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Application of the Inquiry-Based Learning Model with Education for Sustainable Development to Enhance Critical Thinking Skills and Sustainable Awareness

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Abstract: To improve the quality of education and develop students' 21st-century competencies, particularly critical thinking, the inquiry-based learning model presents itself as a viable option to enhance students' cognitive abilities and awareness of sustainability. Incorporating Education for sustainable development into the inquiry-based learning model introduces a relevant approach to addressing contemporary global challenges, especially in sustainable development education. This research seeks to assess the enhancement of students' critical thinking skills and sustainable awareness through the application of the inquiry-based learning model infused with ESD content. The research method used in this study is a quasi-experiment with a non-equivalent control group design. This research was conducted on class X students at one of the MAN in Bandar Lampung, with each class consisting of 35 and 36 students. Data were obtained from the results of pre-tests and post-tests of critical thinking skills, sustainable awareness questionnaires, and student response surveys. The results of the study indicate that there was an improvement in students' critical thinking skills between the experimental and control classes. There was also a significant difference in sustainable awareness between the experimental and control classes. The inquiry-based learning model integrated with ESD content showed a significant and fairly strong positive correlation between students' critical thinking skills and sustainable awareness.

Keywords: Critical Thinking; Education for Sustainable Development; Inquiry; Sustainable Awareness

Introduction

Education plays a crucial role in developing skilled and character-driven individuals. To meet the demands of 21st-century learning, educators must engage in professional development that aligns with contemporary educational objectives. These objectives include fostering critical skills in learning and innovation, information and media literacy, technology, and life and career competencies.(Tridiana & Rizal, 2020).

The 21st-century skills are often referred to as the 4C: critical thinking and problem solving, creative thinking and innovation, collaboration, and communication (Dwijayanti, 2021). However, in the implementation of 21st-century learning, students' skills are still relatively low. This can be identified by the low critical thinking abilities of students in Indonesia (Fuadi et al., 2020). Critical thinking is essential in 21st-century learning for students because it enables them to conclude information from various perspectives, accurately digest problems, devise solutions to tackle issues, and think of alternative solutions related to problem-solving. However, in the current educational reality, there is an issue where students focus more on memorizing concepts rather than developing a deep

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understanding, which does not train their critical thinking abilities. This issue is exacerbated by teacher-centered approaches that don't foster critical thinking. One potential solution is to integrate sustainable awareness early in education, promoting it as a positive habit for future generations.

The cultivation of sustainable environmental awareness can be implemented through school education, as it is one of the competencies included in education for sustainable development (NCCA, 2018). In fact, sustainable awareness among the Indonesian population is still relatively low, as evidenced by the persistent environmental pollution caused by irresponsible human activities (Ghani et al., 2018). The main barrier to addressing environmental issues is the lack of knowledge, concern, and awareness among people. Education is crucial in equipping students with an understanding of the importance of environmental awareness and concern. (Kahfi, 2022). This statement aligns with Grossman (2019) who argues that efforts to address the environmental crisis must begin with the younger generation through education by incorporating ESD aspects into the learning process, especially in subjects related to environmental content such as biology (Baierl et al., 2021; Bezeljak et al., 2020). ESD content can be integrated with biology concepts, including environmental issues, health, and sustainable urbanization (Baierl et al., 2021). Education for sustainable development has three main pillars: social, environmental, and economic, with the hope of making a significant contribution to achieving the SDGs as an effort to solve 21st-century problems.

The topic of environmental change for 10th-grade biology can support future life and contribute to achieving the SDGs. It connects closely to everyday life and can address low critical thinking and sustainability awareness by actively engaging students through the inquiry-based learning model, both individually and collaboratively. This model fosters the development of critical thinking skills by involving students in activities such as problem formulation, experiment design and execution, data collection, data analysis, and drawing conclusions. (Forbes et al., 2020).

The the research questions can be elaborated as follows: First, does the application of the inquiry learning model with education for sustainable development content enhance students' critical thinking skills? Second, does the application of the inquiry learning model with education for sustainable development content enhance students' sustainable awareness? And third, what is the relationship between students' critical thinking skills and sustainable awareness in the context of applying the inquiry learning model with education for sustainable development content in schools?

Method

This study uses a quasi-experimental with a non-equivalent control group design. The population in this study consists of all 10th grade students at Madrasah Aliyah Negeri Bandar Lampung. The research subjects were selected through convenience sampling. Both experimental and control groups were given pre-test and post-test. The experimental group will use an inquiry learning model with ESD content, while the control group will use the inquiry model without ESD content.

The instruments used in this study include a critical thinking skills tool in the form of essay questions based on six indicators according to Facione (2015): interpretation, analysis, inference, evaluation, explanation, and self-regulation. The instrument for sustainability awareness is a questionnaire using a likert scale. The questionnaire is adapted from one developed by Gericke et al., (2019) consisting of 27 statements divided into three indicators of sustainability awareness: knowledge, attitudes, and behavior. These three indicators encompass the three dimensions of sustainable development: environmental, social, and economic. The following is the research flow in this study.

