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ESD-Oriented Guided Inquiry Integrated with Islamic Values: Seventh-Grade Students' Critical Thinking in Ecosystem Learning

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ABSTRACT
Critical thinking is essential in ecosystem learning because students must analyze environmental issues and consider evidence-based solutions. This study descriptively compared changes in seventh-grade students' critical thinking skills after ESD-oriented guided inquiry integrated with Islamic values and after the instruction ordinarily used by the teacher. A quasi-experimental nonequivalent control group design was used with 68 students at SMP Negeri 51 Bandung (34 students in each class). Data were collected through pretests and posttests and analyzed using normalized gain (N-Gain); the Shapiro-Wilk and Levene tests were conducted as prerequisite analyses. The experimental-class mean increased from 57.06 to 89.19, with an N-Gain of 66.02% (moderate), whereas the control-class mean increased from 52.65 to 82.72, with an N-Gain of 60.66% (moderate). Both classes therefore showed moderate improvement, and the experimental class had a descriptively higher N-Gain by 5.36 percentage points. Because no between-group inferential result is reported, this difference should not be interpreted as evidence of a statistically significant treatment effect. The implemented approach was associated with improved critical-thinking scores, but the individual contributions of its ESD and Islamic-value components were not assessed separately.

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Introduction

Preliminary observations at a public junior high school in Bandung indicated that students' critical thinking skills in ecosystem learning required further development. Students experienced difficulty interpreting information, analyzing relationships among ecosystem components, evaluating environmental issues, and drawing evidence-based conclusions. These difficulties are important because ecosystem learning requires students to connect multiple sources of information and reason systematically when examining environmental problems (Khairunnisa et al., 2022).

The ecosystem topic is closely related to students' daily lives. It involves not only biotic and abiotic components but also interactions among those components and the effects of human activities on environmental balance. Linking ecosystem concepts with Islamic values can frame environmental stewardship as both a scientific and moral responsibility. The balance and order of nature reflected in Surah Ar-Rahman, verses 7-8, can be connected to ecosystem balance, while Surah Al-Baqarah, verse 30, can be connected to human responsibility as stewards of the earth (Husamah et al., 2022). In biology education, this integration can relate conceptual understanding to moral values and environmental responsibility (Herlanti et al., 2022).

These learning demands require an approach that actively engages students in inquiry and reasoning. Guided inquiry allows students to construct understanding through problem identification, information gathering, data analysis, and conclusion drawing while receiving structured guidance from the teacher (Joyce et al., 2015). This process can provide repeated opportunities to practice critical thinking rather than only receive information (Kuhlthau et al., 2015).

Guided inquiry becomes more contextual when oriented toward Education for Sustainable Development (ESD). Within an ecosystem unit, ESD can connect biological concepts to environmental problems and encourage students to consider sustainability-oriented responses (Badruttamam et al., 2025).

Critical thinking is also recognized as an important ESD competency because students must evaluate information and compare alternative solutions to sustainability issues (Merma-Molina et al., 2022).

Previous studies have examined guided inquiry, ESD-oriented instruction, and the integration of Islamic values in biology learning. However, limited evidence describes their combined implementation in ecosystem instruction while comparing changes in critical-thinking scores with a class receiving regular instruction. This study therefore aimed to descriptively compare changes in students' critical-thinking scores in an experimental class receiving ESD-oriented

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guided inquiry integrated with Islamic values and a control class receiving the instruction ordinarily used by the teacher. The study addressed the following question: How did pretest-to-posttest changes and N-Gain scores differ descriptively between the experimental and control classes?

Methods

This study used a quasi-experimental method with a nonequivalent control group design. Both the experimental and control classes completed a pretest before instruction and a posttest after instruction. The experimental class received ESD-oriented guided inquiry integrated with Islamic values, whereas the control class received the instruction ordinarily used by the teacher. The design was used to describe and compare changes in students' critical-thinking scores across the two classes.

The study was conducted at SMP Negeri 51 Bandung during the even semester of the 2025/2026 academic year. The population comprised all seventh-grade students. A purposive sample of 68 students was selected: Class VII-3 served as the experimental class and Class VII-4 as the control class, with 34 students in each class. Class selection was based on the consideration that students' initial abilities were relatively equivalent and on recommendations from the science teachers.

Learning activities were conducted over three sessions on the ecosystem topic. In the experimental class, instruction followed the guided-inquiry stages of problem orientation, problem formulation, hypothesis formulation, data collection, hypothesis testing, and conclusion drawing (Sanjaya, 2006). The activities were oriented toward ESD by examining environmental issues and efforts to maintain ecosystem sustainability. Islamic values were integrated by linking ecosystem concepts to human responsibility as stewards of the earth and to Qur'anic verses concerning environmental balance and conservation. The control class studied the same ecosystem topic through the standard approach ordinarily used by the teacher.

Data were collected using test and non-test instruments. The test instruments consisted of pretest and posttest items designed to measure six critical-thinking indicators: interpretation, analysis, evaluation, inference, explanation, and self-regulation (Facione, 2015). The non-test instruments consisted of observation sheets used to document teacher and student activities during instruction.

