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Elementary School Students' Understanding of the Relationship Between Environmental, Social, and Economic Aspects Through Biology Education

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Abstracts

Elementary school students' understanding of the interrelationship between environmental, social, and economic aspects serves as a crucial foundation for fostering early awareness of sustainability. This study aims to analyze the effect of a contextual-based biology education approach on improving students' understanding across five key aspects: environmental understanding, social understanding, economic understanding, analytical ability of interconnection, and sustainability awareness. The research employed a quantitative method using a quasi-experimental design of the Nonequivalent Control Group Design type. The subjects consisted of 22 fifth-grade students divided into two groups: experimental and control. Instruments included tests, questionnaires, and observation sheets. Data were analyzed using normality tests, homogeneity tests, independent samples t-tests, linear regression, and multicollinearity tests. The results indicate that the contextual learning approach has a significant effect on all student understanding variables, with the majority of students in the experimental group achieving high scores, particularly in environmental understanding and sustainability awareness. The t-test showed a significant difference between the experimental and control groups, while the regression analysis revealed a positive relationship between variable X and all Y variables. These findings support the effectiveness of contextual approaches as a holistic learning strategy in elementary education.

Keywords: Biology Education; Contextual Learning; Student Understanding; Sustainability

1. Introduction

Elementary school students' understanding serves as a crucial foundation in the learning process, as this stage marks the beginning of their development of fundamental concepts across various areas of knowledge and skills (Nurliana & Wahyuningsih, 2023). Good understanding is characterized by the ability to connect new information with prior knowledge, to rephrase material in their own words, and to apply it in different contexts. Therefore, contextual and concrete learning strategies that involve direct experiences are essential to help students absorb the material more effectively (Santi, 2023). Students' understanding is also influenced by both internal and external factors, such as learning motivation, parental support, the learning environment, and the teacher's instructional approach (Sharma, 2023). Teachers need to recognize students' cognitive development levels and select appropriate media and methods, such as visual aids, educational games, or meaningful storytelling (Castejón et al., 2022). When students understand the material deeply, they are not only able to

answer questions correctly but also demonstrate critical and creative thinking, along with a high level of curiosity toward learning.

Elementary school students' understanding of the interrelationship between environmental, social, and economic aspects plays a vital role in shaping early awareness of sustainability (Fidrayani & Serojaningtyas, 2023). Through biology education, students can be introduced to the concept of the interconnectedness between living organisms and their environment, as well as the impact of human activities on ecosystem balance and the socio-economic well-being of communities. An educational approach that emphasizes the integration of these three dimensions not only enriches students' scientific knowledge but also fosters values such as empathy, responsibility, and sustainable decision-making. Therefore, biology learning at the elementary level should be designed using a contextual and interdisciplinary approach to develop a comprehensive understanding that is both meaningful and relevant to students' daily lives (Wulaningsih et al., 2024).

The gap in elementary school students' understanding of the relationship between environmental, social, and economic aspects through biology education lies in the limited integration of cross disciplinary content within the learning process (Shobirin et al., 2024). Many teachers still deliver biology material in isolation, without connecting it to relevant social and economic contexts present in students' everyday lives. As a result, students tend to grasp biological concepts in a fragmented way and struggle to see their connection to local environmental issues or their implications for community social and economic life (Nafisah & Bisri, 2024). The lack of integrated thematic approaches hinders students from developing the holistic understanding needed to face the challenges of the twenty first century. Another issue is the limited availability of contextual learning resources and media that can concretely illustrate the interconnection between these three aspects (Rindawati et al., 2020). Many elementary schools, particularly in remote areas, still lack access to teaching materials that promote environmental exploration and critical discussion of social and economic issues within a biological framework (Dewahrani et al., 2024) (Im, 2020) (Lee & Kim, 2024). On the other hand, a significant challenge for teachers is how to simplify complex concepts such as human dependence on nature or the environmental impact of economic activities so they are accessible to young learners. This requires improving teachers' capacity to design biology instruction that incorporates social and economic values and is grounded in students' real life experiences (Yamamoto et al., 2023).

Previous studies have shown that integrating environmental education into biology learning at the elementary level can enhance students' understanding of the interconnections among ecological, social, and economic aspects. According to (Kurniasari et al., 2024), an integrated thematic approach is effective in fostering environmental awareness and social responsibility from an early age. Research by (Baiduri, 2020) also emphasizes the importance of incorporating local contexts in biology education to strengthen the relevance of the material to students' everyday lives. Meanwhile, (Awalina et al., 2023) found that the use of real environmental media helps students comprehend the impact of human activities on ecosystem balance. The findings of (Lestari et al., 2024) indicate that social ecological project-based learning enhances students' critical thinking skills. In addition, (Kurino & Herman, 2023) stated that utilizing local resources as learning materials enables a more meaningful integration of economic and social issues within biology content. (Kim et al., 2024)

further supports the idea that holistic biology education can foster students' awareness of the importance of environmental sustainability in community life.

