Examining the 5E Learning Cycle via Market Place Activity on Students' Scientific Reasoning in Grade VII Science Learning

Syarifatun Nisa, Riezky Maya Probosari*, Muhammad Nur Hudha, Annisa Nur Khasanah, Supurwoko

Universitas Sebelas Maret, Surakarta, Indonesia
*Corresponding author, email: riezkymprobosari@staff.uns.ac.id

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Abstract
Scientific reasoning is a high-level thinking skill essential in science learning that needs to be developed through active, student-centered learning. This study aims to analyze the differences in scientific reasoning between students engaged in the 5E learning cycle integrated with market place activity and those taught using direct instruction on the topic of living organism classification. A quantitative approach with a quasi-experimental method and a pretest-posttest control group design was employed. The population comprised 255 seventh-grade students at State Junior High School X, Surakarta, in the 2025/2026 academic year. Using cluster random sampling, Class VII G was selected as the experimental group with 31 students and Class VII F as the control group with 32 students. The experimental group received 5E learning cycle instruction through market place activity, while the control group received direct instruction. Primary data were collected using 20 two-tier multiple-choice items measuring Lawson's six scientific reasoning indicators. Data were analyzed using ANCOVA with pretest scores as a covariate and N-Gain for improvement. ANCOVA showed a significant difference between groups, with a p-value below 0.001 and a partial eta squared of 0.354. The experimental group had an adjusted mean score of 75.414, with a 95 percent confidence interval from 71.407 to 79.420, compared with 59.287, with a 95 percent confidence interval from 55.343 to 63.230, in the control group. N-Gain was 0.60 for the experimental group and 0.33 for the control group, both categorized as medium. These findings indicate that the experimental group achieved higher scientific reasoning scores after controlling for pretest performance.

1. Introduction

Science learning in the 21st century is not only oriented toward concept mastery, but also toward the development of higher-order thinking skills, one of which is scientific reasoning. Scientific reasoning encompasses the ability to identify scientific problems, formulate questions and hypotheses, generate evidence through modeling or experimentation, and evaluate scientific claims (Krell et al., 2022). Scientific reasoning is an essential skill required to meet the demands of 21st-century learning. This skill comprises a series of interrelated cognitive processes that serve as a foundation for supporting the science learning process. Scientific reasoning plays a vital role in science education, particularly in supporting academic achievement and problem-solving. Van Vo & Csapó (2023) revealed that scientific reasoning is a significant predictor of STEM achievement across various grade levels. Consequently, developing this skill is critical to helping students build scientific understanding and solve science-based problems.

The nature of science comprises four main interrelated elements: attitudes, processes, products, and applications (Suryandai et al., 2022). These four elements indicate that science learning emphasizes not only knowledge mastery, but also the development of process skills, the formation of scientific attitudes, and the application of knowledge in real-life contexts. Furthermore, these four elements support the development of students' scientific reasoning. A scientific attitude fosters curiosity and openness to evidence, whereas the scientific process involves activities such as formulating hypotheses, making predictions, controlling variables, analyzing evidence, and drawing conclusions based on investigation results. In addition, science products and applications assist students in analyzing concepts and applying them across various real-world contexts. Thus, developing scientific reasoning is essential to achieving science learning that aligns with the nature of science. The development of scientific reasoning requires instruction that provides opportunities for students to actively engage in the processes of investigation, information processing, and evidence-based decision-making.

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Therefore, applying relevant, student-centered learning models is necessary to ensure that the learning process not only yields conceptual mastery but also develops scientific reasoning in accordance with the demands of 21st-century science education.

Although scientific reasoning is closely related to the nature of science and essential to be developed through scientific inquiry processes, this ideal condition is not yet fully reflected in school science instruction. Based on interviews and observations at State Junior High School X, Surakarta, the implementation of science learning has not fully optimized student-centered learning approaches. Teachers deliver material in a structured manner through direct explanations, thereby limiting opportunities for students to engage in exploration, discussion, and inquiry. Consequently, students' opportunities to conduct activities related to scientific reasoning such as formulating hypotheses, identifying variables, and making predictions remain limited. These activities constitute integral components of the cognitive processes required to develop scientific reasoning. This situation highlights the need to implement learning models that provide broader opportunities for students to participate in investigative processes and cultivate scientific reasoning.

One learning model with the potential to support the development of scientific reasoning is the 5E learning cycle. This model comprises five stages: engagement, exploration, explanation, elaboration, and evaluation (Bybee et al., 2006). Each stage serves a distinct function in guiding students to engage in the learning process, ranging from activating prior knowledge and conducting exploration to constructing explanations, applying knowledge, and evaluating understanding. These characteristics provide opportunities for students to become actively and cognitively involved in constructing understanding and integrating existing knowledge with newly learned concepts (Ruiz-Martín & Bybee, 2022). Furthermore, the characteristics of each stage in the 5E learning cycle closely align with activities that support the development of scientific reasoning. During the engagement stage, students are guided to identify phenomena or problems and relate them to prior knowledge. The exploration stage provides students with opportunities to conduct investigations through predicting, formulating hypotheses, identifying variables, and collecting as well as analyzing data. Next, in the explanation stage, students utilize investigation findings and gathered evidence to build explanations. The elaboration stage offers opportunities to apply concepts and reasoning to new situations, while the evaluation stage encourages students to assess their understanding based on evidence and investigation results. Thus, the sequence of the 5E learning cycle stages can provide learning experiences that foster student engagement in scientific reasoning processes.

