Reflection, learners integrate conceptual knowledge into practical actions and reflect on the obstacles encountered.

STEAM Stages	Learning Activities	The Relationship of STEAM with Reflective Thinking (Kember)
Society 	The teacher guides students to connect the concept of energy flow with the issue of food security and sustainable agriculture. Group representatives presented a synthesis of the results of the discussion, then students designed a digital poster with the theme of ecosystem energy balance as an environmental campaign on class social media. The activity ended with post-test work in the form of an essay test and a reflective thinking ability questionnaire as the final evaluation of learning	A synthesis presentation and discussion of the linkage between energy efficiency and food security trained Reflection, students communicate and integrate understanding into a broader social context. The creation of digital posters of environmental campaigns and post-test work encourage Critical Reflection, students articulate changes in perspective openly, evaluate the implications of ecological knowledge for people's lives, and demonstrate the depth of reflective thinking that develops during a series of learnings.

The STEAM learning activities were supported by performance-assessment tasks, including discussion performance tasks using LDPD and practicum performance tasks using LKPD. The problems presented in these tasks were contextual and based on real phenomena, requiring students to analyze, identify, and systematically design solutions. In this way, students' reflective thinking skills could be stimulated and developed through meaningful learning experiences. An example of the performance-assessment task used in this study is presented below.

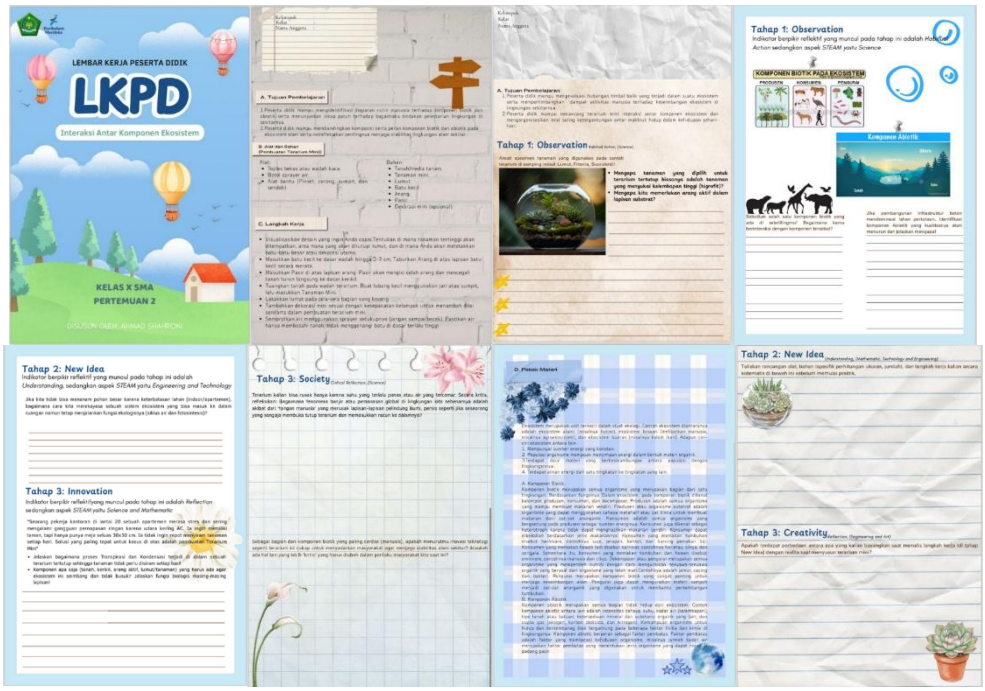

Figure 2. *Performance Assessment Task*

The use of LDPD and LKPD at several stages of STEAM learning illustrates the role of performance assessment in the learning process. One form of performance assessment applied in this study was oral feedback, through which the teacher provided clarification, valuation, attention, suggestions, and appreciation. An example of the application of oral feedback in this study is presented below.