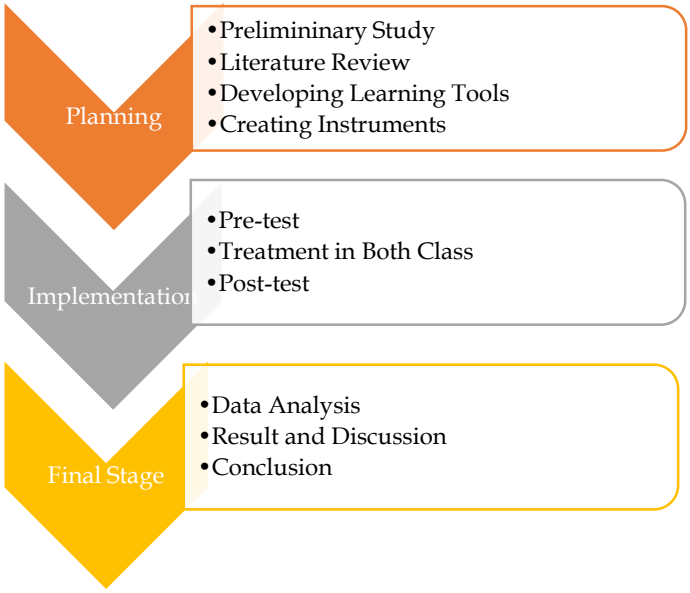

Figure 1. The Percentage

The calculation of the students' scores is done using the Formula 1.

$$\text{Score} = \frac{\text{Obtained Score}}{\text{Maximum Score}} \text{x} 100 \quad (1)$$

Categorization of critical thinking skills is analyzed through Table 1.

Table 1. Categorization of Students Critical Thinking Skills

Percentage	Description
90 ≤ A ≤ 100	Verry Good
75 ≤ B ≤ 90	Good
55 ≤ A ≤ 75	Fair
40 ≤ A ≤ 55	Poor
0 ≤ A ≤ 40	Verry Poor

(Arikunto, 2014)

The results of the questionnaire for student sustainable awareness data begin with scoring each students answer using the following criteria.

Table 2. Scoring Conversion for Sustainable Awareness Questionnaire

Respone Option	Question Score	
	Positive	Negative
Strongly Agree	4	1
Agree	3	2
Disagree	2	3
Strongly Disagree	1	4

(Widyoko, 2013)

After determining the score for each answer, the calculation for categorizing sustainable awareness is done using the Formula 2.

$$\text{Percentage} = \frac{\text{Total score Obtained}}{\text{Maximum Score}} \text{x } 100\% \qquad (2)$$

Clarisa et al., 2020)

The results from the above calculation are then aligned with the sustainable awareness categories. The sustainable awareness categories are presented in table below.

Table 3. Categories of Sustainable Awareness

Average	Category	Meaning
0 – 50 %	Low	Habit not practiced
51 – 70 %	Medium	Habit occasionally prarticed
71 – 100 %	High	Habit always Practiced

Clarisa et al., 2020)

Data analysis of the student response questionnaire on the inquiry-based learning infused with education for sustainable development. This questionnaire asks for "yes" and "no" answers, where a "yes" answer is given a score of 1 and a "no" answer is given a score of 0 for positive statements, and the reverse for negative statements. The student response questionnaire is analyzed by percentage (%) using the Formula 3.

$$\%\ \text{student respon} = \frac{\text{Score obtained}}{\text{Maximal total score}} \text{x} 100\% \qquad (2)$$

Once the data is obtained in numerical form, the next step is qualitative interpretation using the student response percentage categories presented in table below.

Table 4. Percentage Categories for Student Response Questionnaire

Persentase	Klasifikasi
81-100%	Verry good
61-80%	Good
41-60%	Fair
21-40%	Poor
0-20%	Verry poor

(Arikunto, 2014)

Result and Discussion

Findings and discussions are presented in three sections according to the research questions posed. The first section provides an overview and analysis of how the inquiry-based learning model, integrated with ESD, affects students' critical thinking abilities. The second section will present the results and analysis of how the inquiry-based learning model integrated with ESD impacts students' awareness of sustainability. The third section will contain findings and discussions on the relationship between critical thinking skills and sustainable awareness of students in the inquiry-based learning model infused with education for sustainable development.

To compare critical thinking skills between experimental and control classes, N-Gain scores were calculated. This analysis evaluated the effectiveness of the inquiry-based learning model integrated with ESD content in enhancing critical thinking abilities, based on the percentage of N-Gain scores from both classes., as shown in the following figure.

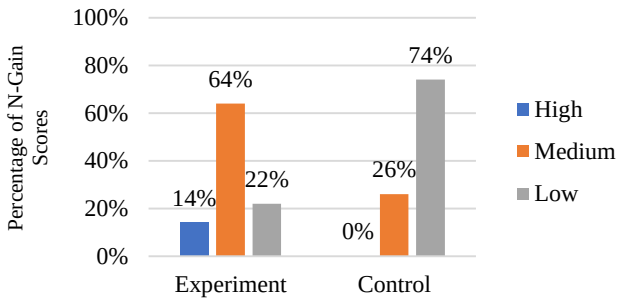

Figure 2. The Percentage of N-Gain Scores for Students Critical Thinking Skills.

Based on the figure, it can be noted that the majority of the experimental class experienced an improvement in critical thinking skills. In the experimental class, the distribution of N-gain categories was as follows: 22% (approximately eight students) were in the low category,

64% (twenty-three students) were in the moderate category, and 14% (five students) were in the high category. Meanwhile, in the control class, the distribution was different: 74% (equivalent to twenty-six students) were in the low category, and only 36% (nine students) were in the moderate category.

This indicates that the application of the inquiry-based learning model infused with ESD content in the experimental class can enhance students critical thinking skills. Based on these results, it can be interpreted that if students are frequently given exercises in critical thinking activities, their critical thinking abilities can develop optimally. This statement is consistent with the research conducted by Winarso et al., (2023) which suggests that through critical thinking, students can automatically solve both simple and complex problems, both in the classroom and in everyday life. Prasasti et al., (2023) also state that if critical thinking skills are effectively practiced, it will increase students' interest in learning and their confidence in problem-solving. As a result, students' learning outcomes will reach an optimal level.

Next, an analysis of students' critical thinking abilities on each indicator is conducted to assess whether the students critical thinking skills on each indicator are either adequate or insufficient before and after the implementation of the learning in the experimental and control classes. The following table shows the distribution of average pre-test and post-test scores for students on each critical thinking ability indicator.