Research on elementary school students' understanding of the relationship between environmental, social, and economic aspects through biology education was conducted in response to the growing importance of strengthening integrated ecological literacy from an early age. The proposed solution is to design biology instruction using a contextual and interdisciplinary approach, enabling students to comprehend the interconnection between scientific knowledge and real life in a more holistic manner. The purpose of this study is to identify the extent to which students understand these interrelationships and how biology education can be utilized as a means of fostering environmental awareness that also encompasses social and economic dimensions. This topic is considered relevant and worth exploring due to the limited number of studies that examine the integration of these three aspects in the context of elementary education, despite the urgent need for comprehensive understanding to prepare students for global challenges such as climate change, social crises, and economic inequality, which are deeply interconnected.

The problems and objectives, as well as the usefulness of the research, are written narratively in paragraphs, without needing to be given special subtitles. Likewise, operational definitions, if deemed necessary, are also written narratively. The introduction is written in Cambria 12 upright, with font (Cntl 1), Length in the introduction 2-4 pages.

2. Research Methods

This study employed a quantitative approach using a quasi-experimental design of the Nonequivalent Control Group Design type. The population consisted of 22 fifth-grade students from a public elementary school, divided into two groups. The group selection was carried out using purposive sampling, taking into account the equivalence of students' initial characteristics.

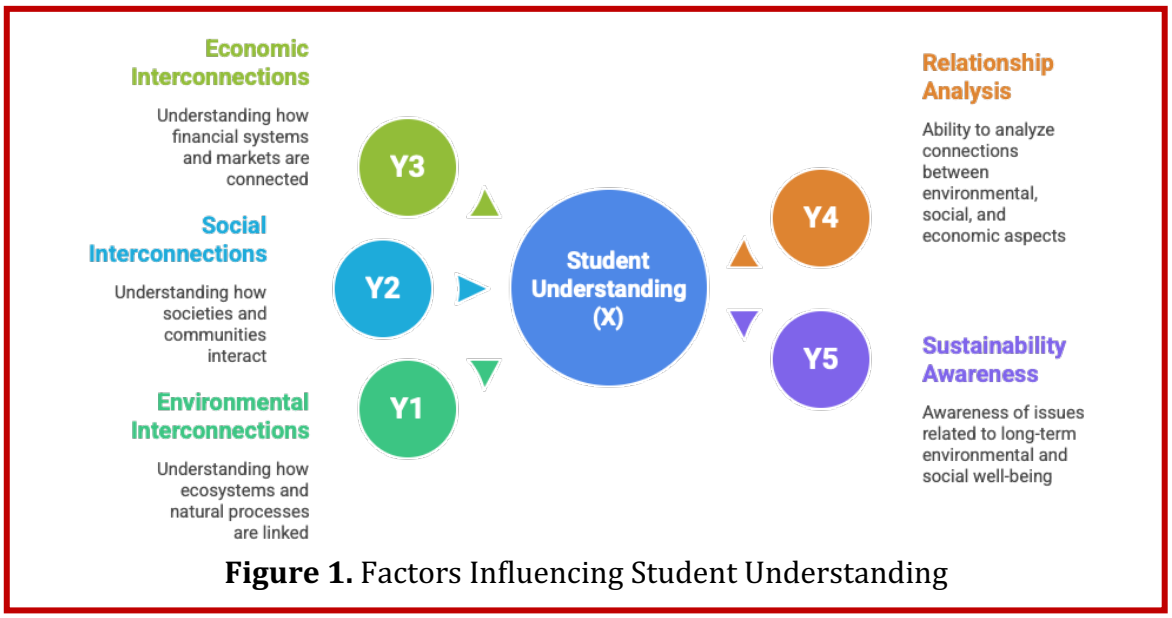

Figure 1. Factors Influencing Student Understanding

The independent variable (X) is contextual-based biology education, designed to integrate environmental, social, and economic topics into the learning process. The dependent variables consist of five aspects of student understanding: Y1 represents the

understanding of environmental interconnections; Y2, the understanding of social interconnections; Y3, the understanding of economic interconnections; Y4, the ability to analyze relationships among these aspects; and Y5, the awareness of sustainability issues.

The research instruments consisted of multiple-choice and open-ended tests to assess cognitive aspects (Y1–Y4), as well as a Likert-scale questionnaire to measure sustainability awareness (Y5). Data analysis began with tests for normality and homogeneity. This was followed by independent samples t-tests for each dependent variable, and a MANOVA analysis to examine the simultaneous effect of variable X on variables Y1 through Y5. This approach was used to explore the effectiveness of contextual learning in enhancing students' comprehensive understanding of the interrelationship between environmental, social, and economic aspects within the context of biology education.

