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Misconceptions in Environmental Learning: A Four-Tier Diagnostic Study in Indonesian Primary Education

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Abstract
This study investigates the misconceptions held by fifth-grade elementary students in learning Natural and Social Sciences. Employing a descriptive quantitative approach, the research utilizes a Four-Tier Diagnostic Test designed to measure not only students' conceptual understanding but also their confidence levels and reasoning behind their answers. The results reveal that 41.4% of students correctly understood the material, while 35.1% demonstrated misconceptions, and 23.2% fell into the category of not understanding. A deeper analysis indicated that students frequently chose "don't know" as a justification, especially on items requiring an understanding of the interrelationship between environmental factors. These findings highlight the persistence of intuitive, yet scientifically inaccurate reasoning, often stemming from daily experiences or insufficient instructional strategies. The study underscores the need for more diverse and contextual teaching methods, including visual media, collaborative discussions, and real-world environmental exploration. Such strategies are essential for correcting misunderstandings and enhancing conceptual comprehension. The diagnostic insight provided by the Four-Tier Test enables educators to design targeted and adaptive learning interventions that respond directly to the identified misconceptions. This research affirms the critical role of diagnostic assessments in improving the quality of science education at the elementary level.

Keywords:
Misconceptions,
Four-Tier Test,
Natural and Social Sciences,
Elementary Education

1. Introduction
Learning Natural and Social Sciences at the elementary school level plays a crucial role in shaping students' scientific literacy and environmental awareness. The *Kurikulum Merdeka* integrates both natural and social perspectives to provide students with holistic knowledge about the world. This integration develops conceptual understanding while fostering attitudes and values that prepare young learners to become responsible citizens. The IPAS curriculum highlights environmental damage as one of its main topics, taught under the theme *"Oh, the Environment is Damaged."* Environmental issues have become global concerns, and schools are expected to contribute to early character formation in terms of care for the environment. Several studies report that students still possess inaccurate understandings or misconceptions about environmental concepts, such as pollution, recycling, and interrelationships among living things within an ecosystem (Hayati et al., 2022; Hunaidah & Erniwati, 2022).

A misconception represents an understanding that is incorrect or inconsistent with scientific knowledge. Misconceptions differ from a simple lack of knowledge because they often reflect strongly held but scientifically inaccurate beliefs. Students may develop misconceptions from personal experiences, misleading media, or instructional approaches by teachers that fail to address prior knowledge effectively (Munawaroh & Hadi, 2022). Examples include beliefs that air pollution comes

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only from visible smoke or that recycling refers solely to reusing plastic bottles. Such examples illustrate the gap between students' ideas and actual scientific concepts. Teachers need valid diagnostic tools that distinguish between students who hold misconceptions and those who are uninformed. The Four-Tier Diagnostic Test offers such an opportunity by assessing conceptual knowledge while evaluating reasoning and confidence. Teachers can more accurately identify misconceptions and their underlying causes through this multidimensional approach (Resbiantoro & Nugraha, 2020; Wahyuni et al., 2021).

Research in elementary science education shows that misconceptions are widespread across many topics. Laeli et al. (2020) found misconceptions in more than 70% of students, including force, light, energy, and ecological processes. Misconceptions hinder conceptual change and slow the development of scientific literacy, which constitutes an essential competency in the 21st century. Students who maintain misconceptions may carry them into higher education, creating barriers to academic progress and limiting engagement with science (Kusuma & Suardana, 2025). Intervention-based studies have attempted to remediate misconceptions through different models. Guided inquiry learning engages students in exploration and experimentation, thereby reducing misconceptions (Margunayasa et al., 2021). The scientific approach encourages observation, questioning, and experimentation to strengthen understanding (Nur'ariyani et al., 2023). Other research highlights the integration of local wisdom to make environmental education more contextual (Albar et al., 2025). These strategies improve learning, yet conventional assessments often fail to uncover persistent misconceptions. Accurate diagnostic tools remain necessary to identify the root of misunderstandings before effective interventions can occur.

The Four-Tier Diagnostic Test has gained attention as a valid and reliable instrument for identifying misconceptions in science (Desstya et al., 2025). Conventional tests typically measure only correctness, while the four-tier format requires an answer, reasoning, and confidence ratings for both. This multidimensional design distinguishes students who guess correctly from those who truly understand concepts and reveals misconceptions held with strong confidence. Applications of the Four-Tier Test demonstrate effectiveness in mathematics (Yansa et al., 2025) and sustainable development-related numeracy (Muhaimin et al., 2024). The application of this diagnostic tool in elementary IPAS, particularly within environmental themes, remains rare. Previous studies in environmental education emphasize scientific literacy and awareness (Yamin et al., 2019) rather than explicit identification of misconceptions. This gap indicates the need for further exploration of diagnostic assessments in environmental topics at the primary level.