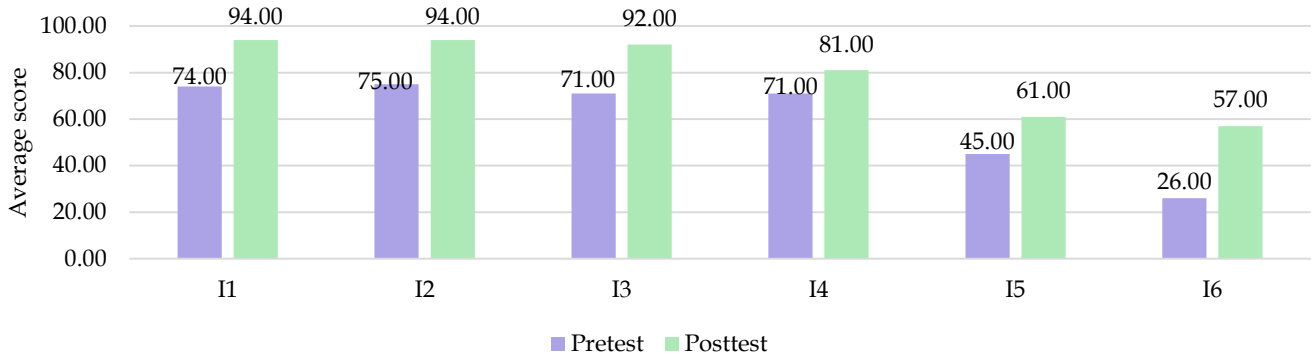

Figure 3. Average Scores of Pre-Test and Post-Test on Critical Thinking Abilities for Each Indicator in the Experimental Class

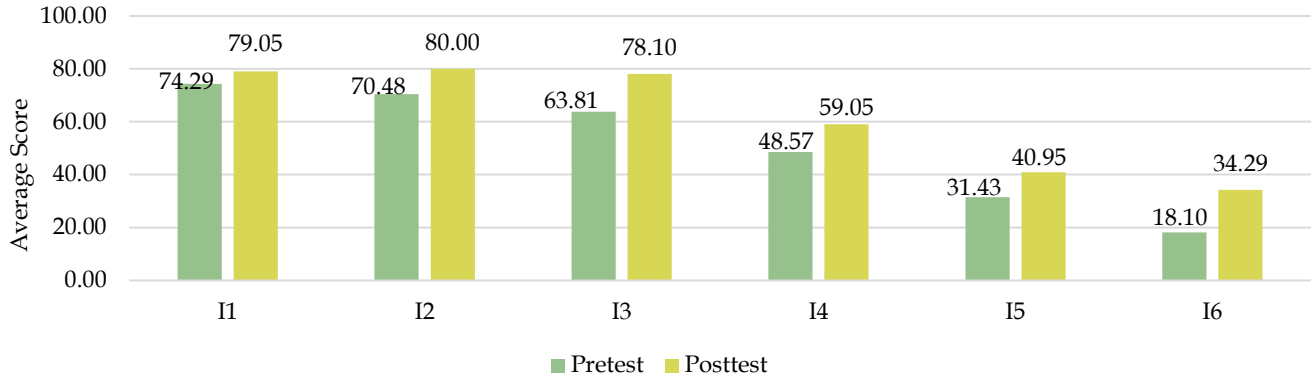

Figure 4. Average Scores of Pre-Test and Post-Test on Critical Thinking Abilities for Each Indicator in the Control Class

In the pre-test of the experimental class, the highest average score for critical thinking skills was obtained in the analysis indicator, with an average score of 75.00, categorized as sufficient. The lowest score was obtained in the self-regulation indicator, with an average score of 26.00, categorized as very poor. For the post-test in the experimental class, the highest scores were achieved in the interpretation and analysis indicators, with an average score of 94.00, categorized as very high. The lowest score was in the self-regulation indicator, with an average score of 57.00, categorized as sufficient. In the control class, the highest average score for critical thinking skills in the pre-test was 74.29 in the interpretation indicator, categorized as sufficient. The lowest score was in the self-regulation indicator, with an average score of 18.10, categorized as very poor.

Each indicator of critical thinking skills is interrelated, so if one or even three or more indicators have low average values, it will affect the other indicators. Critical thinking skills are essential in the

current education system. With critical thinking skills, a student not only absorbs knowledge and accepts others opinions but is also capable of generating new knowledge, new ideas, or new works. Students critical thinking abilities will be effective if supported by good competencies, such as the pedagogical competencies of teachers. Pedagogical competence refers to a teacher's ability to understand students behaviors and characteristics, implement the curriculum, conduct classroom instruction, and evaluate learning to realize the various potentials in skills, attitudes, and intellectual abilities, starting from the initial critical thinking skills (Suci et al., 2019; Syarifuddin, 2020).

Each critical thinking indicator is interrelated, so if one or even all four indicators are low, it will impact the other indicators. The detailed analysis of the impact of applying the inquiry-based ESD learning model on each critical thinking indicator will be discussed in the following points.

Interpretatation

The first indicator of critical thinking skills, according to Facione (2015), is interpretation. Interpretation involves the ability to understand and interpret the meaning of data or information. In other words, interpretation is the skill of comprehending and explaining the meaning of the information received. The following are the average percentages of pre-test and post-test scores for the interpretation indicator in the experimental and control classes.