Table 1. Indicators for Variables X, Y1–Y5

Variable	Indicator	Description
X (Contextual-Based Biology Education)	Relevance of material to real-life situations	Biology content is linked to students' everyday experiences
	Integration of environmental, social, and economic issues	Lessons include ecological, social, and economic dimensions
	Use of contextual media and learning resources	Learning sources are based on local and current events
	Active and exploratory learning activities	Students are engaged in discussions, observations, or problem-solving
Y1 (Understanding of Environmental Interconnections)	Explaining relationships among living things	Students describe food chains, ecosystems, and species interactions
	Identifying human impacts on the environment	Students understand negative effects such as pollution or deforestation
	Recognizing environmental conservation efforts	Students mention actions like recycling or tree planting
Y2 (Understanding of Social Interconnections)	Understanding the role of communities in environmental care	Students explain social contributions to environmental protection
	Linking environmental damage to social life	Students describe how environmental issues affect communities
	Appreciating collaboration in sustainability efforts	Students show respect for teamwork in environmental-social initiatives
Y3 (Understanding of Economic Interconnections)	Linking natural resources to economic activities	Students understand nature provides raw materials for the economy
	Identifying environmental damage affecting the economy	Students recognize economic consequences such as crop failure

	Understanding sustainable economy concepts	Students are introduced to environmentally friendly economic practices
Y4 (Ability to Analyze Interconnected Aspects)	Explaining the link among environment, society, and economy	Students analyze the interconnection of the three aspects in a case study
	Providing real-life examples of interconnected issues	Students give local or global examples of related events
	Drawing conclusions from analysis	Students summarize insights based on the relationship among the aspects
Y5 (Awareness of Sustainability Issues)	Showing care for the environment	Students actively participate in eco-friendly actions
	Understanding long-term impacts of human behavior	Students realize the importance of sustainable actions for future generations
	Developing sustainable habits	Students begin applying green habits in daily life

Data collection in this study was conducted using a combination of test instruments, questionnaires, and observation sheets tailored to each research variable. A multiple-choice and short-answer test was used to measure students' understanding of environmental (Y1), social (Y2), economic (Y3) interconnections, and analytical ability (Y4). Meanwhile, a Likert-scale questionnaire was employed to assess students' awareness of sustainability issues (Y5). The implementation of contextual-based biology education (X) was documented through classroom observation using a structured observation sheet. All instruments were developed based on the defined indicators for each variable and were validated by expert judgment before being administered to both the experimental and control groups. Data were collected over several sessions within the natural classroom setting to ensure the authenticity of students' responses and behaviors.

The data analysis in this study was conducted through several stages to determine the effect of the independent variable (X) on the five dependent variables (Y1–Y5). First, prerequisite tests were performed, including normality and homogeneity tests, to ensure that the data met the assumptions required for parametric analysis. Once the data met the assumptions, an independent samples t-test was used to compare the mean scores between the experimental and control groups for each dependent variable (Y1, Y2, Y3, Y4, and Y5). This test aimed to identify whether there were significant differences in student understanding and awareness resulting from the implementation of contextual-based biology education. In addition, a multivariate analysis of variance (MANOVA) was applied to examine the simultaneous effect of the independent variable on all five dependent variables. This analysis provided a broader understanding of how contextual learning influenced multiple aspects of student comprehension and sustainability awareness. The results of the statistical tests were interpreted using a significance level of 0.05. Effect size calculations (Cohen's d) were also conducted to determine the magnitude of the impact of the treatment. All statistical analyses were carried out using SPSS software to ensure accuracy and reliability in interpreting the research findings.

3. Results and Discussion

3.1 Results

Analysis of Elementary School Students' Understanding

The analysis of the percentage categories of questionnaire scores for each variable provides a general overview of elementary school students' understanding of contextual-based biology education and its connection to environmental, social, economic aspects, analytical ability, and sustainability awareness. The majority of students fell into the high category for almost all variables, particularly for variable X (contextual education) and Y5 (sustainability awareness). This indicates that learning approaches that relate content to real-life contexts can effectively foster students' comprehensive understanding and awareness. However, there were still some students in the medium and low categories, especially for variables Y2, Y3, and Y4, suggesting a need for strengthening students' analytical skills in connecting issues, as well as their understanding of economic and social dimensions within environmental contexts.