Environmental learning provides an especially suitable context for applying the Four-Tier Test. Misconceptions appear in students' understanding of the causes of environmental damage or the ways human activities affect ecological balance. Some students believe deforestation affects only wood supply, ignoring broader impacts on biodiversity and climate regulation. Others think recycling applies only to certain types of waste, overlooking its role in sustainable living. Identifying these misunderstandings allows teachers to design instructional strategies that address misconceptions directly. Leoniza et al. (2025) emphasized that diagnostic assessments provide guidance for teachers to refine learning approaches and target misconceptions more effectively. Insights from the Four-Tier Test therefore inform strategies that enhance conceptual understanding while fostering environmental awareness.

Recognition of students' misconceptions through suitable diagnostic approaches constitutes an essential step toward improving the quality of IPAS learning. Misconceptions left unaddressed undermine scientific literacy and limit students' ability to engage critically with environmental issues. The Four-Tier Diagnostic Test offers a promising solution by diagnosing misconceptions with accuracy and depth. The present study aims to identify misconceptions among elementary students regarding environmental issues using the Four-Tier Diagnostic Test. Results will provide teachers with evidence-based insights for designing effective learning strategies that enhance both scientific understanding and environmental responsibility from an early age.

2. Method

This study employed a quantitative approach with a descriptive research design to identify students' misconceptions in the topic *"Oh, the Environment is Damaged"* within the fifth-grade IPAS subject. The research was conducted at SD Djama'atul Ichwan with Class V C students. The learning session was carried out on Wednesday, April 30, 2025, with a duration of 90 minutes (08.30–10.00) using the Direct Learning model.

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The participants of this study consisted of all students in Class V C (Fase C) of SD Djama'atul Ichwan, totaling 27 students. The fifth grade was chosen as the research subject because the theme *"Oh, the Environment is Damaged"* is part of the official curriculum for Grade V in IPAS. The population and sample were therefore identical, covering the whole class.

Data were collected using the Four-Tier Diagnostic Test instrument, which consists of four levels: (1) a multiple-choice question addressing the scientific concept, (2) a confidence rating for the chosen answer, (3) a reasoning option for selecting the answer, and (4) a confidence rating for the chosen reasoning. This test was designed to detect misconceptions in depth by assessing not only whether an answer was correct or incorrect but also the level of confidence students expressed in both their answers and their reasoning (Putri et al., 2021). The test was administered directly in the classroom during the allocated learning session.

The data analysis involved categorizing students' responses into several groups, including scientific understanding, lack of knowledge, and misconception. Descriptive statistics such as frequencies and percentages were used to determine the proportion of students in each category. The percentage of responses was calculated using the formula:

$$p = \frac{f}{N} x100\%$$

Where *P* represents the percentage, *f* represents the frequency of responses in each category, and *N* represents the total number of students. The results of the analysis were interpreted to reveal the areas of misconception in environmental concepts and to provide insights into students' reasoning patterns.

3. Results and Discussion

3.1 Results

The Four-Tier Diagnostic Test was administered to identify misconceptions among fifth-grade students on the theme *"Oh, the Environment is Damaged."* The overall analysis (see Figure 1) shows that the dominant category was Scientific Understanding (P = 41.7%), indicating that a substantial proportion of students were able to grasp the concepts taught. However, misconceptions remained significant at 35.1%, suggesting persistent conceptual errors. Meanwhile, 23.2% of students fell under the *Lack of Knowledge* category, while the *Error* category was negligible (<1%).

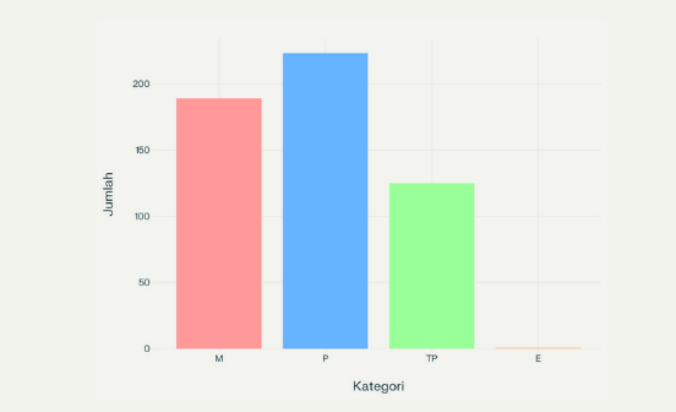

Figure 1. ***Distribution of students' responses based on the Four-Tier Diagnostic Test***

