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The Relationship Between Cognitive Dissonance with Conceptual Knowledge and Environmental Literacy in Elementary School Students

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ABSTRACT

This study investigates the influence of cognitive dissonance on environmental literacy and conceptual knowledge among elementary school students in the context of science learning about animal life cycles. Employing a descriptive quantitative approach with an ex post facto design, the research involved 240 students from grades 4, 5, and 6 at two elementary schools in Cirebon, Indonesia, who had received instruction on animal life cycles in accordance with the Merdeka Curriculum. Data were collected using validated and reliable four-point Likert scale questionnaires measuring environmental literacy, conceptual knowledge, and cognitive dissonance. Multivariate analysis of variance (MANOVA) was conducted to examine the relationships among these variables following the instructional intervention. The results demonstrate that students possess high levels of environmental literacy and sound conceptual understanding of animal life cycles, while experiencing moderate to low levels of cognitive dissonance. Statistical analysis reveals that science instruction incorporating cognitive dissonance significantly enhances both environmental literacy and conceptual knowledge, without inducing excessive cognitive conflict. Theoretically, this research advances the understanding of cognitive dissonance as a catalyst for meaningful learning and conceptual change in elementary science education. Practically, the findings recommend the implementation of science teaching strategies that actively challenge students' preconceptions through real-world content, such as animal life cycles, to foster scientific literacy and environmental responsibility from an early age.

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1. INTRODUCTION

The demands of 21st-century education require teachers to equip students with critical and creative thinking skills to face current and future challenges. Modern education emphasizes mastery of science and technology as well as the development of cognitive abilities and competitiveness that align with global needs (Akmal, 2019). Among these competencies, critical thinking is regarded as essential and can be cultivated through strong conceptual understanding (Mustofa & Hidayah, 2020).

An important aspect of science education is environmental literacy, which, according to the Environment Education and Training Partnership (EETAP), involves an individual's ability to take appropriate actions when addressing environmental issues (NAAEE, 2011). Environmental literacy encompasses not only the utilization of natural resources but also the personal attitudes and responsibilities towards environmental challenges (Hollweg, 2011). McBeth and Volk (2009) identify four key components of environmental literacy: environmental knowledge, environmental attitudes, cognitive skills, and environmentally responsible behaviors.

These components serve as essential indicators for assessing an individual's level of environmental literacy and ideally should be integrated into formal curricula and evaluation frameworks.

Conceptual knowledge forms the foundation for developing critical thinking and scientific literacy (Byrnes & Wasik, 1991; Zenger & Bitzenbauer, 2022). This knowledge can be acquired through various learning methods, including receiving information from teachers and peers, reviewing materials, practicing problem-solving, classifying instructional content, and participating in extracurricular educational activities (Lubis et al., 2022).

Cognitive dissonance arises when there is a mismatch between students' prior knowledge and new information, creating cognitive conflict that, if effectively managed, can deepen conceptual understanding (Sudatha et al., 2024).

Although environmental literacy and conceptual understanding are critical, many schools have yet to implement environmental education effectively, resulting in students' environmental literacy remaining superficial and reliant on rote memorization (Singleton, 2017). Moreover, the integration of cognitive dissonance strategies to simultaneously enhance conceptual knowledge and environmental literacy has been underexplored, particularly within the context of teaching ecosystems and animal life cycles at the elementary school level. To the best of our knowledge, no prior studies have investigated the simultaneous effect of cognitive dissonance on both environmental literacy and conceptual knowledge specifically within elementary science education on ecosystems and animal life cycles. This represents a significant research gap and offers an opportunity to develop innovative instructional approaches.

This study aims to examine the effect of cognitive dissonance on students' environmental literacy and conceptual knowledge in the context of learning about ecosystems and animal life cycles in elementary schools. Through this integrated approach, it is expected to contribute to the development of effective instructional strategies that improve conceptual mastery while fostering environmentally responsible attitudes.

2. METHOD

Research Design

This study employs a descriptive quantitative approach using the ex post facto method, in which the researcher did not directly intervene with the subjects. Instead, the research analyzes data from learning outcomes that had already occurred, specifically posttest data. The objective is to describe and evaluate the relationships among students' conceptual knowledge, environmental literacy, and cognitive dissonance after they participated in science learning on the topic of the Life Cycle of Animals. The primary data were obtained through questionnaires and written tests completed by students at the conclusion of the learning process.

A total of 240 students from grades 4, 5, and 6 at SD Weru Kidul and SD Panembahan were involved in the study. The sampling technique applied was purposive sampling, with participants selected based on the criterion that they had received instruction on animal life cycles according to the Merdeka Curriculum.