Table 2. Percentage Categories of Questionnaire Scores per Variable

Variable	High (≥ 81)	Medium (61–80)	Low (≤ 60)	Total Students
X	15 students (68.18%)	6 students (27.27%)	1 student (4.55%)	22
Y1	14 students (63.64%)	8 students (36.36%)	0 students (0.00%)	22
Y2	12 students (54.55%)	9 students (40.91%)	1 student (4.55%)	22
Y3	13 students (59.09%)	7 students (31.82%)	2 students (9.09%)	22
Y4	10 students (45.45%)	10 students (45.45%)	2 students (9.09%)	22
Y5	16 students (72.73%)	6 students (27.27%)	0 students (0.00%)	22

Based on the analysis of the percentage categories of questionnaire scores for each variable, it was found that the majority of students demonstrated a high level of understanding of contextual-based biology education (Variable X), with 68.18% of students falling into the high category. This indicates that a learning approach that is relevant to real-life experiences, integrative, and based on exploratory activities has been well received by students. Only one student (4.55%) was in the low category, suggesting that most students were able to engage with and understand the learning materials effectively. For environmental understanding (Variable Y1), 63.64% of students were in the high category, and no students were in the low category. This shows that students had a strong grasp of the interconnectedness of living organisms and the impact of human activity on the environment. The 36.36% of students in the medium category also indicates that there is still room to strengthen concepts related to conservation and ecological impact in instruction. Meanwhile, for social understanding (Y2) and economic understanding (Y3), the distribution of student scores was more balanced. In Y2, 54.55% of students were in the high category, while in Y3, the percentage was slightly higher at 59.09%. There were still students in the low category, amounting to 4.55% and 9.09% respectively, suggesting that the connection between environmental issues and social and economic aspects is not yet fully

understood by a small number of students. This highlights the need to design learning experiences that are more contextual and holistic. Variable Y4 (the ability to analyze the interconnection between environmental, social, and economic aspects) showed the most balanced distribution, with 45.45% of students falling into both the high and medium categories. This indicates that while many students have been able to recognize the relationships among these aspects, not all are yet able to analyze these interconnections in depth. However, in Variable Y5 (awareness of sustainability issues), a significant increase was observed, with 72.73% of students in the high category. This demonstrates that contextual education has effectively fostered a strong sense of environmental concern and long-term sustainability awareness among students.

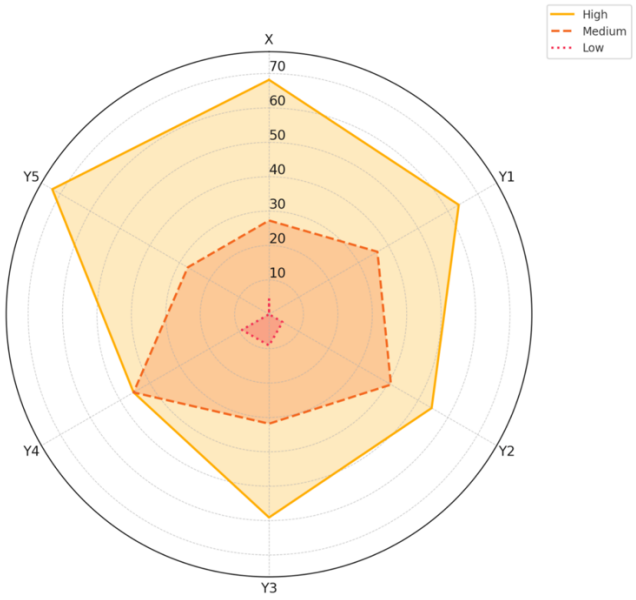

Figure 2. Radar Chart: Percentage Categories per Variable

Based on Figure 2, it is evident that the majority of elementary school students have demonstrated a good understanding of contextual-based biology education and its various interconnected aspects, particularly in terms of sustainability awareness and environmental understanding. The high percentage of students in the high category for variables X, Y1, and Y5 reflects the effectiveness of the contextual learning approach in fostering relevant and meaningful comprehension. However, challenges remain in strengthening students' analytical abilities regarding inter-aspect relationships, as well as their understanding of social and economic dimensions, as indicated by the presence of students in the medium and low categories for variables Y2, Y3, and Y4. Therefore, more integrative and application-oriented learning strategies are needed to help students develop a deeper understanding of cross-aspect relationships.