Previous research has examined the implementation of the 5E learning cycle to develop scientific reasoning through various learning support materials, such as multidimensional thinking diagram-based worksheets, three-dimensional thinking graphs, and multi-representation-based e-worksheets (Ristia et al., 2023; Setiyawati et al., 2023; Wulandari et al., 2024). Other studies have also investigated the application of the 5E learning cycle assisted by PhET to develop scientific reasoning (Mahbubah et al., 2024) as well as its integration with debate methods to enhance scientific argumentation skills (Nuzula & Shofiyah, 2025). These findings indicate that the 5E learning cycle has been implemented using a variety of supporting materials and activities. However, these studies predominantly focused on the use of instructional media and supporting activities, leaving room to explore the integration of the 5E learning cycle with learning activities that facilitate information exchange and evaluation across groups.

The use of these supporting materials assists students in conducting investigations, analyzing information, and constructing explanations based on obtained results. Developing scientific reasoning requires the ability to use evidence, evaluate arguments, and consider alternative explanations. Collaborative activities can support this process through idea exchange and argument revision (Chen et al., 2024; Jafari & Meisert, 2023). Such activities can be strengthened through inter-group interactions and information exchange, enabling students to compare analytical results and evaluate information from other groups. One method capable of facilitating these activities is the market place activity. This method provides opportunities for students to act as both information providers and seekers by presenting group outcomes, obtaining information from other groups, comparing data, and integrating it to reinforce understanding. These characteristics are highly relevant to science learning, as students are required not only to generate explanations but also to evaluate information from external sources and reconsider drawn conclusions. However, these potentials remain insufficient to explain how implementing the market place activity within the stages of the 5E learning cycle supports the development of scientific reasoning. Therefore, the relationship between integrating these two approaches and developing scientific reasoning warrants further investigation.

Based on this review, this study integrates the 5E learning cycle with the market place activity to support scientific reasoning. This integration connects the processes of investigation and explanation construction in the stages of the 5E learning cycle with activities involving communicating outcomes, comparing evidence, and evaluating explanations across groups through the market place activity. Consequently, the aspect examined in this study is not merely the standalone application of either the 5E learning cycle or the market place activity, but rather their integration in facilitating students' scientific reasoning processes.

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In its application, the market place activity is positioned within the elaboration stage of the 5E learning cycle. The engagement, exploration, and explanation stages prepare the foundational knowledge and investigation results that students subsequently utilize during the market place activity in the elaboration stage. Through this activity, students gain opportunities to exchange information, compare analytical results, consider explanations from other groups, and evaluate conclusions based on the acquired information. The novelty of this study lies in integrating the market place activity as an essential component of the elaboration stage within the 5E learning cycle and examining the impact of this integration on scientific reasoning in science learning on the topic of living organism classification. Consequently, this study aims to analyze the scientific reasoning of seventh-grade students following the implementation of the 5E learning cycle integrated with the market place activity on the topic of living organism classification.

2. Method

This study employed a quantitative approach with a quasi-experimental method and a pretest-posttest control group design. The research was conducted at State Junior High School X, Surakarta, during the 2025/2026 academic year. The experimental class received instruction using the 5E learning cycle integrated with market place activity, whereas the control class was taught using direct instruction.

The population of this study comprised all seventh-grade students at State Junior High School X, Surakarta, distributed across eight classes with a total of 255 students. The sample was selected using a cluster random sampling technique because the students were already organized into intact classes. Based on a random draw, Class VII G was selected as the experimental class consisting of 31 students, while Class VII F was selected as the control class consisting of 32 students. Prior to sample selection, normality and homogeneity tests were conducted on the end-of-semester examination scores of all seventh-grade classes to ensure that the population met the appropriate characteristics for sampling. The test results indicated that the data were normally distributed and possessed homogeneous variances, with a homogeneity test significance value of 0.348 ($p > 0.05$). Furthermore, an independent samples t-test conducted on the PAS scores of Class VII F and VII G yielded a significance value of 0.576 ($p > 0.05$). These results demonstrate no significant difference in initial academic ability between Class VII F and Class VII F, thereby confirming that both classes were eligible to serve as the experimental and control classes. The pretest scientific reasoning scores were subsequently used as a covariate in the ANCOVA analysis to control for baseline differences. However, because each learning condition was represented by only one class, the treatment effect could not be fully separated from potential unmeasured class-level characteristics.