Figure 1 illustrates the distribution of students' responses across the four categories. Scientific Understanding (P) had the highest frequency, followed by Misconceptions (M), Lack of Knowledge (TP), and Error (E), which had an extremely small proportion. This pattern confirms that while a considerable number of students comprehended the material, a substantial portion still held misconceptions, highlighting the persistence of alternative conceptions in environmental science (Rahman et al., 2025; Fariza et al., 2025).

The ranking of misconceptions per item (Table 1) shows that certain items were particularly challenging. Items 8 and 10 recorded the highest proportion of misconceptions (45.45%), followed by Items 7, 9, and 13 (39.39%). This indicates that nearly half of the students consistently answered some

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questions incorrectly with strong confidence in their reasoning, confirming that the issue is not a lack of knowledge but rather entrenched misconceptions (Wahyuni et al., 2021).

Table 1
Ranking of Misconceptions by Item

Rank	Item	Misconception (%)
1	8	45.45
2	10	45.45
3	7	39.39
4	9	39.39
5	13	39.39
6	15	36.36
7	3	30.30
8	4	30.30
9	19	30.30
10	17	30.30

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3.2 Discussion

The results highlight a paradoxical trend: a substantial portion of students demonstrated scientific understanding while misconceptions were nearly as prevalent. This finding reflects a persistent challenge in science education at the elementary level where prior experiences and intuitive reasoning often conflict with established scientific concepts. Rahmawati and Suparman (2021) as well as Fariza et al. (2025) confirmed that elementary students frequently construct explanations based on daily observations or cultural beliefs that are not scientifically valid. Many students in this study associated environmental damage exclusively with waste disposal and water pollution while neglecting deforestation, biodiversity loss, and climate change. This tendency is consistent with the learning context observed in the classroom, where environmental damage was mainly introduced through concrete and visible examples, such as pictures of natural disasters presented in student worksheets (LKS). Abasto et al. (2023) observed similar limitations among teachers who themselves carried alternative conceptions about environmental issues, underscoring how pervasive and persistent these misconceptions are. The tendency of students to interpret scientific content narrowly indicates the difficulty of mastering concepts that require causal and systemic reasoning.

Evidence from previous literature strengthens these observations. Hartanti et al. (2024) emphasized that textbooks with inaccurate explanations and teachers with limited mastery often contribute directly to misconceptions during classroom instruction. Classroom observation in this study showed that IPAS learning was implemented using a Direct Learning model, with earning activities dominated by teacher explanations and question-answer interactions. Such conditions may restrict opportunities for students to explore cause-effect relationships and interconnections among environmental components. Ariffia and Kurniawati (2025) reported that misconceptions among fourth graders reached 56–64% in topics such as photosynthesis and plant reproduction, illustrating the scale of misunderstanding across domains of science. Misconceptions identified in this study align with their findings, especially where complex processes such as ecosystem interdependence or energy flow demand higher-order reasoning. Fariza et al. (2025) revealed that sixth graders misunderstood the water cycle, photosynthesis, and gravity, providing further evidence that alternative conceptions persist even into later years of primary education.

The Four Tier Diagnostic Test proved effective in uncovering these patterns. Its strength lies not only in detecting correctness but also in revealing reasoning and confidence levels, offering a more nuanced profile of student understanding. Kusumaningtyas et al. (2025) described tiered diagnostic tools as highly valuable for differentiating between ignorance and firmly held misconceptions. Resbiantoro and Nugraha (2020) highlighted that misconceptions represent structured frameworks defended with confidence. In this study, nearly half of the students who answered incorrectly expressed certainty in their reasoning, showing how strongly misconceptions were embedded. Students' confidence in incorrect answers reflects that learning activities emphasizing explanation and recall, without sufficient conceptual elaboration or reflective discussion, may unintentionally strengthen students' initial assumptions rather than challenge them. Hajiriah (2025) further validated the importance of multi-tier

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instruments and the Certainty of Response Index as essential methods for detecting misconceptions comprehensively, reinforcing the appropriateness of the diagnostic strategy applied.