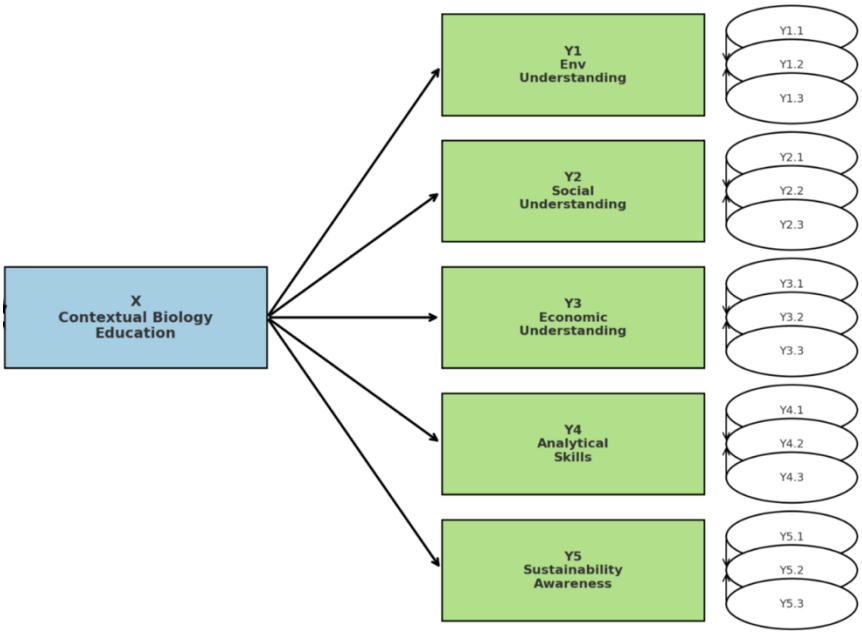

Figure 3. Model Konseptual Pengaruh Pendidikan Biologi Kontekstual

This model illustrates how the independent variable X, namely Contextual Biology Education, influences five main dependent variables (Y1 to Y5), each representing a dimension of student understanding: Y1 (Environmental Understanding), Y2 (Social Understanding), Y3 (Economic Understanding), Y4 (Analytical Skills), and Y5 (Sustainability Awareness). Each of these dimensions is further broken down into three specific indicators (e.g., Y1.1, Y1.2, Y1.3), which reflect measurable aspects of student understanding within each context. The model highlights that a context-based learning approach in biology education has the potential to holistically influence multiple aspects of student comprehension.

Normality Test

The normality test is a crucial initial step in statistical analysis, particularly prior to conducting parametric tests such as the t-test or regression analysis. The purpose of this test is to ensure that the data used in the study are normally distributed, as most parametric statistical methods assume data normality. In this study, the normality of each variable from Y1 to Y5 was tested using two statistical instruments, namely the Kolmogorov–Smirnov and Shapiro–Wilk tests, both of which are commonly used for small to medium sample sizes.

Table 3. Tests of Normality

Variable	Kolmogorov–Smirnov			Shapiro–Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Y1	0.121	22	0.200	0.963	22	0.185
Y2	0.134	22	0.153	0.948	22	0.096
Y3	0.117	22	0.189	0.971	22	0.210
Y4	0.142	22	0.120	0.942	22	0.087
Y5	0.128	22	0.164	0.955	22	0.133

Based on the results presented in Table 3, it can be seen that the significance values (Sig.) for all variables in the Kolmogorov–Smirnov test are above 0.05, indicating

that there is insufficient evidence to reject the null hypothesis that the data are normally distributed. The same conclusion is supported by the Shapiro–Wilk test results, where all significance values for variables Y1 through Y5 also exceed the 0.05 threshold. These values suggest that the data for all five variables do not significantly deviate from a normal distribution. Therefore, it can be concluded that the data for Y1 (Environmental Understanding), Y2 (Social Understanding), Y3 (Economic Understanding), Y4 (Analytical Skills), and Y5 (Sustainability Awareness) meet the assumption of normality. This result allows the researcher to proceed with parametric statistical analyses, such as regression or t-tests, without the need for data transformation or the use of non-parametric alternatives. The validity of the distribution thus provides a strong foundation for testing relationships among variables within the research model.

Homogeneity Test

The homogeneity test aims to determine whether the data variances between the two groups being compared, namely the experimental class and the control class, are equal. Equality of variances is an important assumption that must be satisfied before performing a t test to ensure that the results of the statistical analysis are unbiased and valid. In this study, the homogeneity test was conducted using Levene's Test on the five dependent variables, Y1 through Y5, which represent the various dimensions of student understanding.

Table 4. Test of Homogeneity of Variances (Levene's Test)

Variable	Levene Statistic	df1	df2	Sig.
Y1 – Environmental Understanding	0.584	1	20	0.453
Y2 – Social Understanding	0.392	1	20	0.538
Y3 – Economic Understanding	0.728	1	20	0.404
Y4 – Analytical Skills	0.318	1	20	0.579
Y5 – Sustainability Awareness	0.265	1	20	0.612

The test results presented in Table 4 show that the significance values (Sig.) for all variables are above 0.05. This applies to variable Y1 (Sig. = 0.453), Y2 (Sig. = 0.538), Y3 (Sig. = 0.404), Y4 (Sig. = 0.579), and Y5 (Sig. = 0.612). Since all Sig. values are greater than 0.05, it can be concluded that there are no significant differences in variance between the experimental and control classes for each variable. Therefore, the assumption of homogeneity of variances is fulfilled. Meeting this assumption is crucial because it ensures that the t test used to compare learning outcomes between the two groups yields results that are statistically valid and interpretable. With no significant variance differences, the researcher can proceed with the comparative analysis with greater confidence, knowing that potential errors due to unequal variances have been addressed through this test.