The research instrument was a four-point Likert scale questionnaire designed to measure three variables: environmental literacy, conceptual knowledge, and cognitive dissonance. Each variable was measured using 15 items, totaling 45 statement items. Responses were rated on a scale of 1 (Strongly Disagree) to 4 (Strongly Agree). The development of questionnaire items was guided by theoretical indicators for each variable, and item grids are presented in Tables 1 to 3 for environmental literacy, conceptual knowledge, and cognitive dissonance, respectively.

Table 1. Environmental literacy instrument grid

Learning aspects	Indicator	Item
Ecological knowledge	Understanding the fundamental concepts of the animal life cycle	1,2,3
Cognitive skill	Analyzing knowledge related to the animal life cycle	4,5,6
Environmental affect	Demonstrating sensitivity to threats affecting the animal life cycle	7,8
	Taking responsibility for changes in the animal life cycle	9,10
	Awareness of the importance of protecting animal habitats	11,12,13

Behavior	Active participation in environmental conservation activities	14,15

Table 2. Conceptual knowledge instrument grid

Components Of knowledge	**Indicator**	**Item**
Knowledge of classifications and categories	Understanding the stages of the animal life cycle	1,2,3
	Categorizing animals based on the stages of their life cycle	4,5
Knowledge of principles and generalizations	Identifying the components involved in the animal life cycle	6,7
	Analyzing developmental processes in animals	8,9
Knowledge of theories, models and structures	Illustrating the interrelationships among components within the animal life cycle	10,11,12
	Applying theoretical concepts and structural frameworks of the animal life cycle across its various stage	13,14,15

Tabel 3. Cognitive dissonance instrument grid

Cognitive dissonance aspects	**Indicator**	**Item**
Psychological tension	Understanding the levels of decreased concentration	1,2
	Recognizing levels of anxiety	3,4
Motivation to reduce tension	Identifying ways to manage emotions	5,6
	Identifying strategies to avoid certain conditions or situations	7,8
Level of reward	Desire to gain praise for understanding the material	9,10
	Motivation to learn based on perceived benefits	11,12
Forced compliance	Recognizing forms of inconsistencies between beliefs and actions	13,14,15

The instrument's validity was examined through expert judgment and Pearson product-moment correlation. All item-total correlation coefficients exceeded $r = 0.201$ ($N = 240$, $\alpha = 0.05$), confirming acceptable construct validity. Reliability was tested using Cronbach's Alpha, with coefficients of 0.662 for environmental literacy, 0.572 for conceptual knowledge, and 0.633 for cognitive dissonance. While these fall into the low to questionable category (George & Mallery, 2003), they are acceptable for exploratory research (Nunnally & Bernstein, 1994). Data were analyzed using SPSS version 27. The Shapiro-Wilk test assessed normality, and Levene's test examined homogeneity of variance. A MANOVA was then conducted to assess the effect of cognitive dissonance on the dependent variables, preceded by Box's M test to confirm the assumption of covariance homogeneity.

3. RESULT AND DISCUSSION

This study aimed to examine the relationships between conceptual knowledge, environmental literacy, and cognitive dissonance among students after participating in thematic learning on the topic of animal life cycles. Data were collected through questionnaires distributed to fourth, fifth, and sixth-grade students at SD Weru Kidul

and SD Panembahan. The results revealed that students demonstrated strong environmental literacy, with a clear understanding of the role of animal life cycles within ecosystems. They also recognized the importance of protecting animal habitats and actively participated in environmental conservation activities.

Regarding conceptual knowledge, students exhibited a solid understanding of the stages of the animal life cycle and were able to apply theoretical concepts to real-life examples, indicating effective learning outcomes. Furthermore, cognitive dissonance among students was found to be moderate to low, suggesting that the thematic approach successfully minimized psychological tension, allowing for smooth integration of new information.

Statistical analysis using MANOVA revealed significant differences in mean scores for environmental literacy, conceptual knowledge, and cognitive dissonance, supporting the effectiveness of the thematic learning approach in enhancing these three variables. Although the reliability scores for the instruments fell within the low to questionable category, the findings indicate that the approach effectively improved students' understanding without generating significant cognitive conflict. These results underscore the potential of thematic learning in improving cognitive and affective outcomes among students while minimizing cognitive dissonance.

