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CRI PROFILE: CLIMATE CHANGE LITERACY AND SUSTAINABILITY AWARENESS

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ABSTRACT

This study aimed to analyze the profile of Climate Change Literacy (CCL) and Sustainability Awareness (SA) among junior high school students on the topic of global warming using the Certainty of Response Index (CRI) instrument and to map understanding patterns based on students' academic categories. A descriptive quantitative design was employed involving 14 Class IX students at SMPN Satu Atap 5 Hanau, Seruyan Regency, Central Kalimantan. Data were collected using a 20-item multiple-choice test integrated with a 0–5 CRI scale, then categorized into four understanding types: Conceptual Understanding, Lucky Guess, Misconception, and Does Not Know the Concept. Results showed that 35.7% of students demonstrated good conceptual understanding, 42.9% were classified as Sufficient Understanding, 14.3% showed dominant misconceptions, and 7.1% did not understand the concepts; overall, 23.9% of all responses were identified as misconceptions. The most common misconceptions were on greenhouse gas sources from the agricultural sector (item 6: 6 students) and mitigation-adaptation terminology (item 17: 5 students). Academic category analysis showed that high-achieving students were predominantly in the understanding category, while low-achieving students showed patterns of misconception and incomplete understanding.

INTRODUCTION

Global warming is one of the most critical environmental challenges facing humanity in the 21st century. Scientific data show that atmospheric CO_2 concentration reached 421 ppm in 2023, the highest level in the last 3 million years, and the global average surface temperature has risen by 1.1°C since the pre-industrial era (IPCC, 2021). The resulting impacts include melting polar ice, sea-level rise, changes in extreme rainfall patterns, and an increasing frequency of hydrometeorological disasters. This situation makes climate change education a global priority, as stated in Sustainable Development Goals (SDGs) target 13.3 on climate change education and awareness (UNESCO, 2021).

Climate Change Literacy (CCL) is an essential competency that the younger generation must master as part of their readiness to face environmental sustainability challenges. Rousell and Cutter-Mackenzie-Knowles (2020) define CCL as an individual's ability to understand the main manifestations of climate change and to take meaningful action based on that understanding. Furthermore, Choi et al. (2022) operationalize CCL into four competency dimensions: (1) the ability to provide accurate conceptual explanations (elementary clarification), (2) the ability to analyze environmental data and information scientifically (basic support), (3) the ability to draw evidence-based conclusions (inference), and (4) the ability to design mitigation and adaptation strategies (strategies and tactics). These four dimensions align with the critical climate awareness framework proposed by Clark (2024), which underpins the instrument used in this study.

Sustainability Awareness (SA) is an affective-conative dimension that complements CCL. Gericke et al. (2019) define SA as an individual's internal condition reflecting alignment between knowledge, attitudes, and behavioral tendencies toward sustainable development issues. Berglund and Gericke (2016) elaborate SA into four components: (1) positive perception of nature conservation, (2) active motivation and effort to contribute, (3) genuine participation in sustainability practices, and (4) the ability to build critical thinking patterns to minimize disaster risk. In science education, SA bridges students' conceptual understanding and their actions toward the environment (Kelfina et al., 2025).

The reality on the ground shows that students' conceptual understanding of global warming remains far from adequate. Various studies indicate a high prevalence of misconceptions on this topic, ranging from confusion between global warming and ozone layer depletion, misunderstanding of the natural greenhouse effect, to unclear distinctions between mitigation and adaptation (Marlina et al., 2021; Samsuddin, 2024; Ningrum et al., 2021). Unidentified and unaddressed misconceptions will hinder the development of correct conceptual understanding and impede the formation of students' SA (Putri et al., 2025).

Prior studies have approached climate-change misconceptions and CRI-based diagnostics from different angles, yet an important gap remains. Ningrum et al. (2021) mapped misconception patterns among junior high school students. However, they did not disaggregate findings by students' academic achievement level, while Samsuddin (2024) profiled climate-change misconceptions using CRI without linking the results to an affective outcome such as sustainability awareness. Similarly, Herlanti et al. (2020) applied a four-tier CRI diagnostic to biology misconceptions in general, without extending the analysis toward sustainability-related affective outcomes, and Suharsono et al. (2022) synthesized CRI applications across Indonesian science education. However, they did not focus on remote-area schools specifically. What has not yet been done, therefore, is a joint diagnosis of CCL and SA using CRI within a remote, under-resourced school setting. This gap in the literature — combining cognitive (CCL) and affective (SA) profiling through CRI in a remote-area context — is the specific contribution addressed by the present study.