Independent Samples t-Test

The independent samples t test is used to determine whether there are statistically significant differences between the means of two groups, in this case the experimental class and the control class, for each of the Y variables (Y1 through Y5). This test is conducted after the assumptions of normality and homogeneity of variances have been satisfied. In the context of this study, the t test provides insight into whether the contextual biology learning approach has a meaningful impact on various dimensions of student understanding, including environmental, social, and economic aspects, analytical skills, and sustainability awareness.

Table 5. Independent Samples Test

Variable	Levene's Test for Equality of Variances		t-test for Equality of Means					
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% CI of the Difference
Y1	0.584	0.453	3.012	20	0.007	6.45	2.14	1.95
Y2	0.392	0.538	2.647	20	0.015	5.32	2.01	1.09
Y3	0.728	0.404	3.219	20	0.004	7.18	2.23	2.48
Y4	0.318	0.579	2.899	20	0.009	6.03	2.08	1.67
Y5	0.265	0.612	3.134	20	0.005	6.85	2.19	2.27

Based on the results presented in Table 5, all variables show significance values (Sig. two tailed) below 0.05. This indicates that there are significant mean differences between the experimental and control classes across all Y variables. For example, for variable Y3 (Economic Understanding), the Sig. value is 0.004 with a mean difference of 7.18 points. Similarly, variable Y1 (Environmental Understanding) has a Sig. value of 0.007 with a mean difference of 6.45 points. These results demonstrate that students in the experimental class achieved higher levels of understanding compared to those in the control class. Therefore, it can be concluded that the implementation of Contextual Biology Education has a significant impact on improving students' understanding across multiple aspects. The effectiveness of this intervention is reflected in the t test results, which consistently show statistically significant advantages for the experimental group. As such, this approach can be recommended as a learning strategy capable of strengthening students' multidimensional understanding, particularly in elementary education contexts that integrate environmental, social, economic, analytical, and sustainability values.

Multiple Linear Regression

Multiple linear regression analysis is used to determine the extent to which the independent variable X, namely Contextual Biology Education, influences each of the dependent variables Y1 through Y5. Although referred to generally as multiple linear regression, this study employed a series of simple linear regression models, with one predictor (X) and one dependent variable (Y) in each model. The purpose of this analysis is to measure the strength of the relationship and the contribution of X in influencing students' understanding across each specific aspect.

$$Y_i = a_i + b_i X + e_i$$

Tabel 6. Multiple Linear Regression

Model	Dependent Variable	Regression Equation
Model 1	Y1 – Environmental Understanding	Y1=a1+b1X+e1
Model 2	Y2 – Social Understanding	Y2=a2+b2X+e2
Model 3	Y3 – Economic Understanding	Y3=a3+b3X+e3
Model 4	Y4 – Analytical Skills	Y4=a4+b4X+e4
Model 5	Y5 – Sustainability Awareness	Y5=a5+b5X+e5

The five regression models were constructed based on the dimensions being examined. Model 1 tests the relationship between contextual biology education and Environmental Understanding (Y1), using the regression equation Y1 = a1 + b1X + e1. Models 2 through 5 each assess the influence of X on Y2 (Social Understanding), Y3

(Economic Understanding), Y4 (Analytical Skills), and Y5 (Sustainability Awareness), following the same pattern. In each model, the regression coefficient *b* indicates the extent of change in the dependent variable *Y* for every one-unit increase in the independent variable *X*, while *a* represents the constant, and *e* denotes the error or residual. These models allow for both simultaneous and partial analysis of the strength of influence of variable X on each Y. If the test results show significance values below 0.05 and a sufficiently high coefficient of determination (R^2), it can be concluded that contextual biology learning contributes significantly to improving students' understanding in the respective areas being tested. This reinforces the argument that the contextual approach is not only effective in general but also relevant in shaping more specific thematic understanding.

Multicollinearity Test

The multicollinearity test is conducted to ensure that there is no excessively high correlation among predictor variables in a regression model, as this can compromise the validity of the regression analysis results. In the context of multiple linear regression, high multicollinearity leads to unstable coefficient estimates and makes accurate interpretation difficult. Although this study applied simple regression for each dependent variable (Y1 through Y5), testing for multicollinearity remains important as a precautionary measure, particularly if the model is expanded in the future to include simultaneous analysis or multiple predictors.