Primary research data were collected using a scientific reasoning test consisting of 20 two-tier multiple-choice items. The instrument was developed based on Lawson's six indicators of scientific reasoning: conservation reasoning, proportional reasoning, control of variables reasoning, probability reasoning, correlation reasoning, and hypothetico-deductive reasoning. Each item comprises two tiers: the first tier consists of a multiple-choice response to the presented problem, while the second tier consists of the rationale supporting that response. Scoring was conducted using the pair scoring method, where a score of 1 was awarded only if both the first-tier response and the second-tier rationale were correct, whereas any other response combination received a score of 0.

The content validity of the instrument was examined by experts who assessed the alignment among Lawson's scientific reasoning indicators, learning objectives, and test items. The evaluation results were analyzed using the Gregory formula, yielding a content validity coefficient of 1.00. Subsequently, student responses during the instrument trial phase were analyzed using the Rasch model to evaluate item fit based on Outfit Mean Square (MNSQ), Outfit Z-Standard (ZSTD), and Point Measure Correlation (PTMEA CORR) statistics. All items were retained as each met at least two of the three item fit criteria. The Rasch analysis also yielded an item reliability of 0.90, a person reliability of 0.85, and a Cronbach's alpha of 0.88 for the pretest instrument, as well as an item reliability of 0.90, a person reliability of 0.87, and a Cronbach's alpha of 0.89 for the posttest instrument. Expert judgment provided evidence of content validity, while the Rasch analysis provided information regarding item fit and measurement reliability.

The pretest and posttest instruments utilized different test forms to minimize potential memory effects from previously completed items. Nevertheless, both test forms were constructed based on identical learning objectives and scientific reasoning indicators. However, empirical equivalence between the two test forms cannot be fully ensured solely on the basis of indicator alignment and individual instrument reliability values. In addition to the scientific reasoning test, supporting data were collected using observation sheets and questionnaires to identify students' basic science process skills and scientific attitudes. These supporting data were employed to enrich the interpretation of research findings and provide supplementary insights regarding the learning process, however, they were not utilized as the primary basis for hypothesis testing.

This study comprised three stages. The first stage was preparation, which included obtaining research permits from school authorities, coordinating with subject teachers, and developing as well as validating

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teaching modules, worksheets, test instruments, observation sheets, and questionnaires. The second stage was implementation, comprising five meetings on the topic of living organism classification. The experimental class applied the engagement, exploration, explanation, elaboration, and evaluation stages. The market place activity was implemented during the elaboration stage, wherein students presented group outcomes, visited other groups to obtain information, compared classification results, and integrated relevant information. The control class received direct instruction consisting of explanations, demonstrations, guided practice, feedback, and independent practice. The third stage involved quantitative analysis of the pretest and posttest data.

Research data were quantitatively analyzed using Analysis of Covariance (ANCOVA) at a significance level of 0.05. Prior to conducting the ANCOVA, the data were tested to ensure that key analytical assumptions were met, including normality, homogeneity, normality of residuals, linearity, and homogeneity of regression slopes. In the ANCOVA model, posttest scientific reasoning scores served as the dependent variable, the learning model as the independent variable, and pretest scores as the covariate. In addition to ANCOVA, N-gain values were calculated to evaluate the improvement in scientific reasoning within each class. The magnitude of the learning model's effect on scientific reasoning was determined based on the partial eta squared value.

3. Results and Discussion

3.1. Results

Scientific reasoning data were obtained through a two-tier multiple-choice test consisting of 20 items. The analysis results indicated an increase in scientific reasoning scores in both the experimental and control classes after learning. The comparison of pretest and posttest results for both classes is presented in Table 1.

Table 1. Scientific Reasoning Test Results

Description	Experimental Class		Control Group	
	Pretest	Posttest	Pretest	Posttest
Average	36.45	75.48	35.78	59.22
Minimum Value	5	40	5	35
Maximum Value	70	95	65	80

Based on Table 1, the average scientific reasoning scores of students in both classes increased after the instruction. The experimental class showed an average increase from 36.45 to 75.48, while the control class increased from 35.78 to 59.22. These results indicate that the improvement in scientific reasoning in the experimental class was greater than that in the control class. In more detail, the average pretest and posttest scores for each scientific reasoning indicator are presented in Table 2.

Table 2. Average Pretest and Posttest Scores for Each Scientific Reasoning Indicator

Scientific Reasoning Indicators	Experimental Class		Control Group	
	Pretest	Posttest	Pretest	Posttest
Conservation Reasoning	40.86	75.27	40.62	64.58
Proportional reasoning	29.03	62.36	28.12	46.88
Control of Variables	36.29	79.03	36.71	62.5
Probability reasoning	30.11	82.79	32.29	59.37
Correlation reasoning	37.9	68.55	34.37	52.34
Hypothetical-deductive Reasoning	44.09	86.02	42.71	70.83

Based on Table 2, all scientific reasoning indicators showed improvement from the pretest to the posttest in both classes. The experimental class scored higher on the posttest than the control class on all indicators. Furthermore, the improvement in students' scientific reasoning was analyzed using N-Gain scores, as presented in Table 3.