One diagnostic instrument that has proven effective in identifying misconceptions is the Certainty of Response Index (CRI). Various researchers have further developed CRI, including a recent factor-mixture-model approach that identifies student knowledge profiles from item responses combined with certainty indices (Chen, Andersson, & Zhu, 2023). Compared to conventional multiple-choice tests, CRI can distinguish more accurately between four categories of student understanding: Conceptual Understanding (Correct + CRI $\geq$ 3), Lucky Guess (Correct + CRI < 3), Does Not Know the Concept (Incorrect + CRI < 3), and Misconception (Incorrect + CRI $\geq$ 3). This advantage makes CRI a highly relevant instrument for diagnostic purposes in conceptual-understanding-based science learning (Suharsono et al., 2022; Herlanti et al., 2020), although the relationship between confidence and the presence of a genuine misconception still requires careful interpretation (Hull et al., 2022).

This study is set at SMPN Satu Atap 5 Hanau, a school in a remote area of Central Kalimantan with limited access to quality learning resources. The geographic and socio-economic characteristics of this region increase the risk of low CCL and SA among students due to limited exposure to accurate scientific information about climate change

(Velayati & Prastowo, 2022). Research on CCL and SA in remote areas specifically remains very limited, so the data generated from this study carry significant contributory value.

Given this gap, the present study addresses the following research question: what are the profiles of Climate Change Literacy and Sustainability Awareness among junior high school students at a remote school, as diagnosed through the Certainty of Response Index, and how do these profiles vary across misconception types, item topics, and students' academic categories?

Based on this background, this study aims to: (1) analyze the CCL and SA profile of Class IX students at SMPN Satu Atap 5 Hanau based on CRI categories; (2) identify the distribution of misconceptions per item and topic indicator; (3) map understanding patterns based on students' academic categories; and (4) identify the implications of the findings for the development of ESD-oriented science learning. This study is expected to contribute to the development of learning strategies that better meet the diagnostic needs of students in remote areas.

MATERIALS AND METHODS

Research Design and Subjects

This study used a descriptive quantitative design to systematically describe students' CCL and SA profiles without manipulating variables. This approach was chosen because it aligns with the study's diagnostic and mapping purpose (Sugiyono, 2019). The research subjects were 14 Class IX students at SMPN Satu Atap 5 Hanau, Seruyan Regency, Central Kalimantan, selected using a total sampling technique due to the limited population size. SMPN Satu Atap 5 Hanau is a small, remote "satu atap" (one-roof) school; at the time of the study, the entire school enrolled only 38 students across Grades VII–IX combined, of whom 14 were in Grade IX, so the 14 students studied represent the complete population of the Grade IX cohort rather than a sample drawn from a larger pool. All students had completed science instruction on the Global Warming topic (Chapter 7, Grade IX Semester 2) in accordance with the Merdeka Curriculum. Based on the previous semester's academic scores, students were grouped into three categories: Low (score < 70, n=5), Medium (score 70–79, n=3), and High (score ≥ 80, n=6).

Research Instrument

The research instrument was a 20-item multiple-choice diagnostic test developed based on CCL indicators (4 indicators: elementary clarification, basic support, inference, mitigation strategy) and SA indicators (4 indicators: positive perception, active motivation, participation, critical thinking pattern), integrated with a CRI scale (0–5). Each item was accompanied by two response components: (a) answer choices A–D and (b) a CRI scale indicating the student's level of confidence in the chosen answer. The item distribution covered six main topics: Basic Concepts of Global Warming (items 1–4), Causes of Greenhouse Gases/GHG (items 5–8), Impacts on the Environment (items 9–12), Scientific Evidence of Climate Change (items 13–15), Mitigation and Adaptation (items 16–18), and the Relationship between Human Activity and Climate Change (items 19–20). Two experts (a content expert and an instrument expert) validated the instrument, which obtained a Content Validity Ratio (CVR) of 0.87 and was classified as valid. Table 1 shows the definition of the CRI scale used.

Table 1. Definition of the CRI Scale

Scale	Category	Description of Confidence Level
0	Totally Guessed	No knowledge; answered by pure guessing
1	Almost Guess	Almost guessing; very minimal knowledge (< 25%)
2	Not Sure	Less confident; knowledge about 25–50%
3	Sure	Confident; knowledge about 50–75%
4	Almost Certain	Nearly certain; knowledge about 75–99%
5	Certain	Very confident; full knowledge (100%)

Source: adapted from Chen, Andersson, & Zhu (2023)

Data Analysis Technique

Data analysis was conducted in three stages. First, each student's understanding per item was categorized using the CRI matrix based on the combination of answer accuracy and CRI scale value (Table 2). The threshold used was CRI ≥ 3 for the "confident" category and < 3 for "not confident," consistent with the standard most commonly used in the Indonesian science education literature (Suharsono et al., 2022).