Table 4. *Application of Oral Feedback*

Performance	Examples of Oral Feedback
Mini-Terrarium Practicum (LKPD)	The teacher divides students into five groups to discuss the problems and answer the questions in the LKPD, and then provides oral feedback. Oral feedback dialogue: Teacher: "I see that you selected a narrow-mouthed jar and placed a thick layer of charcoal at the bottom. Can you explain why you chose this design and layer?" (Clarification) Student: "I chose a jar with a small opening and enough charcoal so that water filtration in the terrarium would be more effective, Sir." Teacher: "That is correct. I appreciate the way you considered the function of charcoal in relation to the water in the mini terrarium." (Valuation) Teacher: "You can explain it in greater depth. Charcoal is indeed related to water quality in the terrarium. If no charcoal is used, or if too little is used, the water at the bottom of the jar may become odorous and mold may grow because air circulation is limited. Also consider your choice of a narrow-mouthed jar. Aesthetically, it is attractive, but you should also think about the water-evaporation cycle. How will oxygen enter, or how will you control humidity if the opening is very small?" (Attention) Teacher: "My suggestion is to use a jar with a wider opening and add a sufficient amount of charcoal to improve the likelihood of successfully constructing the terrarium." (Suggestion) Student: "Yes, Sir. Thank you for the advice and feedback. We will improve it." Teacher: "I am proud of the result you have produced. Reusing a jar is a simple form of waste utilization, and the artistic decoration you created is also commendable." (Appreciation)

Based on the study, the recapitulation of essay-test scores and Reflective Thinking Scale questionnaire results for Grade X students at Al-Kautsar High School, Bandar Lampung, is presented in Table 5.

Table 5. *Recapitulation of Reflective Thinking Skills Results*

No.	Indikator	Percentage	Criteria
1	Habitual Action	64.38	Fairly Good
2	Understanding	63.47	Fairly Good
3	Reflection	64.74	Fairly Good
4	Critical Reflection	65.78	Fairly Good

Table 5 shows that the reflective thinking skills of Grade X students at Al-Kautsar High School, Bandar Lampung, were categorized as fairly good across all measured indicators. Critical reflection obtained the highest percentage at 65.78%, followed by reflection at 64.74% and habitual action at 64.38%. Understanding obtained the lowest percentage at 63.47%. The combined analysis of the essay-test and questionnaire indicators is presented in Figure 2.

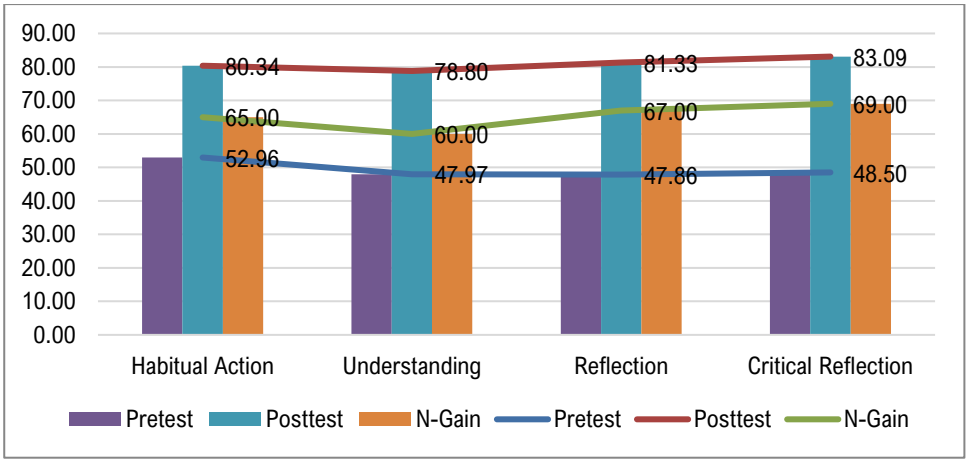

Figure 3. *Reflective Thinking Ability Indicator Analysis*

Figure 3 shows that the N-Gain scores for all four indicators were in the moderate category. The highest score was found for critical reflection at 69%. This indicates that students reached the highest level of reflective thinking. This finding is consistent with the previous studied, who explain that critical reflection represents a deeper level of reflection in which learners consciously examine the reasons underlying how they perceive, think, feel, or act (Kenari & Subiantoro, 2023). Critical reflection involves analyzing, reviewing, and questioning experiences within the broader context of an issue or phenomenon and may lead to changes in students' perspectives regarding fundamental beliefs and conceptual understanding of a particular phenomenon. The results of the reflective thinking essay-test analysis for the three research classes are presented below.