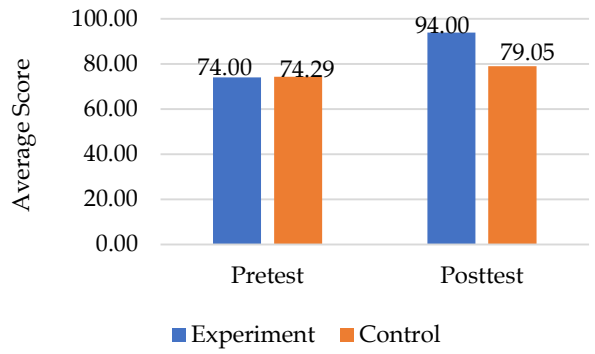

Figure 5. Average Scores for the Interpretation Indicator in the Experimental and Control Classes.

According to Figure 5, the initial data on students critical thinking skills, prior to applying the ESD-integrated inquiry-based learning model for the interpretation indicator, indicated an average score of 74.29 in the control class and 74.00 in the experimental class, with a 0.29 point difference between the two classes at the start. Following the introduction of the ESD-integrated inquiry-based learning model in the experimental class, the average post-test score for the interpretation indicator rose to 94.00, which falls into the very good category. Conversely, while the control class also showed improvement, it was less pronounced, with an average post-test score of 79.05, reflecting a modest increase of 4.76 points from the pre-test average.

It can be concluded that the application of the inquiry-based learning model integrated with ESD in the experimental class has effectively improved students' critical thinking skills on the interpretation indicator. This is because the learning approach and the context provided by ESD, which include real and relevant environmental, social, and economic issues, enable students not only to understand the available information but also to interpret it within a broader context. This process encourages students to think critically and deeply about the material being studied, rather than merely memorizing or understanding it at a basic level.

Analysis

The analysis indicator involves the ability to investigate and identify relationships between statements, data, concepts, and the ability to draw conclusions. After understanding the importance of the analysis indicator in critical thinking skills, the following presents the average pre-test and post-test scores for the analysis indicator in the experimental and control classes, as shown in the Figure 6.

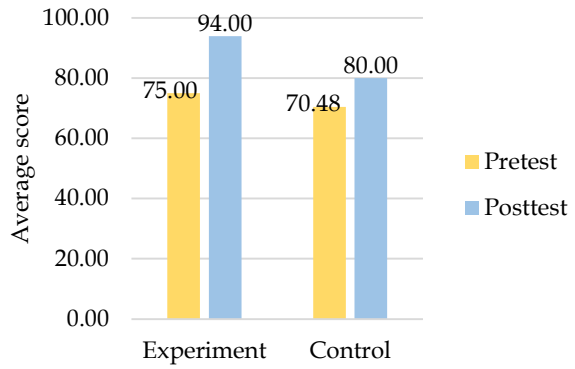

Figure 6. Average Scores for the Analysis Indicator in the Experimental and Control Classes

Based on Figure 6, it can be observed that the average pre-test score for the analysis indicator in the experimental class was 75.00, while in the control class it was 70.48, resulting in a 4.56 point difference in initial critical thinking abilities between the two classes. After applying the inquiry-based learning model with ESD content to the experimental class, the average post-test score increased to 94.00, which falls into the very good category. In contrast, the control class, which also received the inquiry-based learning model treatment but without ESD content, showed an increase in the average

score to 85.00, falling into the good category. Both classes experienced improvements, although the experimental class showed a higher increase compared to the control class. Therefore, it can be concluded that the application of the ESD-based inquiry learning model effectively enhances the analysis indicator in students' critical thinking abilities, as the learning process integrates steps that require students to identify, analyze, and evaluate problems, and provide in-depth solutions, compared to only applying the inquiry-based learning model without ESD content as implemented in the control class.

This finding is consistent with research by Risnanosanti et al., (2019) which emphasizes the importance of analyzing information in accordance with existing data, allowing students to solve problems accurately. The "analyze and evaluate" syntax in this inquiry-based learning model is highly effective in developing analytical skills for critical thinking, as it encourages students to understand the causes of problems, gather and analyze data, and evaluate solutions based on relevant evidence. Since analytical skills support the overall critical thinking process by providing a solid foundation for inference, evaluation, and explanation, the implementation of the inquiry-based ESD model not only enhances students analytical abilities but also fosters awareness of the importance of sustainability in addressing complex global issues.

Inference

The inference indicator refers to students' ability to draw logical and reasoned conclusions based on available information or evidence. Inference involves a thinking process that connects existing data or arguments to form new understanding or make decisions. To gain a better understanding, the average pre-test and post-test scores for critical thinking skills related to the inference indicator are shown in Figure 7.

Based on Figure 7 it can be observed that the average pre-test score for the experimental class is higher compared to the control class. The experimental class has an average pre-test score of 71.00, while the control class has an average score of 63.81. Each class was then given a treatment, with the experimental class receiving the inquiry-based learning model integrated with ESD. The average post-test score for the experimental class increased to 92.00, whereas the control class's post-test score increased to 78.10. Both classes experienced improvement, but the experimental class, which received the ESD-integrated inquiry-based learning model, showed a greater increase. This may be because the ESD content provided a more diverse and meaningful context for students during the learning process. Through the inquiry-based learning model, students learn to develop better inference skills by connecting existing facts and making reasonable conclusions (Nirfayanti et al., 2022). This finding aligns with research by (Nurlina et al., 2022), which states that the improvement in students' critical thinking skills is influenced by their ability to access information easily. Students not only passively receive information but also actively process and analyze it to draw more accurate and in-depth conclusions during the learning process.