Critical-thinking data were analyzed using pretest and posttest scores and normalized gain (N-Gain). The Shapiro-Wilk test was used to examine normality, and Levene's test was used to examine homogeneity as prerequisite analyses. Classroom implementation data were analyzed descriptively using the percentages of teacher and student activities completed. The comparative results reported in this manuscript are descriptive.

Results and Discussion

Pretest and posttest scores from the experimental and control classes were used to describe changes in students' critical-thinking skills. Improvement was summarized using N-Gain scores, while teacher and student activities were examined descriptively.

Students' Critical-Thinking Skills

Changes in students' critical-thinking scores were examined by comparing the pretest, posttest, and N-Gain values of the experimental and control classes. The descriptive results are presented in Table 1

Table 1. Descriptive Results for Students' Critical-Thinking Skills

Class	Pretest	Posttest	N-Gain (%)	Category
Experimental (n = 34)	57.06	89.19	66.02%	Moderate
Control (n = 34)	52.65	82.72	60.66%	Moderate

As shown in Table 1, the mean score in the experimental class increased from 57.06 on the pretest to 89.19 on the posttest, with an N-Gain of 66.02% in the moderate category. The control-class mean increased from 52.65 to 82.72, with an N-Gain of 60.66%, also in the moderate category. The experimental-class N-Gain was 5.36 percentage points higher than the control-class N-Gain. This difference is descriptive because no between-group inferential result is reported.

Both classes showed improved critical-thinking scores and reached the same N-Gain category. The slightly higher N-Gain in the experimental class indicates a descriptive pattern rather than evidence that the experimental instruction was statistically superior to the control instruction

Students' critical-thinking scores improved in both classes. The experimental class achieved an N-Gain of 66.02%, while the control class achieved 60.66%; both values were in the moderate category. The difference of 5.36 percentage points favors the experimental class descriptively, but it does not establish a statistically significant advantage because no inferential between-group comparison is reported. Guided inquiry has been associated with critical-thinking development in ecosystem learning (Irwan et al., 2019), and a meta-analysis by Sari et al. (2023) also identified a positive contribution of guided inquiry to students' critical-thinking skills. The present results are consistent with that literature at a descriptive level.

The instructional experiences in the experimental class may help explain the observed pattern. Students were guided through problem formulation, information collection, analysis, hypothesis testing, and conclusion drawing. In ecosystem learning, these activities allowed students to examine environmental issues while connecting evidence to biological concepts. Similar inquiry processes have been linked to information processing and critical-thinking practice (Harahap et al., 2020; Irwan et al., 2019). Nevertheless, the design does not isolate which component of the combined instruction contributed to the observed score changes.

The substantial improvement in the control class requires equal attention. Students in both classes received instruction on the same topic and completed pretests and posttests, so improvement may partly reflect learning from regular instruction or familiarity with the testing format. Teacher and classroom effects, maturation during the study period, and the limited room for additional improvement at the high posttest scores may also have influenced the observed pattern. These alternatives prevent the score increases from being attributed solely to the experimental approach.

Critical-Thinking Skills by Indicator

The experimental instruction engaged students in identifying environmental problems, gathering and examining information, analyzing relationships among ecosystem components, and drawing conclusions. These activities were aligned with the six critical-thinking indicators assessed in the study: interpretation, analysis, evaluation, inference, explanation, and self-regulation.

ESD and Islamic values served as instructional contexts within the experimental class. ESD connected ecosystem concepts to environmental issues, while Islamic values framed environmental balance and stewardship. Because sustainability awareness, moral awareness, and environmental responsibility were not measured as outcomes, the present findings are limited to students' critical-thinking scores.

Table 2 presents changes in the six critical-thinking indicators in the experimental class. The table reports indicator-level pretest, posttest, and N-Gain values.

Table 2. Critical-Thinking Skills by Indicator in the Experimental Class

Indicator	Pretest	Posttest	N-Gain	Category
Interpretation	71	91	0.69	Moderate
Analysis	81	92	0.58	Moderate
Evaluation	54	84	0.65	Moderate
Inference	37	86	0.78	High
Explanation	29	93	0.90	High
Self-regulation	32	97	0.96	High
Mean	50.67	90.50	0.76	High

The unweighted arithmetic mean across the six indicator-level scores increased from 50.67 on the pretest to 90.50 on the posttest, with a mean indicator-level N-Gain of 0.76 in the high category. These values differ from the participant-level overall means in Table 1 because the two tables use different units of aggregation: Table 1 summarizes students' total scores, whereas Table 2 averages the six indicator-level values.

The highest indicator-level gains were observed for self-regulation (0.96), explanation (0.90), and inference (0.78), all in the high category. Interpretation (0.69), evaluation (0.65), and analysis (0.58) were in the moderate category.

This profile shows that improvement was not uniform across the measured components of critical thinking. In particular, the lower gain for analysis indicates that students may still require additional practice in breaking down information and identifying relationships among multiple pieces of evidence.