Table 2. Understanding Categorization Criteria Based on CRI

Answer	CRI Scale	Understanding Category	Interpretation
Correct	≥ 3	Conceptual Understanding (CU)	Understands the concept well and confidently
Correct	< 3	Lucky Guess (LG)	Correct answer but not confident / guessing
Incorrect	< 3	Does Not Know the Concept (DK)	Does not understand the concept and is not confident
Incorrect	≥ 3	Misconception (M)	Confident but holds an incorrect concept

Source: Chen, Andersson, & Zhu (2023)

Second, we calculated the average CRI per student (the sum of CRI values for all items divided by 20) and the average CRI per item (the sum of CRI values for all students on a given item divided by 14). Third, each student's dominant understanding conclusion was determined using the following criteria: Conceptual Understanding (if the proportion of CU ≥ 75%), Sufficient Understanding (if CU + LG ≥ 60% without misconception dominance), Misconception (if the proportion of M ≥ 50%), and Does Not Understand (if the proportion of DK ≥ 50%). Data were analyzed descriptively and presented in tables, bar charts, and pie charts, which were interpreted narratively. To protect students' privacy, this report identifies individual students using anonymous codes (S1–S14) rather than names.

RESULTS AND DISCUSSION

Student Understanding Profile Based on CRI Analysis

The results of the CRI analysis of 14 Class IX students at SMPN Satu Atap 5 Hanau are presented in full in Table 3. The data show significant variation in both average CRI scores and the distribution of understanding categories among students.

Table 3. Complete Profile of CRI Analysis Results per Student

No	Student Code	Cat.	Avg CRI	CU	LG	DK	M	Conclusion
1	S1	Low	3.6	8	2	1	9	Sufficient Understanding
2	S2	High	4.0	17	3	0	0	Conceptual Understanding

No	Student Code	Cat.	Avg CRI	CU	LG	DK	M	Conclusion
3	S3	High	4.2	17	2	0	1	Conceptual Understanding
4	S4	Medium	2.7	7	8	1	4	Sufficient Understanding
5	S5	High	4.7	18	0	0	2	Conceptual Understanding
6	S6	Low	0.8	0	4	15	1	Does Not Understand
7	S7	Low	4.7	8	0	0	12	Misconception
8	S8	High	2.1	4	6	6	4	Sufficient Understanding
9	S9	High	4.2	16	1	0	3	Conceptual Understanding
10	S10	Medium	2.9	6	7	2	5	Sufficient Understanding
11	S11	Low	1.6	1	5	9	5	Sufficient Understanding
12	S12	High	4.9	17	0	0	3	Conceptual Understanding
13	S13	Low	4.7	6	0	0	14	Misconception
14	S14	Medium	3.0	8	7	2	3	Sufficient Understanding

Note: CU = Conceptual Understanding; LG = Lucky Guess; DK = Does Not Know the Concept; M = Misconception

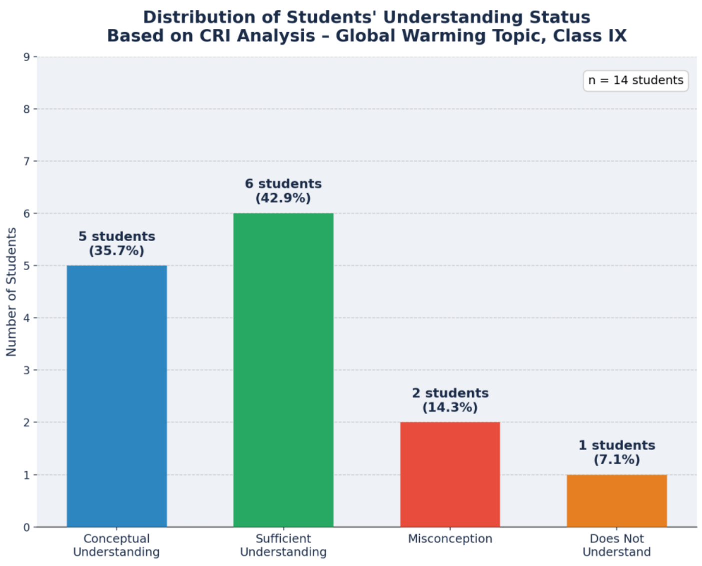

Figure 1. Percentage Distribution of Students' Understanding Status (n = 14)

Based on Table 3, the distribution of students' understanding conclusions shows a varied pattern. Five students (35.7%) were classified as having Conceptual Understanding (S2, S3, S5, S9, S12), six students (42.9%) as Sufficient Understanding (S1, S4, S8, S10, S11, S14), two students (14.3%) experienced dominant Misconception (S7 and S13), and one student (7.1%) fell into the Does Not Understand category (S6). This distribution is visualized in Figure 1.