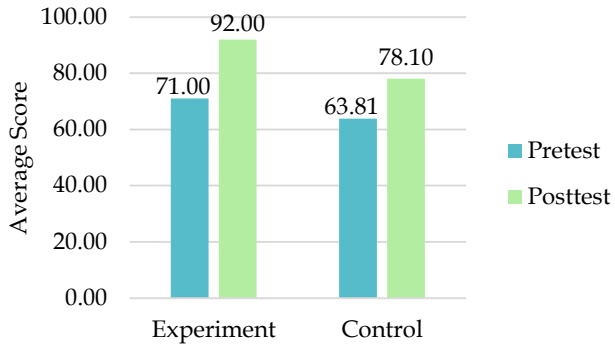

Figure 7. Average Scores for the Inference Indicator in the Experimental and Control Classes

Evaluation

This evaluation indicator involves the ability to assess the credibility of a statement or representation, as well as to access the relationships between statements, data, facts, concepts, or other forms. Evaluation is key to assessing the quality of information, arguments, and evidence available. Without strong evaluation skills, one may accept invalid arguments or make decisions based on inaccurate information. The following presents the average scores for the evaluation indicator of students in the experimental and control classes.

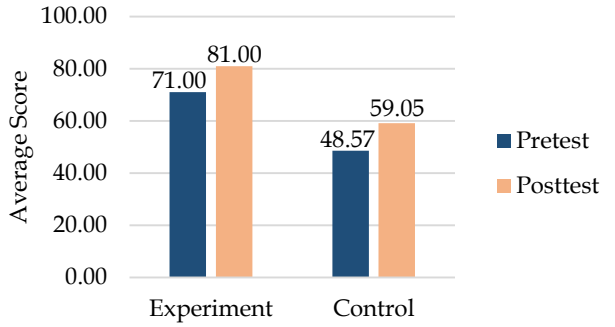

Figure 8. Average Scores for the Evaluation Indicator in the Experimental and Control Class

Based on Figure 8, the initial average score for critical thinking ability on the evaluation indicator was 71.00 for the experimental class, which falls into the "fair" category, and 48.57 for the control class, which falls into the "poor" category. This indicates that the experimental class had a higher initial capability for the evaluation

indicator compared to the control class. Subsequently, both classes were treated: the experimental class achieved a post-test average score of 81.00, which falls into the "good" category, while the control class achieved a post-test average score of 59.05, which falls into the "fair" category. The increase in the average score for the evaluation indicator shows that the students were able to effectively identify, analyze, and evaluate the information they received.

Explanation

In the context of learning and assessment, understanding the explanation indicator helps us evaluate how effectively students present and explain their arguments, which is a crucial aspect of critical thinking. Below is a diagram showing the average scores for the explanation indicator in both the experimental and control classes, providing an overview of the development of students' ability to express and explain arguments effectively.

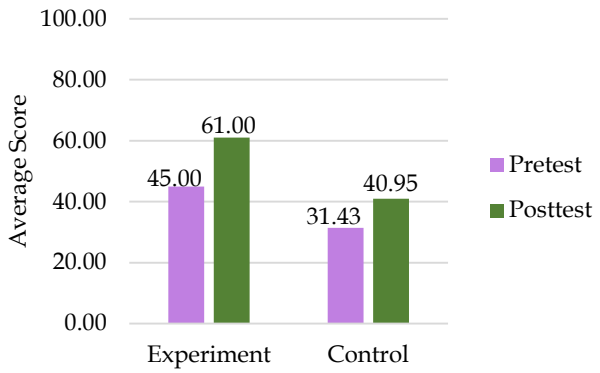

Figure 9. Average Scores for the Explanation Indicator in the Experimental and Control Class

Based on Figure 9 the initial data for the explanation indicator showed that the experimental class had an average score of 45.00, which falls into the low category, while the control class had an average score of 31.43, which falls into the very low category. The low average scores for the explanation indicator were due to a lack of deep understanding of the material being studied. Consequently, when students do not fully grasp the concepts being taught, they tend to struggle with connecting relevant information and providing logical and coherent explanations. Both classes were then subjected to the same treatment, resulting in improvements for both. The experimental class showed an increase of 61.00, whereas the control class showed an increase of 40.95. The experimental class experienced a higher average score improvement compared to the control class, indicating that the implementation of the inquiry-based learning model with ESD content effectively enhanced the explanation indicator.

The application of the inquiry-based learning model with ESD content positively impacts students' explanation skills. This model engages students in actively gathering and analyzing information from various sources, helping them understand topics more deeply. It promotes independent research, allowing students to identify questions, seek answers, and organize information, which enhances critical thinking, analysis, and synthesis key components for effective explanation skills.

This statement aligns with the study conducted by (Hsu, Ching, & Grabowski, 2019), which explored the effect of inquiry-based learning on students explanation skills in the context of science. They found that students involved in inquiry-based learning showed improvement in their explanation skills, including their ability to summarize information, organize ideas, and communicate their understanding more clearly. Additionally, research by (Wu, Hsu, & Wu, 2018) examined the application of inquiry-based learning in mathematics education and its impact on students' explanation skills. Their findings showed that students engaged in inquiry-based learning had better explanation skills, including their ability to present mathematical problem-solving processes logically and coherently.

Self-regulation

The self-regulation indicator involves the ability to monitor oneself in applying, analyzing, and evaluating previous thinking outcomes to solve a problem. In other words, self-regulation helps students become more independent because they are not entirely reliant on the teacher to guide their thinking. Below are the average pre-test and post-test scores for the self-regulation indicator in critical thinking skills for the experimental and control classes.

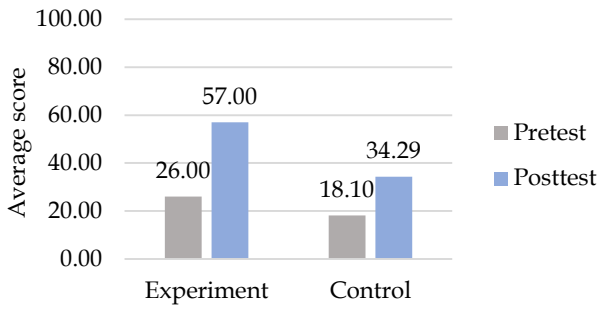

Figure 10. Average Scores for the Self-Regulation Indicator in the Experimental and Control Classes

Based on Figure 10, the initial average score for the self-regulation indicator in critical thinking skills was 26.00 for the experimental class and 18.10 for the control class, both of which fell into the very poor category.