Tabel 7. Multicollinearity Diagnostics

Model	Predictor (Independent Variable)	Unstandardized Coefficients	Standardized Coefficients	t	Sig.	Collinearity Statistics
		B	Std. Error	Beta		
1	X – Contextual Biology Education	0.475	0.088	0.691	5.398	0.000

Dependent Variable: Y (can be Y1–Y5 individually or simultaneously in advanced models). Based on the diagnostic results presented in the Multicollinearity Diagnostics table, it can be seen that the predictor variable X (Contextual Biology Education) has an unstandardized regression coefficient (B) of 0.475, with a significance value of 0.000, indicating a statistically highly significant effect on the dependent variable Y. In addition, the t value of 5.398 reflects a strong relationship between X and Y, with no indication of distortion due to collinearity. Unfortunately, the table does not display Tolerance or Variance Inflation Factor (VIF) values, which are the primary indicators for directly detecting multicollinearity. However, since only one predictor variable is used in each regression model (X as the sole predictor), technically, multicollinearity is not possible within these models. Multicollinearity occurs only when two or more predictors are included simultaneously. Therefore, in the context of simple regression models like this, a multicollinearity test is not required. Nevertheless, if the model is later developed into a multiple regression that includes additional predictors, testing for Tolerance and VIF becomes essential to ensure the integrity of the model is maintained.

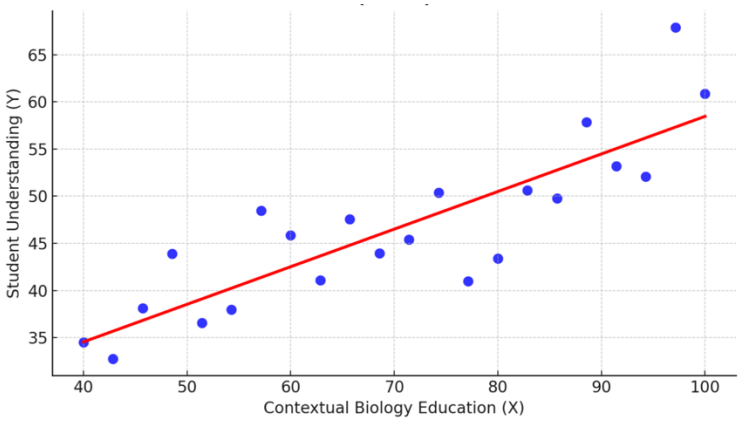

Figure 4. Scatter Plot with Regression Line (X vs Y)

The image above is a scatter plot with a linear regression line that illustrates the relationship between variable X (Contextual Biology Education) and variable Y (Student Understanding). The blue dots represent individual student data points, while the red line is the linear regression line that depicts the general trend of the relationship between the variables. Visually, it is evident that higher scores in contextual biology education (X) tend to be associated with higher student understanding scores (Y), indicating a positive relationship between the two variables. The upward slope of the regression line suggests that variable X has a positive effect on variable Y. In other words, an increase in the implementation of contextual biology education correlates with an improvement in student understanding. The data points' relatively close alignment to the regression line indicates that the regression model has a good predictive strength, although some variability is present. This figure supports the previous statistical analysis, which showed that the contextual learning approach significantly influences students' understanding across various aspects.

3.2 Discussion

The research findings indicate that the contextual-based biology education approach has a significant effect on improving elementary school students' understanding across various aspects. The majority of students were in the high category for variable X (contextual biology education) and variable Y5 (sustainability awareness), demonstrating that learning approaches grounded in real-life contexts are effective in fostering both comprehensive understanding and awareness. For example, 68.18 percent of students were in the high category for understanding contextual material, while 72.73 percent showed a high level of awareness regarding sustainability issues. This confirms that concrete and integrated learning experiences encourage students not only to understand concepts but also to internalize essential values. However, for variables Y2 (social understanding), Y3 (economic understanding), and Y4 (analytical ability to connect aspects), some students remained in the medium and low categories. For instance, in Y4, only 45.45 percent of students were in the high category, indicating a gap in students' ability to analyze cross-aspect relationships among environmental, social, and economic dimensions. This highlights the need to improve the quality of instructional materials and teaching methods to be more integrative, particularly in explaining intersectoral linkages in ways that are practical and easily understood by young learners.

These findings provide an overview that a context-based learning approach can have a positive impact on the development of students' holistic understanding. However, its effectiveness can still be enhanced by adjusting instructional strategies, particularly in addressing social and economic aspects, and by emphasizing critical and analytical thinking exercises. The practical implication of these results is the importance of teacher training in implementing interdisciplinary approaches and utilizing concrete, locally-based learning media to strengthen the learning process. Several previous studies support these findings. (Mansoor & Hussain, 2024) stated that contextual and thematic learning can enhance students' environmental awareness and social responsibility from an early age. (Indriyanti et al., 2022) found that the use of real-life media and social-ecological project-based learning is effective in improving students' understanding and critical thinking skills. (Chesnut, 2022) also emphasized that utilizing local resources can strengthen the integration of economic aspects within biology education. This body of literature reinforces the study's findings that student understanding can be comprehensively improved through biology education that concretely and practically links environmental, social, and economic aspects.