The group's average CRI value ranged from 0.8 (S6) to 4.9 (S12), reflecting very high heterogeneity in confidence levels within a single class. The classical average CRI was 3.46, which in aggregate falls into the "confident" category (CRI $\geq$ 3), but this figure conceals significant individual disparities. This finding is consistent with Herlanti et al. (2020), who found that the classical average CRI cannot be used as the sole indicator of understanding quality, since it can be masked by extreme distributions among students.

Special attention is needed for two students with dominant misconceptions: Student S7 (12 misconceptions, average CRI 4.7) and Student S13 (14 misconceptions, average CRI 4.7). The combination of very high CRI with many incorrect answers is a typical characteristic of a "deep-rooted misconception," in which strong confidence in an incorrect concept has become well-structured within the student's cognitive schema (Li, Li, & Wang, 2023). This condition is far more difficult to address than ordinary ignorance, because students tend to reject new information that contradicts their beliefs (Choi et al., 2022). Cases like these require a conceptual-change intervention based on cognitive confrontation.

The case of Student S6 (average CRI 0.8, 15 items categorized as Does Not Know the Concept) represents a different profile: a student who is neither confident nor understanding of the concept. The very low CRI value indicates that this student answered nearly all items by guessing, without an adequate knowledge base. This condition may be associated with low learning motivation or barriers to following instruction (Samsuddin, 2024). Students in this group need an intensive scaffolding approach that builds basic concepts from the ground up.

Misconception Distribution per Item

Analysis of misconceptions per item number produced the distribution profile shown in Table 4 and Figure 2.

Table 4. Number of Students with Misconceptions per Item Number

Item No.	Indicator/Topic	No. of Misconceptions	% of Total
1	Basic Concept – Definition of Global Warming	4	28.6%
2	Basic Concept – Greenhouse Effect	3	21.4%
3	Basic Concept – Global Warming vs Climate Change	4	28.6%
4	Basic Concept – History of Global Warming	4	28.6%
5	Causes of GHG – Carbon Cycle	2	14.3%
6	Causes of GHG – Agricultural Contribution	6	42.9%
7	Causes of GHG – Deforestation	5	35.7%
8	Causes of GHG – Electricity Use	2	14.3%
9	Impact – Polar Ice Melting	3	21.4%
10	Impact – Clean Water Availability	3	21.4%
11	Impact – Coral Reefs	5	35.7%
12	Impact – Animal Adaptation	2	14.3%
13	Scientific Evidence – Weather vs Climate	4	28.6%
14	Scientific Evidence – Scientific Consensus	4	28.6%
15	Scientific Evidence – Impact in Indonesia	1	7.1%
16	Mitigation & Adaptation – Definition of Mitigation	2	14.3%
17	Mitigation & Adaptation – Definition of Adaptation	5	35.7%
18	Mitigation & Adaptation – Renewable Energy	2	14.3%
19	Human Activity – Causal Attribution	3	21.4%
20	Human Activity – Individual Action	2	14.3%

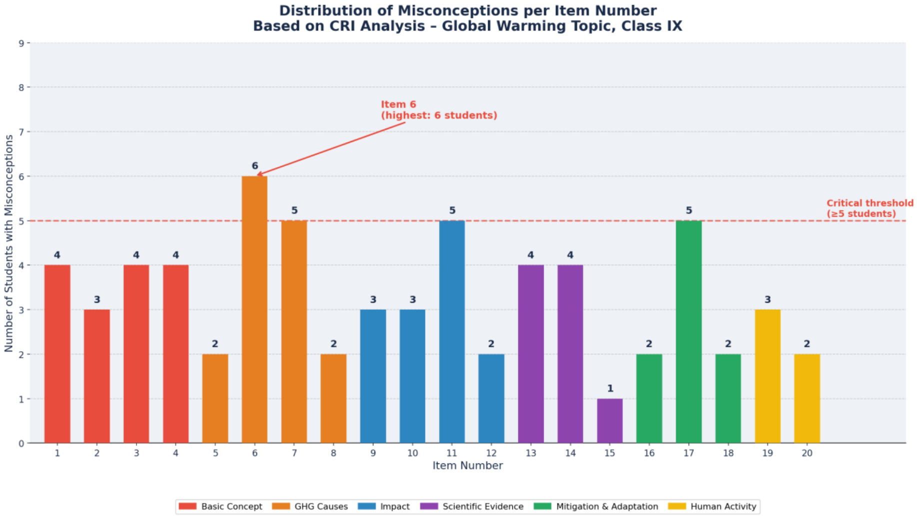

Figure 2. Distribution of the Number of Students with Misconceptions per Item Number Based on CRI Analysis