Table 3. N-Gain Results

Class	N-Gain Score	Description
Experimental	0.60	Currently
Control	0.33	Currently

Based on Table 3, the experimental class had a higher N-Gain value than the control class. This indicates that the improvement in scientific reasoning in the experimental class was greater after implementing the 5E learning cycle through the marketplace activity. This study is also supported by data from observations and questionnaires regarding basic science process skills and scientific attitudes. The results of the observations of students' basic science process skills are presented in Table 4.

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Table 4. Results of Observations of Basic Science Process Skills

Basic Science Process Skills	Experimental Class	Control Group
Identifying the characteristics of observed objects based on the results of observations	74.19	71.09
Presenting and communicating the results of observations	79.84	60.16
Grouping objects based on similarities and differences in characteristics	72.58	60.94

Based on Table 4, the experimental class showed a higher percentage than the control class in all aspects of basic science process skills. This indicates that students in the experimental class were more active in making observations, identifying the characteristics of objects, classifying objects, and communicating their observations during the learning process. In addition to basic science process skills, the observation results also revealed differences in scientific attitudes between the experimental and control classes, as presented in Table 5.

Table 5. Results of the Observation of Scientific Attitudes

Aspects of Scientific Attitude	Experimental Class	Control Group
Demonstrating curiosity about the objects being observed	74.19	60.94
Accepting and considering others' opinions during discussions	81.45	64.84
Demonstrating precision in classifying organisms based on observed characteristics	71.37	59.37
Making decisions based on data or evidence obtained	79.84	63.28

Based on Table 5, the experimental class showed a higher percentage than the control class across all aspects of scientific attitudes. This indicates that students in the experimental class demonstrated greater curiosity, thoroughness, openness to different opinions, and the ability to make evidence-based decisions during the learning process. In addition to observations, supporting data were also obtained through questionnaires assessing students' basic science process skills and scientific attitudes. The results of the basic science process skills questionnaire are presented in Table 6.

Table 6. Results of the Basic Science Process Skills Questionnaire

Basic Science Process Skills	Experimental Class	Control Group
Identifying the characteristics of observed objects based on the results of observations	81.45	77.73
Presenting and communicating the results of observations	82.06	74.41
Grouping objects based on similarities and differences in characteristics	79.84	76.07

Based on Table 6, the survey results show that the experimental class achieved a higher percentage than the control class across all aspects of basic science process skills. Students in the experimental class responded more positively to activities involving identifying the characteristics of objects based on observations, presenting and communicating observation results, and grouping objects based on similarities and differences in characteristics. These questionnaire results are consistent with the observation results, which showed that basic science process skills were demonstrated more frequently during lessons in the experimental class. Furthermore, the results of the questionnaire on students' scientific attitudes are presented in Table 7.

Table 7. Results of the Scientific Attitude Survey

Aspects of Scientific Attitude	Experimental Class	Control Group
Demonstrating curiosity about the objects being observed	79.64	73.24
Accepting and considering others' opinions during discussions	83.87	78.91
Demonstrating precision in classifying organisms based on observed characteristics	82.26	76.66
Making decisions based on data or evidence obtained	83.06	78.12

Based on Table 7, the survey results show that the experimental class achieved a higher percentage than the control class across all aspects of scientific attitudes. Students in the experimental class demonstrated more positive responses regarding curiosity, openness to considering others' opinions, precision in classifying organisms, and the ability to make decisions based on data or evidence obtained. These survey results reinforce the observational findings that learning activities in the experimental class provided students with opportunities to engage in scientific processes that support the development of scientific reasoning.

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The effect of the 5E learning cycle integrated with market place activity on students' scientific reasoning was analyzed using Analysis of Covariance (ANCOVA) with pretest scores as a covariate. Prior to the ANCOVA, the data satisfied all analytical assumptions based on prerequisite testing, which included normality, homogeneity of variance, normality of residuals, linearity, and homogeneity of regression slopes. A summary of the assumption test results is presented in Table 8.

Table 8. Summary of Prerequisite Test Results

Prerequisite Test	Data/Indicator	Sig.	Test Result
Normality	Experimental pretest	0.200	Normal
	Control pretest	0.123	
	Experimental posttest	0.197	
	Control posttest	0.148	
Homogeneity	Pretest	0.764	Homogeneous
	Posttest	0.741	
Normality of Residuals	Model residuals	0.200	Normal
Linearity	Deviation from Linearity	0.767	Linear
Homogeneity of regression slopes	Treatment interaction × pretest	0.432	Homogeneous

Based on the test results in Table 8, the significance values for the normality tests, homogeneity of variance, and normality of residuals were all above 0.05. The linearity test showed a deviation from linearity value of 0.767, whereas the homogeneity of regression slopes test yielded an interaction significance value of 0.432. These results support the appropriateness of conducting the ANCOVA based on the examined assumptions. Following the assumption checks, ANCOVA was employed to examine the difference in scientific reasoning between the experimental and control classes while controlling for pretest scores. The ANCOVA results are presented in Table 9.