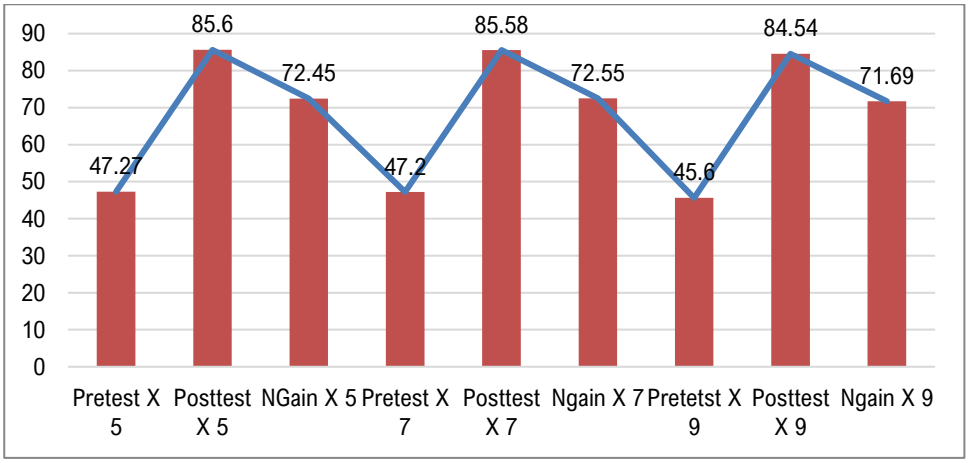

Figure 4. *Analysis of the Average Reflective Thinking Essay-Test Scores*

Based on Figure 4, all research classes showed consistent improvement in reflective thinking skills as indicated by their N-Gain scores. Research Class I obtained an N-Gain score of 72.45%, Research Class II obtained 72.55%, and Research Class III obtained 71.69%. Overall, all three classes were categorized as high. The average Reflective Thinking Scale questionnaire results for each research class are presented below.

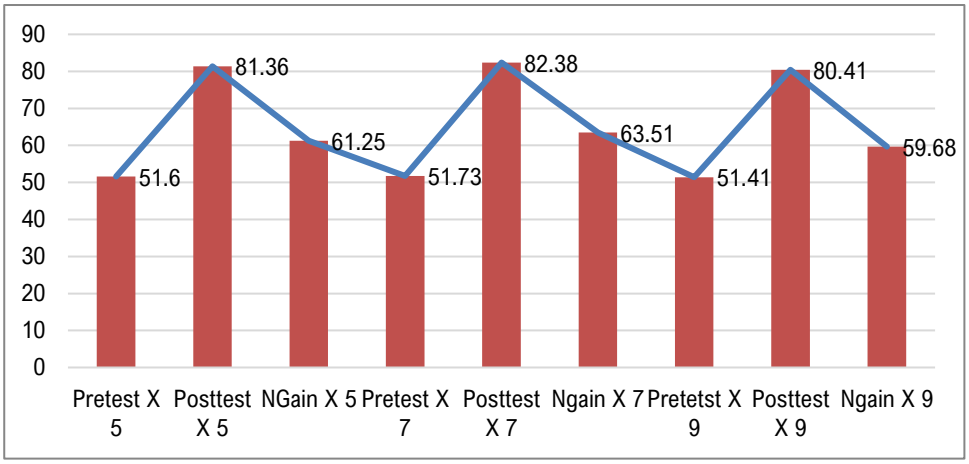

Table 5. *Average Reflective Thinking Scale Questionnaire Results*

Research Class II obtained an N-Gain score of 63.51%, followed by Research Class I at 61.25% and Research Class III at 59.68%; all three were categorized as moderate. After implementation of the STEAM approach assisted by performance assessment, improvement in students' reflective thinking skills across the three research classes was examined using the One-Sample Wilcoxon Signed-Rank Test, as presented in the following table.

Table 6. *Hypothesis Testing and Non-Parametric Contribution Analysis*

No.	Test Name	Results
1	One-Sample Wilcoxon Signed Rank Test	0.000
2	Spearman's Rho	0.763
3	Coefficient of Determination (R^2)	0.582

The results of the One-Sample Wilcoxon Signed-Rank Test indicated that the STEAM approach assisted by performance assessment had a significant effect on the reflective thinking skills of Grade X students in biology. The analysis was then continued to examine the contribution of the STEAM approach assisted by performance assessment to Grade X students' reflective thinking skills.

As shown in Table 6, the Spearman's rho correlation coefficient was 0.763 with a Sig. (2-tailed) value of 0.000. Because the significance value was less than 0.05 (0.000 < 0.05), H_0 was rejected and H_1 was accepted, indicating a significant relationship between practicum scores and the N-Gain of students' reflective thinking skills. The correlation coefficient of 0.763 falls within the strong correlation category, indicating that higher practicum scores were associated with greater improvement in reflective thinking skills. This finding is supported by the previous studied, who states that practicum-based learning provides students with opportunities to apply science-process skills in biology, thereby encouraging more meaningful higher-order thinking processes (Suryaningsih, 2017).