After the intervention, the experimental class showed an improvement to 57.00, while the control class also improved to 34.29. Overall, both classes experienced an increase, but the experimental class had a higher improvement compared to the control class. This is because the experimental class was given the treatment of applying the inquiry-based learning model with ESD content. The difference in improvement between the experimental and control classes may be indicated by variations in individual characteristics, such as personality, intrinsic motivation, or family background, which can influence self-regulation levels, along with the application of the inquiry-based learning model with ESD content in the experimental class.

Self-regulation is vital in inquiry-based learning as students must independently plan and organize tasks like designing experiments, collecting data, and preparing reports. Effective self-regulation helps in maintaining clear direction, preventing biased thinking and emotional control issues. It enables students to manage their thought processes, from information gathering to decision-making, leading to more effective problem-solving and higher quality analyses.

The findings focus on how implementing the inquiry-based learning model with ESD content affects students' sustainable awareness. The sustainable awareness questionnaire consists of three constructs: knowledge, attitude, and behaviour, with each construct comprising 9 statements integrated by environmental, social, and economic dimensions. Sustainable awareness refers to the understanding, attitudes, and actions that reflect an awareness of the importance of maintaining a balance between economic, social, and environmental needs for both present and future generations. This awareness encompasses various aspects such as resource conservation, reducing negative environmental impacts, and contributing to social well-being. Below is the data on the percentage of N-Gain scores for the experimental and control classes can be seen in Figure 11.

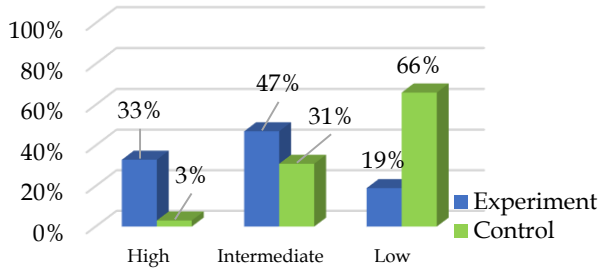

Figure 11. Percentage N-Gain scores of Sustainable Awareness in Experimental and Control Classes

Based on the presented figure, In the experimental class, 19% of students, or approximately seven participants, were categorized as low, 47% or seventeen participants were categorized as medium, and 33% or twelve participants were categorized as high. In the control class, 66% of students, or approximately twenty-three participants, were categorized as low, 31% or eleven participants were categorized as medium, and 3% or one participant was categorized as high. Thus, it is concluded that learning with the application of the inquiry-based learning model with ESD content has a significant influence.

The inquiry based learning model combined with ESD content can enhance students' sustainability awareness, especially concerning environmental issues. This approach encourages active student participation, making learning more meaningful and relevant. By engaging directly with the material, students gain a deeper understanding of the connections between environmental, social, and economic systems, as well as practices for sustainable activities (Niaga et al., 2023).

The application of the inquiry-based learning model with ESD content in the experimental class significantly enhances students sustainability awareness compared to the control class. This is because the ESD content addresses real-world issues relevant to students' daily lives, such as climate change, natural resource management, and social welfare. By connecting the material to real-world contexts, students gain a deeper understanding of sustainability and the impact of their actions on the environment and society. Further details on each aspect of students sustainability awareness will be provided based on the following points.

Knowledge Construction

The construction of knowledge in sustainable awareness refers to theoretical thinking about sustainability issues that reflect the environmental, social, and economic dimensions of sustainable development. Gericke et al. (2019) explain that knowledge construction involves fundamental thinking about sustainability that is useful for investigating knowledge in sustainable awareness. The average scores of the pre-test and post-test for students' sustainable awareness in the knowledge construction for both the experimental and control classes are presented in Figure 12.

Based on the figure above, average of the pre-test and post-test scores for knowledge construction in the control and experimental classes show only a slight difference. The experimental class had an average pre-test score of 78.78, while the control class had an average pre-test score of 78.25. Both classes were then given the same treatment. As a result, both classes experienced improvement. In the experimental class, the improvement was significant, with the average pre-test score rising from 78.78 to 85.03. In contrast, the control

class saw only a slight increase, with the average pre-test score rising from 78.25 to 78.33, reflecting an increase of just 0.08.

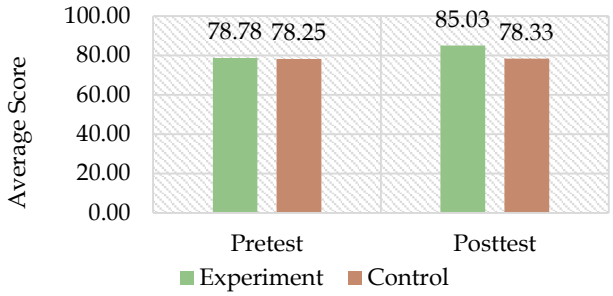

Figure 12. Average Scores of The Pre-Test and Post-Test for Students Sustainable Awareness in The Knowledge Construction

The post-test results indicate that the ESD-focused inquiry-based learning model enhanced students' contextual understanding of sustainability issues in the experimental class. This model actively engaged students by incorporating real-world contexts and integrating disciplines like biology, geography, economics, and sociology, which provided a comprehensive view of sustainability. It also fostered the development of students' critical thinking skills. This aligns with Berglund et al., (2020), who state that ESD-related learning aims to integrate cognitive and affective aspects by combining knowledge, values, and attitudes. Sustainable development involves achieving equity across three aspects: environmental, social, and economic. The results of measuring knowledge indicators for these three aspects after implementing an inquiry-based learning model with ESD content can be seen in Figure 13.