Table 9. ANCOVA Results

	df	F	Sig.	Partial Eta Squared
Treatment (Learning Model)	1	32.925	0.000	0.354
Error	60	-	-	-

The ANCOVA results in Table 9 indicate a significant difference in scientific reasoning between the experimental and control classes after controlling for pretest scores, with a partial eta squared value of 0.354 indicating a large effect size. The difference in achievement between the two groups after controlling for pretest scores is presented through the adjusted means and 95% confidence intervals in Table 10.

Table 10. Adjusted Means for Scientific Reasoning

Class	Mean	Std. Error	95% CI Lower Bound	95% CI Upper Bound
Control	59.287	1.971	55.343	63.230
Experimental	75.414	2.003	71.407	79.420

Based on Table 10, the adjusted mean for scientific reasoning in the experimental class was higher than that in the control class after controlling for pretest scores.

3.2. Discussion

Based on the analysis, students' scientific reasoning in both the experimental and control classes underwent changes following instruction. These changes were evident from the increase in average scientific reasoning scores (the difference between posttest and pretest scores) of 23.44 in the control class and 39.03 in the experimental class, based on the pretest and posttest values in Table 4. Meanwhile, the N-gain values for the control and experimental classes were 0.33 and 0.60, respectively, as presented in Table 3. The ANCOVA results demonstrated a significant difference in scientific reasoning between the two classes after controlling for pretest scores ($p < 0.001$), with a partial eta squared value of 0.354, as shown in Table 10. These findings indicate a difference in scientific reasoning achievement between students who participated in the 5E learning cycle integrated with market place activity and those who engaged in direct instruction.

The difference in scientific reasoning achievement is related to the characteristics of the instruction implemented in each class. In the control class, direct instruction assisted students in acquiring conceptual understanding through explanations, demonstrations, guided practice, and structured feedback. Direct instruction emphasizes clear, structured, and systematic delivery of information, with the teacher providing explanations and demonstrating learning material step-by-step (Anđić et al., 2024). However, these instructional characteristics provided limited opportunities for students to actively engage in exploration, inquiry, and information exchange. Consequently, although students' scientific reasoning still showed

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improvement, it was not as optimal as that observed in the experimental class. This aligns with the findings of Antonio & Prudente (2023), who demonstrated that inquiry-based learning has a positive impact on higher-order thinking skills in science education. Meanwhile, in the experimental class, each stage of the 5E learning cycle integrated with market place activity facilitated the development of students' scientific reasoning through observing, formulating hypotheses, conducting investigations, analyzing data, communicating results, and drawing evidence-based conclusions. The 5E learning cycle fosters student understanding through meaningful learning experiences (Bybee et al., 2006). These characteristics align with the 5E model, which provides space for exploration and active student engagement in science learning (Ünlü & Dökme, 2022).

The implementation of the 5E learning cycle integrated with market place activity places intergroup information exchange during the elaboration stage, following students' exploration and formulation of explanations based on observational findings. Within this sequence, the 5E learning cycle provides the structural framework of instructional stages, whereas market place activity serves as the operational format utilized to present and discuss analytical results across groups. Throughout the learning process, students not only completed tasks within their home groups but were also required to present their group's analytical results to other groups as "information sellers," visit other groups to acquire information as "information buyers," compare the classification criteria utilized by different groups, pose questions and provide feedback on the work of peer groups, and integrate new information into their existing understanding. The market place activity provided opportunities for students to exchange information, convey discussion outcomes, engage in dialogic Q&A sessions, and respond to the work of other groups. These activities provided students with opportunities to express ideas, pose questions, and evaluate evidence through peer-group discussions. This process aligns with Iwuanyanwu (2023) ,who explained that dialogic interactions among students enable them to exchange perspectives, ask questions, and consider evidence in scientific problem-solving processes.

The improvement in scientific reasoning within the experimental class was supported by the implementation of the 5E learning cycle integrated with market place activity, which engaged students in exploration, investigation, discussion, information exchange, and evaluation activities. During the engagement stage, students were presented with phenomena or problems related to the characteristics of living organisms, classification, and the five-kingdom system to elicit prior knowledge and formulate initial hypotheses. According to Bybee et al. (2006), the engagement stage aims to stimulate curiosity and connect students' prior experiences with the concepts to be learned. This initial hypothesis formulation activity facilitated hypothetical-deductive reasoning, as students proposed tentative explanations based on prior information before obtaining evidence through investigatory activities. According to Kalinowski & Pelakh (2024), hypothetical-deductive reasoning involves testing hypotheses through predictions compared against observations or empirical testing. Furthermore, phenomena linking organism characteristics to their grouping helped develop correlational reasoning, as students began associating specific traits with classification concepts. This activity aligns with correlational reasoning, defined as reasoning used to recognize relationships between variables or traits within a phenomenon (Bhaw et al., 2023).