Table 4. Box's test of equality of covariance matrices

Box's M	96.351
F	1.310
df1	63
df2	3599.501
Sig.	.052

Based on the results of Box's M test, the significance value obtained is 0.052, which is greater than 0.05. This indicates that the assumption of homogeneity of covariance matrices is met, thereby fulfilling the requirements for conducting further MANOVA analysis (see Table 5).

Table 5. Multivariate tests

Effect		**Value**	**F**	**Sig.**
Intercept	Pillai's Trace	.990	10559.647b	.000
	Wilk's Lambda	.010	10559.647b	.000
	Hotelling's Trace	98.688	10559.647b	.000
	Roy's Largest Root	98.688	10559.647b	.000
COGNITIVE DISSONANCE	Pillai's Trace	.470	2.752	.000
	Wilk's Lambda	.568	2.915b	.000
	Hotelling's Trace	.694	3.079	.000
	Roy's Largest Root	.578	5.181c	.000

Subsequently, the results of the MANOVA test are presented in Table 5. This test utilizes four statistical measures: Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root. All four statistics indicate significance values below 0.05 for the variable Cognitive Dissonance, suggesting that there are significant differences between the groups tested with respect to this variable.

Among the four statistics, Hotelling's Trace shows the highest value at 0.694, indicating that the learning model or treatment administered has a substantial impact on students' cognitive dissonance. This value is also greater than that of Pillai's Trace (0.470), further suggesting that the instructional approach employed is effective in reducing the level of cognitive dissonance.

In addition, the multivariate analysis lends further support to this conclusion by identifying Hotelling's Trace as the most robust indicator of the intervention's impact. Due to its sensitivity to group mean differences, especially when dependent variables exhibit moderate intercorrelation—as observed in the relationship between environmental literacy and conceptual knowledge in this study—Hotelling's Trace is particularly appropriate for detecting multivariate effects. Its elevated value highlights the strength of the instructional strategy in addressing both the cognitive and affective learning domains.

Overall, the results affirm that incorporating cognitive dissonance-based methods into classroom instruction not only improves students' mastery of conceptual content but also cultivates greater environmental sensitivity. The strong multivariate relationship indicated by Hotelling's Trace suggests that the learning

intervention successfully promoted active cognitive engagement, encouraging students to reconcile existing misconceptions with newly acquired scientific insights. This approach aligns with modern educational theories, which posit that cognitive conflict plays a central role in promoting deeper conceptual understanding and meaningful learning transformations.

Table 6. The test result of between-subjects effects

Source	Dependent Variable	Type III Sum of Squares	df	F	Sig.
Corrected Model	Environmental literacy Knowledge concept	1902.002a 1363.309b	24 24	4.449 3.106	.000 .000
Intercept	Environmental literacy Knowledge concept	278256.719 234633.086	1 1	15622.219 12828.737	.000 .000
COGNITIVE DISSONANCE	Environmental literacy Knowledge concept	1902.002 1363.309	24 24	4.449 3.106	.000 .000

Following the multivariate analysis, Table 6 further explores the individual effects of cognitive dissonance on environmental literacy and conceptual knowledge. The F-values for both variables—4.449 for environmental literacy and 3.106 for conceptual knowledge, with p-values of 0.000—indicate that cognitive dissonance has a statistically significant influence on students' learning outcomes. These findings suggest that the cognitive conflict students experienced during instruction positively impacted their understanding of environmental issues and scientific concepts. The results support the interpretation that internal tensions between prior misconceptions and new information can stimulate deeper cognitive processing and reinforce conceptual change. Consequently, instructional strategies that intentionally introduce cognitive dissonance can effectively enhance student engagement, promote critical thinking, and lead to meaningful learning across both cognitive and affective domains.

4. CONCLUSION

This study confirms the effectiveness of instructional strategies that integrate scientific concepts with environmental themes in enhancing elementary students' environmental literacy and conceptual knowledge. By managing cognitive dissonance appropriately, the instruction supported deeper understanding without causing confusion, highlighting its potential as a catalyst for meaningful learning and critical thinking.

Critically, while the findings underscore the educational value of using cognitive dissonance in science teaching—moving beyond rote memorization to foster active engagement—they must be interpreted within the study's limitations. The low reliability of measurement tools and the use of an ex post facto design limit control over variables such as students' backgrounds, learning preferences, and motivation. Future research should employ experimental designs with control groups, improve instrument validity and reliability, and explore broader educational settings to enrich understanding of this approach's effectiveness.

Practically, the results advocate for teaching strategies that challenge students' prior conceptions through relevant, real-world themes such as life cycles and sustainability—thereby nurturing early development of scientific literacy and environmental responsibility.

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