A significant divergence from earlier research was observed when compared to the study by Sari et al. (2022), who found that misconceptions persisted even after remedial interventions. The relatively higher proportion of scientific understanding in this study suggests that instructional practices employed by the classroom teacher might have contributed to partial improvements, although misconceptions were not eradicated. The use of structured explanations and guided questioning during Direct Learning may have supported basic concept recognition, yet it was insufficient to facilitate deeper conceptual change. Nurfadilah et al. (2025) demonstrated that the Learning Cycle 5E model effectively reduced misconceptions in force concepts among fourth graders, highlighting the potential of structured constructivist models to yield more substantial shifts in conceptual accuracy.

Pedagogical implications arising from this study are substantial. Specific items, such as numbers 8 and 10, revealed concentrated misconceptions, indicating insufficient treatment of certain subtopics during instruction. Teaching strategies dominated by factual recall appear inadequate to promote conceptual reasoning. Munawaroh and Hadi (2022) and Satuti and Atmojo (2025) advocated reflective and problem-based approaches that encourage students to confront prior beliefs directly. Leoniza et al. (2025) demonstrated that linking science content to daily experiences increased conceptual understanding, while Fakhriyah et al. (2025) warned that oversimplified textbooks could themselves reinforce misconceptions. Satuti and Atmojo (2025) further argued that project-based learning, visual media, and group discussion are particularly effective for climate and environmental topics. Considering that instructional media in the observed classroom were limited to LKS, future instruction should integrate more varied media and activities that explicitly address mehanisms and environmental interrelationships. The findings of this study are consistent with these recommendations, suggesting that traditional instruction must be complemented by interactive and exploratory methods.

Teacher competence emerges as a central determinant. Teachers require skills to diagnose not only incorrect answers but also the reasoning underpinning them. Hartanti et al. (2024) stressed that inadequate teacher knowledge exacerbates misconceptions, while Hajiriah (2025) called for sustained teacher training and contextual curriculum development to address this problem systematically. When instruction focuses primarily on delivering content within limited time frames, teachers may have fewer opportunities to probe students' reasoning in depth allowing misconceptions to remain unchallenged. Visual media and simulations can concretize ecological processes, and group discussions enable peer critique of reasoning. Field-based exploration connects abstract content to observable phenomena, a strategy recommended by Satuti and Atmojo (2025) to help students contextualize complex processes like climate change. Such constructivist approaches, when applied consistently, foster conceptual reconstruction rather than rote memorization.

The persistence of misconceptions indicates that these are not isolated errors but alternative frameworks shaped by experience, culture, and sometimes by instructional practices themselves. Nearly equivalent rates of scientific understanding and misconceptions found in this study suggest that conceptual errors remain a central obstacle to achieving scientific literacy at the elementary level. Systematic reviews, including those by Hajiriah (2025) and Hartanti et al. (2024), underscore that misconceptions are resistant to correction unless instructional strategies are deliberately designed for conceptual change. The Four Tier Diagnostic Test demonstrated its diagnostic utility, but its ultimate value lies in guiding teachers to design interventions that are corrective and adaptive. Effective science education must therefore move beyond memorization toward evidence-based reasoning supported by contextualized learning experiences. Identification, analysis, and sustained remediation of misconceptions represent essential steps toward enabling students to construct accurate conceptual frameworks and engage meaningfully with environmental challenges in their communities and beyond.

4. Conclusion

This study set out to identify misconceptions among elementary students regarding environmental issues in the IPAS theme "Oh, the Environment is Damaged" using the Four-Tier Diagnostic Test. The findings demonstrate that misconceptions remain a significant obstacle to developing scientific literacy, despite the presence of substantial scientific understanding. By distinguishing between lack of knowledge and firmly held misconceptions, this study advances current

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knowledge by providing empirical evidence of how misconceptions are distributed across specific environmental concepts and how strongly they are sustained by students' reasoning and confidence.

The use of the Four-Tier Diagnostic Test proved scientifically justified as it offered a multidimensional diagnosis that conventional tests cannot provide. This work contributes to the growing literature on diagnostic assessment in science education by showing its applicability within environmental contexts, an area previously underexplored at the elementary level. Applications of these findings include designing targeted instructional interventions that address misconceptions directly through inquiry, contextual, and constructivist approaches. Extensions may involve integrating diagnostic assessment as a routine practice in IPAS learning to inform adaptive teaching strategies. Future research should test the effectiveness of specific remedial models, such as project-based learning or the Learning Cycle 5E, in reducing misconceptions and strengthening students' long-term conceptual frameworks.

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