During the exploration stage, students conducted observations, identified object characteristics, collected information, and determined classification criteria based on investigatory results. Exploration activities provide opportunities for students to construct concepts through data collection and information analysis (Siew & Chai, 2024). When students identified specific traits as criteria for classifying living organisms, utilized dichotomous classification keys, and determined organism groups, these activities facilitated control of variables reasoning because students specified the characteristics used as the basis for decision-making. Control of variables reasoning pertains to the ability to identify, control, and relate variables to derive accurate conclusions. Furthermore, when students evaluated several possible identification outcomes prior to determining an organism's group, these activities supported probabilistic reasoning. This aligns with Ashari (2025), who explained that probabilistic reasoning assists students in considering various potential outcomes in uncertain situations. Understanding that organisms may exhibit different morphological forms while still retaining fundamental characteristics of living beings also supported conservation reasoning, as students recognized that visual changes do not alter an object's core properties. According to Nadifah & Wardani (2024), demonstrate sound conservation reasoning when they understand that alterations in the shape or appearance of an object do not change its fundamental nature.

During the explanation stage, students formulated explanations based on their observational and discussion findings. By connecting observational results with the concepts of living organism characteristics, classification, taxonomic ranks, and the five-kingdom system, students developed correlational reasoning as they recognized the relationship between organism traits and their resulting classification. Furthermore, analyzing the relationships among taxonomic ranks, the number of member organisms, and shared characteristics supported proportional reasoning, as students understood the proportional relationship between classification levels and the degree of shared traits among organisms. This aligns with Bhaw et al. (2023), who noted that proportional reasoning involves the ability to understand multiplicative relationships between two quantities rather than merely comparing their absolute differences.

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The elaboration stage was implemented through market place activity as a medium for intergroup information exchange. In this activity, students presented their group's analytical results, acquired information from other groups, and subsequently integrated this information to broaden their understanding. The market place activity provided opportunities for students to interact and exchange information during the learning process. Through these discussions and peer interactions, students had opportunities to formulate explanations and refine their understanding of scientific concepts (McLure et al., 2023). Comparing observational data and classification outcomes across different groups facilitated correlational reasoning, as students synthesized various pieces of information to comprehend relationships between organism traits and their classification. During the evaluation stage, students evaluated their acquired understanding through questioning, reflection, and comparing their initial hypotheses against observational evidence. This process supported hypothetical-deductive reasoning, as students reassessed the validity of their initial hypotheses based on evidence obtained throughout the lesson. Evaluating the rationales behind organism classification further reinforced correlational reasoning, as students connected organism characteristics to classification conclusions using available evidence.

In addition, supporting data from observations and questionnaires indicated that basic science process skills and scientific attitudes were evident during the implementation of the 5E learning cycle integrated with market place activity. Basic science process skills such as identifying characteristics of observed objects based on observational findings, presenting and communicating results, and classifying objects according to similarities and differences achieved average scores of 75.54 from observations and 81.17 from questionnaires, respectively. Meanwhile, scientific attitudes including demonstrating curiosity toward observed objects, accepting and considering others' opinions during discussions, exhibiting precision in classifying organisms based on observed traits, and making decisions based on data or evidence obtained average scores of 76.71 and 82.21, respectively. The manifestation of basic science process skills and scientific attitudes throughout the instructional process indicates that students actively engaged in observation, classification, communication, and evidence utilization. These activities are essential to acquiring and processing information required for students' scientific reasoning. Scientific attitudes are closely tied to an inquiry mindset, critical thinking capabilities, and evidence-based reasoning in science education (Sharma & Tripathy, 2025). Moreover, science process skills represent a fundamental aspect of science learning associated with scientific investigation activities. Li et al. (2024) demonstrated a positive relationship between students' creative tendencies and their science process skills in science education. Thus, the student-centered 5E learning cycle integrated with market place activity provides opportunities to conduct investigations, discuss, exchange information, and independently construct knowledge. This active engagement supports the development of scientific reasoning as students undergo a more meaningful learning process.

Based on the research findings, the 5E learning cycle integrated with market place activity influenced students' conceptual understanding of living organism classification and facilitated their scientific reasoning more optimally than direct instruction. The findings of this study align with previous research demonstrating that the 5E learning cycle effectively enhances students' scientific reasoning, whether through student worksheets based on multidimensional thinking diagrams, three-dimensional thinking graphs, or multi-representational electronic worksheets (Ristia et al., 2023; Setiyawati et al., 2023; Wulandari et al., 2024). However, in this study, the 5E learning cycle was uniquely integrated with market place activity. This instructional sequence provided students with opportunities to expand their interactive space for exchanging information, expressing viewpoints, asking questions, and responding to the work of peer groups. Consequently, the findings of this study demonstrate that the 5E learning cycle integrated with market place activity effectively supports scientific reasoning.