Furthermore, the coefficient of determination (R^2) was obtained by squaring the correlation coefficient: $0.763^2 = 0.582$, or 58.2%. This indicates that the STEAM approach assisted by performance assessment contributed 58.2% to the improvement of students' reflective thinking skills, while the remaining 41.8% was associated with other factors not examined in this study, such as learning motivation, learning style, and the learning environment. These findings are consistent with the previous studied, who showed that problem-oriented project-based learning using PEKERTI worksheets significantly improved biology students' reflective thinking skills (Suhaiba et al., 2024). Similarly with the previous studied found that learning models that encourage learners to analyze real issues in biology can effectively improve reflective thinking skills (Hayati et al., 2023).

Discussion

The findings showed that the STEAM approach assisted by performance assessment had a significant effect on the reflective thinking skills of Grade X students in biology. This was demonstrated by the non-parametric One-Sample Wilcoxon Signed-Rank Test, which produced a significance value of 0.000, lower than 0.05. Accordingly, H_0 was rejected and H_1 was accepted, indicating a significant effect of learning through the STEAM approach assisted by performance assessment. This significant effect is closely related to the characteristics of the STEAM approach, which integrates Science, Technology, Engineering, Arts, and Mathematics within a series of student-centered learning activities. Through this approach, students actively engage in observation, problem identification, solution design, and presentation of learning outcomes, all of which can stimulate reflective thinking skills (Thapaliya, 2023). Emphasized that a STEAM approach combined with project-based learning can encourage learners to think more critically and reflectively because it involves authentic and contextual problem-solving processes (Cahyani, 2021).

Reflective thinking is a learner's ability to apply prior knowledge to solve new problems (Hayati et al., 2023). Reflective thinking skills can improve when students engage in learning

that develops problem-solving abilities (Kirana et al., 2024). This is consistent with the previous studied, who highlight that reflective thinking in mathematics includes students' ability to explore relationships among concepts while engaging in problem solving and problem discovery (Hatisaru, 2023). Through reflection, students can therefore develop their thinking by connecting previously acquired knowledge with new problem-solving experiences. Reflective thinking is consequently an important ability for achieving meaningful learning outcomes.

The use of performance assessment as an evaluation instrument in this study also supported the development of students' reflective thinking skills. Performance assessment allows learners to demonstrate their abilities directly through authentic activities so that their thinking processes can be observed and evaluated. The previous studied states that performance assessment in science learning can increase work productivity and encourage students to engage actively in higher-order thinking (Irawati, 2021). The performance assessment applied in laboratory-based science learning had a positive effect on learning outcomes and students' thinking skills (Hartina et al., 2020).

The performance-assessment tasks used in this study consisted of two forms: a discussion task using LDPD and a practicum task using LKPD. Both tasks were designed around contextual problems based on real ecosystem phenomena, requiring students to actively analyze, evaluate, and reflect on their learning experiences. The previous studied reported that performance assessment in biology practicum activities can significantly improve students' science-process skills (Purnawati et al., 2020). This suggests that authentically designed practicum tasks provide meaningful learning experiences that encourage the development of reflective thinking skills (Kurniasari & Fauziah, 2022). The further reported a close relationship between students' reflective thinking skills and self-confidence, indicating that internal learner factors also contribute to the level of reflective thinking (Prisila et al., 2021).

Conclusion

Based on the results and discussion, the STEAM approach assisted by performance assessment had a significant effect on the reflective thinking skills of Grade X students in biology, as indicated by the One-Sample Wilcoxon Signed-Rank Test significance value of 0.000 (< 0.05) across the three research classes. In addition, the STEAM approach assisted by performance assessment contributed 58.2% to the improvement of students' reflective thinking skills, based on the Spearman's rank correlation coefficient of 0.763. Thus, the STEAM approach assisted by performance assessment was shown to be an effective learning strategy for supporting the development of students' reflective thinking skills. This study was limited by its pre-experimental one-group pretest-posttest design without a control class; therefore, generalization of the findings should be made cautiously. In addition, the study was conducted only on the topic of ecosystem components and their interactions in Grade X, and therefore does not represent all biology topics.

Acknowledgment

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