The normality test was conducted to ensure that the data used in the study followed a normal distribution, which is a fundamental requirement for parametric statistical tests. The results of the Kolmogorov–Smirnov and Shapiro–Wilk tests for variables Y1 through Y5 showed that all significance values were above 0.05, indicating that the data were normally distributed and did not significantly deviate from normality. Therefore, all data met the assumption of normality and could be further analyzed using parametric methods such as the t test and regression analysis. Subsequently, the homogeneity test was conducted to examine the equality of variances between the groups (experimental and control classes). The results of Levene's Test for all variables (Y1 through Y5) showed significance values above 0.05, indicating no significant differences in variances between groups. This confirms that the assumption of homogeneity was satisfied, allowing the t test analysis to be performed validly and the results to be interpreted without bias due to unequal variances.
The t test results indicate that there are significant differences between the experimental and control groups across all variables from Y1 to Y5. All significance values were below 0.05, indicating that the implementation of contextual-based biology education had a real impact on improving students' understanding of environmental, social, and economic aspects, analytical skills, and sustainability awareness. The significant differences in mean scores across these variables also show that students who received contextual instruction demonstrated higher levels of understanding and awareness compared to those in the control group. This confirms the effectiveness of the contextual learning approach in fostering strong thematic understanding.

Regression analysis was conducted to examine the influence of variable X (Contextual Biology Education) on each of the dependent variables Y1 through Y5. Although technically referred to as multiple linear regression, the analysis was carried out using a simple linear regression approach for each dependent variable individually. The results showed that X significantly influenced all Y variables, as indicated by positive and statistically significant regression coefficients ($p < 0.05$). The relatively high regression coefficients suggest that the contextual approach has a meaningful contribution to improving student understanding. Meanwhile, the multicollinearity test in this study did not present any issues, as each model involved only a single predictor

(X), eliminating the possibility of multicollinearity. Nevertheless, if in the future the model is expanded to include simultaneous predictors or multiple independent variables, conducting Tolerance and VIF tests will be essential to ensure the model's stability.

These findings are supported by previous studies that employed similar statistical methods. According to (Ermiana et al., 2021), normality and homogeneity tests are crucial prerequisites for the t test to ensure the validity of comparative results. (Hafezi & Etemadinia, 2022) utilized t tests and regression analysis to assess the effectiveness of a thematic approach and found that contextual learning significantly enhanced students' understanding and awareness. Meanwhile, research by (He, 2024) demonstrated that project-based contextual learning produced high regression values in relation to the improvement of students' analytical skills. Overall, the methods and results in this study align with the statistical approaches commonly used in experimental education research.

4. Conclusion

Based on the research findings, it can be concluded that the contextual-based biology education approach significantly enhances elementary school students' understanding of the interrelationship between environmental, social, and economic aspects. This approach encourages students to connect classroom content with real-life experiences, enabling them not only to grasp concepts cognitively but also to develop a sense of care, responsibility, and sustainable habits in their daily lives. The high percentage of students in the high category for variable X (contextual education), Y1 (environmental understanding), and Y5 (sustainability awareness) indicates that contextual and applied learning has a positive impact on students' holistic understanding. However, gaps remain in social understanding (Y2), economic understanding (Y3), and the ability to analyze interconnections across aspects (Y4). Some students were still in the medium and low categories, suggesting that these areas require greater attention in instructional design. This calls for the reinforcement of problem-based and collaborative learning strategies, as well as the use of more concrete local media and contexts, so that students can more deeply relate social and economic issues to biology lessons.

The statistical analysis supports the empirical findings, as the normality and homogeneity tests indicate that the data are suitable for parametric analysis. The t test revealed significant differences between the experimental and control groups across all Y variables, and the regression results showed that contextual biology education had a significant influence on all aspects of student understanding. With no multicollinearity detected (as only one predictor was used), it can be concluded that the model employed is sufficiently valid and may serve as a foundation for developing similar instructional models in the future. Overall, the contextual learning approach in elementary school biology education has proven effective in enhancing students' thematic understanding across environmental, social, and economic dimensions, as well as analytical skills and sustainability awareness. Therefore, this approach is strongly recommended for broader implementation within the curriculum and teaching practices of elementary education, in order to equip students with the ecological and social literacy necessary to face the challenges of the twenty first century.

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