3.3. Implications

The results of this study have practical implications for science teachers. The implementation of the 5E learning cycle integrated with market place activity can be considered an instructional alternative to support the development of scientific reasoning. Its execution requires clear group tasks, designated roles as information providers and seekers, structured activity time limits, and guiding questions to ensure that information exchange focuses on scientific evidence and reasoning. Theoretically, the application of the 5E learning cycle integrated with market place activity has the potential to foster scientific reasoning through inquiry processes, knowledge construction, and student-to-student interactions. However, these instructional recommendations remain preliminary and require further validation through research incorporating treatment replication across multiple classes.

3.4. Limitations

This study is limited by its execution in a single school, a relatively small sample size, and a focus restricted to the topic of living organism classification over five instructional sessions. Furthermore, the study involved only one experimental class and one control class, lacking class-level replication for each treatment condition. This restricts the interpretation of the results, as class-specific characteristics could potentially confound the findings. Consequently, the results cannot be widely generalized to other educational contexts. Future research is recommended to involve multiple schools and several classes per treatment condition. Moreover,

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instructional recommendations derived from these findings should be further validated in broader learning contexts.

4. Conclusion

Based on the data analysis and discussion, it can be concluded that there is a difference in scientific reasoning achievement between students in the experimental class implementing the 5E learning cycle integrated with market place activity and those in the control class following five instructional sessions. The ANCOVA results demonstrated a statistically significant difference ($p < 0,001$), with an effect size of 0.354, which falls into the large category according to established criteria. Furthermore, the improvement in scientific reasoning in the experimental class was higher than that in the control class. Consequently, these findings provide preliminary evidence regarding the potential of the 5E learning cycle integrated with market place activity to support students' scientific reasoning.

Author Contributions

This study is the result of a collaboration among all authors. All authors contributed to the research planning, data collection, interpretation of results, and manuscript preparation. Each author has reviewed and approved the final manuscript for publication.

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Declaration of Conflicting Interests

The authors declare no conflict of interest regarding the research, authorship, or publication of this article.

Ethics and Consent Declarations

This study was conducted in accordance with ethical research principles. Research approval was obtained from the school where the study was conducted, and all participants provided informed consent prior to data collection. The identities of the school and participants were kept confidential through anonymization, and participant privacy was protected throughout the research process.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to participant confidentiality and institutional guidelines.

Declaration on AI Use

AI-assisted technologies, such as ChatGPT and Perplexity, were used on a limited basis to improve the readability, grammar, and language structure of the manuscript under the author's supervision. The research design, data, statistical analysis, scientific interpretation, and conclusions were established and verified by the author.

References

Anđić, B., Maričić, M., Mumcu, F., Prodromou, T., Leoste, J., Saimon, M., & Lavicza, Z. (2024). Direct and indirect instruction in educational robotics: A comparative study of task performance per cognitive level and student perception. *Smart Learning Environments, 11*, Article 12. https://doi.org/10.1186/s40561-024-00298-6

Antonio, R. P., & Prudente, M. S. (2024). Effects of inquiry-based approaches on students' higher-order thinking skills in science: A meta-analysis. *International Journal of Education in Mathematics, Science and Technology, 12*(1), 251–281. https://doi.org/10.46328/ijemst.3216

Ashari, N. W. (2025). Exploring visual probabilistic reasoning: A qualitative study on junior high school students' problem-solving in probability. *Pedagogy: Jurnal Pendidikan Matematika, 10*(2), 667–676. https://doi.org/10.30605/pedagogy.v10i2.6172

Bhaw, N., Kriek, J., & Lemmer, M. (2023). Insights from coherence in students' scientific reasoning skills. *Heliyon, 9*(7), Article e17349. https://doi.org/10.1016/j.heliyon.2023.e17349

Bybee, R. W., Taylor, J. A., Gardner, A., Van Scotter, P., Carlson Powell, J., Westbrook, A., & Landes, N. (2006). *The BSCS 5E instructional model: Origins, effectiveness, and applications*. BSCS.