The experimental-class indicator profile had a mean N-Gain of 0.76, calculated as the arithmetic mean of the six indicator-level gains. This value should not be equated with the class-level N-Gain of 66.02% in Table 1, which was calculated from participant-level overall scores. At the indicator level, the results suggest that the measured aspects of critical thinking developed at different rates, a pattern also reported in previous research (Ekamilasari et al., 2021; Sobari et al., 2022).

Self-regulation, explanation, and inference showed the highest gains in the experimental class. The inquiry sequence required students to review information, examine whether evidence supported their ideas, communicate their reasoning, and draw conclusions from their investigations.

These features are compatible with the measured indicators and may have supported practice in those areas. However, because the instrument measured outcomes only at pretest and posttest, the indicator pattern should be interpreted as an association rather than a verified mechanism (Harahap et al., 2020; Irwan et al., 2019; Sari et al., 2023).

Interpretation, evaluation, and analysis showed moderate gains in the experimental class, with analysis recording the lowest N-Gain (0.58). Analysis requires students to distinguish relevant information, identify relationships, and connect evidence across parts of a problem. The lower result suggests that these processes may require more sustained practice than was possible during the three-session intervention. Differences across critical-thinking indicators have also been reported by Ekamilasari et al. (2021), Harahap et al. (2020), and Sobari et al. (2022). Table 3 presents indicator-level changes in the control class using the same descriptive calculation as Table 2.

Table 3. Critical-Thinking Skills by Indicator in the Control Class

Indicator	Pretest	Posttest	N-Gain	Category
Interpretation	68	82	0.44	Low
Analysis	76	91	0.63	Moderate
Evaluation	47	72	0.47	Low
Inference	31	77	0.67	Moderate
Explanation	29	91	0.87	High
Self-regulation	31	94	0.91	High
Mean	47.00	84.50	0.66	Moderate

The unweighted arithmetic mean across the six indicator-level scores increased from 47.00 on the pretest to 84.50 on the posttest, with a mean indicator-level N-Gain of 0.66 in the moderate category. As in Table 2, these values are indicator-level arithmetic means and therefore differ from the participant-level overall means reported for the control class in Table 1.

The highest indicator-level gains in the control class were observed for self-regulation (0.91) and explanation (0.87), both in the high category. Inference (0.67) and analysis (0.63) were in the moderate category, while evaluation (0.47) and interpretation (0.44) were in the low category. The control-class pattern therefore also showed uneven improvement across the six indicators.

The control class also showed high gains for self-regulation (0.91) and explanation (0.87), while interpretation and evaluation remained in the low category. This pattern reinforces the need for caution when interpreting the experimental-class results. Some measured skills may have been responsive to instruction in both classes or to repeated testing, whereas interpretation and evaluation may require more explicit and sustained support.

Contextual Integration and Limitations

Within the experimental instruction, ESD provided a context for linking ecosystem concepts to environmental sustainability issues. Such contexts can make biological reasoning more relevant by requiring students to consider the relationships between scientific knowledge and real-world problems (Ekamilasari et al., 2021; Sobari et al., 2022). In this study, however, ESD functioned as an instructional feature; sustainability awareness and environmental literacy were not measured as outcomes.

Islamic values likewise functioned as an instructional frame for discussing environmental balance and human responsibility. Previous research has described the relevance of integrating Islamic values into environmental and inquiry-based biology learning (Fazira & Jayanti, 2023; Fitriana et al., 2025; Husamah et al., 2022). Because the present study did not measure moral awareness, religious values, or environmental responsibility, no conclusion can be drawn about changes in those constructs.

Overall, the experimental and control classes both showed improved critical-thinking scores. The experimental class had a modestly higher N-Gain, but the available analysis supports only a descriptive comparison. The findings therefore suggest that ESD-oriented guided inquiry integrated with Islamic values can be implemented as a contextual approach to ecosystem learning, while stronger evidence is required to determine whether it produces an advantage over regular instruction or whether its individual components have distinct effects.

This study has several limitations. The classes were not randomly assigned, and the sample came from one school, which limits generalizability. The three-session intervention was brief, and teacher, classroom, maturation, and testing effects may have contributed to improvement in both classes. The available results do not include an inferential between-group comparison, variability estimates, or a delayed posttest. In addition, the study did not separately measure the effects of the ESD and Islamic-value components. The findings should therefore be interpreted as short-term descriptive evidence of changes in critical-thinking scores.

Conclusions

Students' critical-thinking scores improved in both classes. The experimental-class mean increased from 57.06 to 89.19, with an N-Gain of 66.02%, while the control-class mean increased from 52.65 to 82.72, with an N-Gain of

60.66%; both gains were in the moderate category. The experimental-class N-Gain was descriptively higher by 5.36 percentage points. Because no inferential between-group result is reported, the findings do not establish a statistically significant advantage of the experimental instruction. They also do not isolate the effects of the ESD and Islamic-value components. Within these limitations, the implemented approach was associated with short-term improvement in students' critical-thinking scores in ecosystem learning.

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