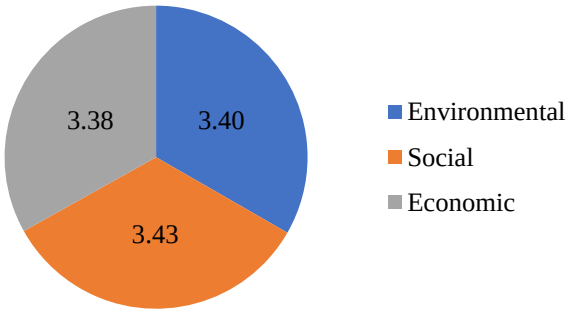

Figure 13. Average Scores for the Sustainable Awareness Aspect in Knowledge Construction

The figure presented above shows that the highest average scores were obtained for the social knowledge construction aspect with an average score of 3.43, and for the environmental aspect with an average score of 3.40. This suggests that students' understanding of sustainable development is mainly centered on social and environmental aspects, with limited knowledge about economic sustainability. Educators need to incorporate economic sustainability literacy into their teaching to broaden students understanding. Implementing inquiry based learning with ESD content helps students become more aware of sustainability issues, including the social and economic dimensions that are less familiar to them. This approach enhances students' overall knowledge of sustainability across environmental, social, and economic dimensions (Msengi et al., 2019).

Attitudes construction

The construction of attitudes toward sustainable awareness begins with individual awareness of existing environmental and social issues, including understanding the negative impacts of human activities on the environment and society, as well as the desire to contribute to sustainable solutions. The construction of attitudes is also related to values, beliefs, and individual reactions to objects, situations, and other individuals within the scope of sustainable development (Berglund et al., 2020). The average pre-test and post-test scores of students' sustainable awareness in the attitude construction for the experimental and control classes are shown in Figure 14.

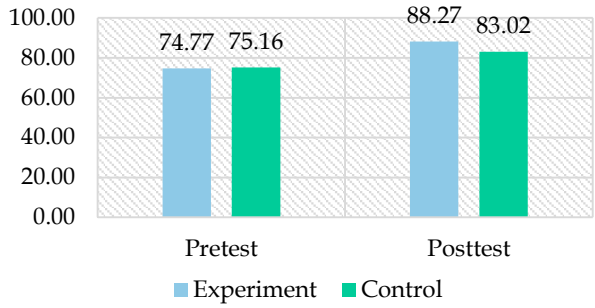

Figure 14. The Average Pretest and Post-Test Scores of Attitude Construction in the Experimental and Control Class

Based on the data presented above, the average pre-test score for the experimental class was 74.77, while the control class had an average of 75.16. The small difference in pre-test scores indicates that both groups had nearly the same initial abilities, making them ideal for evaluating the effectiveness of the intervention applied to the experimental class. Afterward, both the experimental and control classes received their respective treatments. Following the treatment, the average post-test scores for both classes increased. The experimental class's average score increased from 74.77 to 88.27, while the control class's average score rose from 75.16 to 83.02.

After the treatment was given to both classes, the difference in the average post-test scores between the two classes became apparent, with the experimental class having a higher average post-test score compared to the control class. Based on the results of inferential statistical testing with a mean difference test between the experimental and control classes, there is a significant difference in attitude awareness levels at the end of the learning process (p-value (0.000)<(0.002)). This shows that the learning process applying the inquiry-based learning model with ESD content has a significant impact on students' attitude awareness because during the learning process, students are required to be more actively involved in exploring sustainability-related issues.

This improvement will not only enhance their understanding of environmental issues but also help them internalize sustainability values more deeply. This aligns with the statement by Berglund et al., (2020) that the improvement in attitude construction is influenced by the students' cultural background and that through the application of the inquiry-based learning model with ESD content, students are trained to develop pro-environmental values and perceptions. The following data presents the measurement results for attitude construction in three aspects: environmental, social, and economic.

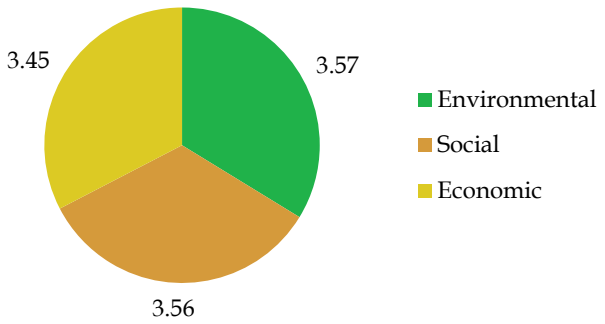

Figure 15. Aspects of Students' Sustainable Awareness in Attitude Construction

Based on the data presented above, shows that the highest average score for the sustainable awareness aspect in the attitude construction was obtained for the environmental aspect, with an average score of 3.57. The second highest was the social aspect, with an average score of 3.45. This suggests that students primarily focus on social and environmental aspects of sustainable development, while their awareness of economic sustainability is relatively low. This is due to insufficient prior knowledge about economic sustainability, which influences their attitudes. Developing constructive attitudes requires consistent conditioning; students need continuous and regular training to be concerned, observe, and question the objects and phenomena they encounter (Sugiarto & Gabriella, 2020).

Attitudes are more easily formed when students have direct experiences. Direct exposure helps them understand and feel impacts firsthand. For environmental sustainability, students who visit or live in polluted areas can personally experience the effects, making it easier to develop related attitudes. In social sustainability, observing and feeling the impacts of their surroundings also aids in forming attitudes. However, despite observing economic factors, developing attitudes towards economic sustainability remains challenging for students.

Behavioral Construction

In this study, the construction of behavior refers to a form of awareness where an individual or group not only recognizes environmental issues but is also able to take concrete actions to address or minimize the negative impacts of these problems, in other words, to support sustainable development. The average results of students sustainable awareness in terms of their behavioral constructs before and after treatment are shown in Figure 16.