Chen, W., Han, Y., Tan, J., Chai, A. S. C., Lyu, Q., & Lyna. (2024). Exploring students' computer-supported collaborative argumentation with socio-scientific issues. *Journal of Computer Assisted Learning, 40*(6), 3324–3337. https://doi.org/10.1111/jcal.13073

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Iwuanyanwu, P. N. (2023). When science is taught this way, students become critical friends: Setting the stage for student teachers. *Research in Science Education, 53*(6), 1063–1079. https://doi.org/10.1007/s11165-023-10122-9

Jafari, M., & Meisert, A. (2023). Potential of group-based negotiation to promote learner-based reasoning and weighting of arguments on socioscientific issues. *Research in Science Education, 53*(2), 377–403. https://doi.org/10.1007/s11165-022-10059-5

Kalinowski, S. T., & Pelakh, A. (2024). A hypothetico-deductive theory of science and learning. *Journal of Research in Science Teaching, 61*(6), 1362–1388. https://doi.org/10.1002/tea.21892

Krell, M., Vorholzer, A., & Nehring, A. (2022). Scientific reasoning in science education: From global measures to fine-grained descriptions of students' competencies. *Education Sciences, 12*(2), Article 97. https://doi.org/10.3390/educsci12020097

Li, X., Zhang, Y., Yu, F., Zhang, X., Zhao, X., & Pi, Z. (2024). Do science teachers' believes related to inquiry-based teaching affect students' science process skills? Evidence from a multilevel model analysis. *Disciplinary and Interdisciplinary Science Education Research, 6*, Article 1. https://doi.org/10.1186/s43031-023-00089-y

Mahbubah, I. N., Nuha, U., & Ahmad, N. (2024). Development of LKPD (student worksheets) based on learning cycle 5E assisted by PhET simulation to improve scientific reasoning skills for junior high school students. *Journal of Educational Sciences, 8*(3), 362–378. https://doi.org/10.31258/jes.8.3.p.362-378

McLure, F., Won, M., & Treagust, D. F. (2023). The productive interplay between student-student and teacher-student dialogic interactions and the affordances of student generated explanatory drawings to understand plate tectonics. *International Journal of Science Education, 45*(18), 1552–1570. https://doi.org/10.1080/09500693.2023.2214688

Nadifah, A., & Wardani, I. B. (2024). Exploration of scientific reasoning skills students' on material growth and development of plants class XII MIPA based gender at SMAN Ambulu Jember. *META: Journal of Science and Technological Education, 3*(1), 62–75. https://meta.amiin.or.id/index.php/meta/article/view/91

Nuzula, J. F., & Shofiyah, N. (2025). 5E learning cycle debate model improves scientific argumentation skills. *Academia Open, 10*(1). https://doi.org/10.21070/acopen.10.2025.12328

Ristia, H. P., Nuha, U., & Supeno. (2023). Model learning cycle 5E berbantuan LKPD berbasis three-dimensional thinking graph dan pengaruhnya terhadap scientific reasoning pada siswa SMP. *Jurnal Paedagogy, 10*(3), 703–713. https://doi.org/10.33394/jp.v10i3.7283

Ruiz-Martín, H., & Bybee, R. W. (2022). The cognitive principles of learning underlying the 5E model of instruction. *International Journal of STEM Education, 9*, Article 21. https://doi.org/10.1186/s40594-022-00337-z

Setiyawati, Z., Supeno, & Ridlo, Z. R. (2023). Pengaruh model learning cycle 5E dengan E-LKPD berbasis multirepresentasi terhadap scientific reasoning siswa SMP. *Edukasi: Jurnal Pendidikan, 21*(2), 241–255. https://doi.org/10.31571/edukasi.v21i1.6027

Sharma, A., & Tripathy, P. (2025). A review on assessment of scientific attitudes of school students: A case study of Indonesia. *Journal of Scientific Temper, 13*(1), 5–24. https://doi.org/10.56042/jst.v13i1.13975

Siew, N. M., & Chai, W. L. (2024). The integration of 5E inquiry-based learning and group investigation model: Its effects on level four science process skills of form four students. *Problems of Education in the 21st Century, 82*(1), 133–148. https://doi.org/10.33225/pec/24.82.133

Suryandai, K. C., Rokhmaniyah, Salimi, M., & Fatimah, S. (2022). Involvement of teachers, parents, and school committees in improving scientific attitudes of elementary school students: Application of Rasch model analysis. *International Journal of Educational Methodology, 8*(4), 783–794. https://doi.org/10.12973/ijem.8.4.783

Ünlü, K. Z., & Dökme, İ. (2022). A systematic review of 5E model in science education: Proposing a skill-based STEM instructional model within the 21-st century skills. *International Journal of Science Education, 44*(13), 2110–2130. https://doi.org/10.1080/09500693.2022.2114031

Van Vo, D., & Csapó, B. (2023). Exploring inductive reasoning, scientific reasoning and science motivation, and their role in predicting STEM achievement across grade levels. *International Journal of Science and Mathematics Education, 21*(8), 2375–2398. https://doi.org/10.1007/s10763-022-10349-4

Wulandari, T., Supeno, & Wahyuni, D. (2024). Pengaruh model learning cycle 5E disertai LKPD berbasis diagram berpikir multidimensi terhadap kemampuan scientific reasoning siswa SMP. *Jurnal Sains dan Edukasi Sains, 7*(1), 1–11. https://doi.org/10.24246/juses.v7i1p1-11

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