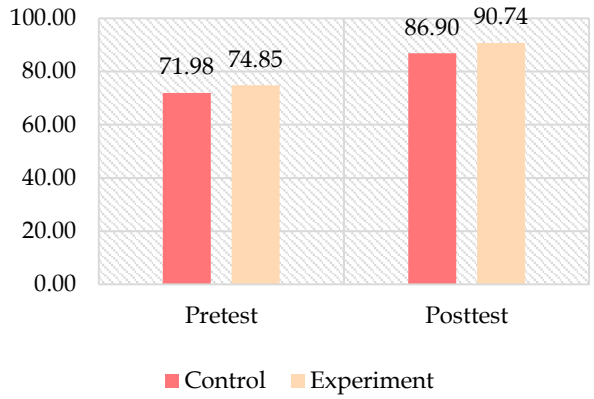

Figure 16. The Average Pretest and Post-Test Scores of Behavior Construction in the Experimental and Control Classes

Based on the results the average pre-test score for behavior construction in the experimental class was 74.85, while in the control class, it was 71.98. The difference in pre-test scores between the experimental and control classes was 2.87. After the treatment was administered, both classes showed improvement. The experimental class increased from 74.85 to 90.74, while the control class, which initially had an average score of 71.98, increased to 86.90.

This improvement was confirmed by inferential statistical tests using a t-test for differences in means, which revealed a significant difference in attitude awareness between the experimental and control classes

at the end of the learning period (p-value < 0.000). This indicates that the application of the inquiry-based learning model with an ESD component had a significant impact on students behavioral awareness in the experimental class. This finding is consistent with the opinion of Badea et al., (2020), which suggests that improvements in behavioral construction are influenced by teacher involvement during the learning process. The results of the measurements for behavior indicators in the three aspects after applying the inquiry-based learning model with an ESD component can be seen in Figure 17.

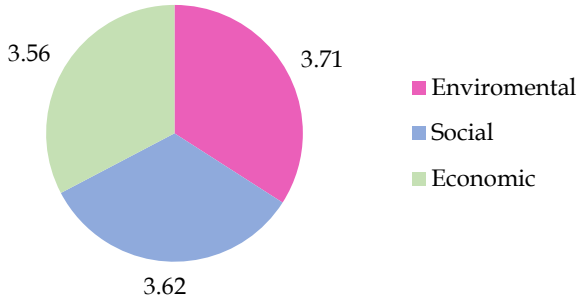

Figure 17. Average Score of Sustainable Awareness Aspect in Behavioral Construction

From the graph presented in the Figure, it is shown that the highest average N-gain values were obtained for the behavioral indicators in the environmental aspect with a value of 0,16 and the social aspect with a value of 0,10. This indicates that students behavior regarding sustainable development is predominantly influenced by environmental and social components. In contrast, students behavior regarding the economic aspect remains relatively low. This is because students previous attitudes toward economic sustainability were also low, which affects the behavior that is formed.

One strategy for applying the inquiry-based learning model with an ESD component to improve behavioral construction is to divide students into groups and involve them in an environmental project, like a "reduce" initiative. This approach encourages student engagement with sustainability issues in their surroundings, boosting their motivation to participate in community projects and initiate sustainability activities within the school.

The final discussion concerns the relationship between critical thinking skills and sustainable awareness in the application of the inquiry-based learning model with an ESD component. To determine the relationship between students critical thinking skills and sustainable awareness in the application of the Inquiry-Based Learning Model with an ESD component, a correlation test was conducted. The results of the correlation test between students' critical thinking skills and sustainable awareness can be seen in Table 6.

Tabel 6. Correlation Analysis of Critical Thinking Skills and Sustainable Awareness

Data	Critical Thinking	Sustainable Awareness
Average	70,06	88,05
N	36	36
Normality Test (Shapiro-Wilk)	0.208 Normal	0.687 Normal
Linearity Test (Deviation from linearity)		0.444 Linier
Correlation Test (Rank Spearmen Correlation)		0.317 Moderately strong 0.048 Significant

Based on Table 6, the results of the correlation test show a moderately strong correlation between critical thinking skills and students sustainable awareness. This is indicated by a correlation coefficient of 0.317, which falls into the category of a moderately strong correlation. Additionally, the positive correlation coefficient indicates a direct relationship between the two variables, meaning that as critical thinking skills increase, students' sustainable awareness also improves.

Table 6 also shows a significance value (sig) (2-tailed) of 0.048. According to the decision rule for correlation tests, if the sig. value is less than 0.05, there is a significant relationship. Therefore, it can be concluded from the table that there is a significant, moderately strong, and direct relationship between critical thinking skills and students' sustainable awareness. This means that critical thinking skills and sustainable awareness are interrelated in the context of inquiry-based learning that integrates ESD.

Critical thinking skills are crucial for integrating with ESD because they enable students to understand, evaluate, and make informed decisions about sustainability issues. These skills help students analyze problems from various perspectives and find innovative solutions. Inquiry-based learning enhances sustainable awareness by allowing students to deeply explore sustainability issues. Through critical thinking, students also grasp the impact of their actions on the environment and society, fostering a commitment to sustainability.

Conclusion

Integrating the inquiry based learning model with ESD enhances students critical thinking and sustainable awareness. This approach prompts students to tackle complex problems from holistic perspectives,

considering economic, social, and environmental aspects. In contrast, using the inquiry model alone might lead to focusing on simpler, less relevant problems within a single discipline. ESD content fosters environmental responsibility and supports the achievement of the SDGs by promoting sustainability awareness, integrating knowledge from various fields, and encouraging students to address global challenges and contribute to a sustainable future.

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D The authors declare no conflict of interest

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