Item number 6 (agriculture's contribution to GHG emissions) ranked highest, with 6 students showing misconceptions (42.9%). The high misconception rate on this item can be explained through conceptual change theory (Li, Li, & Wang, 2023): students construct a mental representation in which pollution sources come only from visibly obvious sources (factories, motor vehicles), while agricultural activity is perceived as a "natural" activity that does not produce harmful emissions. In fact, the agricultural sector contributes approximately 10–12% of global GHG emissions, mainly through methane (CH_4) production from rice paddies and ruminant livestock, as well as nitrous oxide (N_2O) from nitrogen fertilizers (IPCC, 2021). This category of misconception falls under "ecological misconception," formed from everyday experience without adequate scientific correction.

Item 7 (the role of deforestation), item 11 (impact on coral reefs), and item 17 (definition of adaptation) each produced 5 students with misconceptions (35.7%). The misconception on item 17 in particular deserves attention, as it reflects a fundamental conceptual confusion between two climate-change response strategies. Students who experienced misconceptions on this item generally defined adaptation as an action to reduce the causes of climate change (which should be the definition of mitigation), or vice versa. This terminological confusion is common in similar studies in Indonesia (Marlina et al., 2021; Putri et al., 2025), indicating that instruction needs to place greater emphasis on the distinction between mitigation and adaptation.

Interestingly, item number 15 (the impact of global warming in Indonesia) showed the lowest misconception rate (1 student, 7.1%). This is likely because the topic of Indonesia is closer to students' everyday context and is discussed more frequently in local media, giving students better exposure to information on this topic (Velayati & Prastowo, 2022). This finding indicates that contextualizing learning material with local issues can effectively reduce misconceptions.

Cumulatively, 67 misconception occurrences were identified across 280 student responses (14 students × 20 items), yielding an average misconception index of 23.9%. This figure is higher than Ningrum et al. (2021) in a similar population (18.7%), which can be attributed to the remote-area context with more limited access to learning resources. The spread of misconceptions across nearly all indicators (except item 15) indicates that the misconceptions are systemic rather than localized to a particular topic. This calls for a comprehensive remediation approach within the framework of ESD-oriented science learning.

Overall Proportion of Understanding Categories

Figure 3 presents the overall proportion of understanding categories obtained from a total of 280 student responses. Figure 4 compares proportions by academic category.

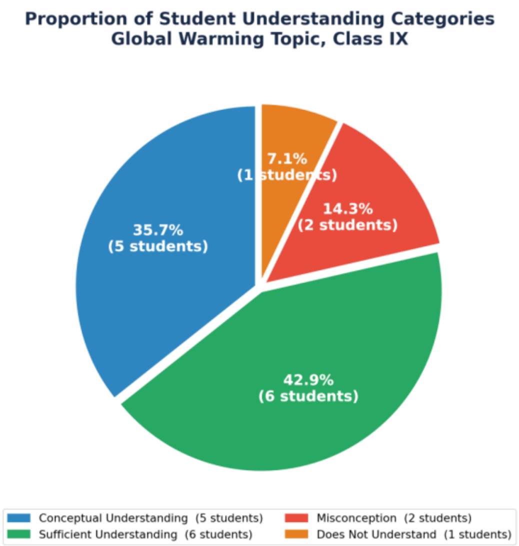

Figure 3. Proportion of Understanding Categories Based on CRI Analysis (n = 14 students)

Of the 280 total responses, 66 (23.6%) were classified as Conceptual Understanding, 111 (39.6%) as Lucky Guess, 34 (12.1%) as Does Not Know the Concept, and 69 (24.6%) as Misconception. The high proportion of Lucky Guess

(39.6%) deserves special attention. It indicates that most of the students' correct answers were not grounded in strong conceptual confidence, but were more the result of guessing or intuition. This condition shows that conventional assessment based solely on answer accuracy can give a misleading picture of students' actual level of understanding (Herlanti et al., 2020).

Understanding Pattern Based on Academic Category

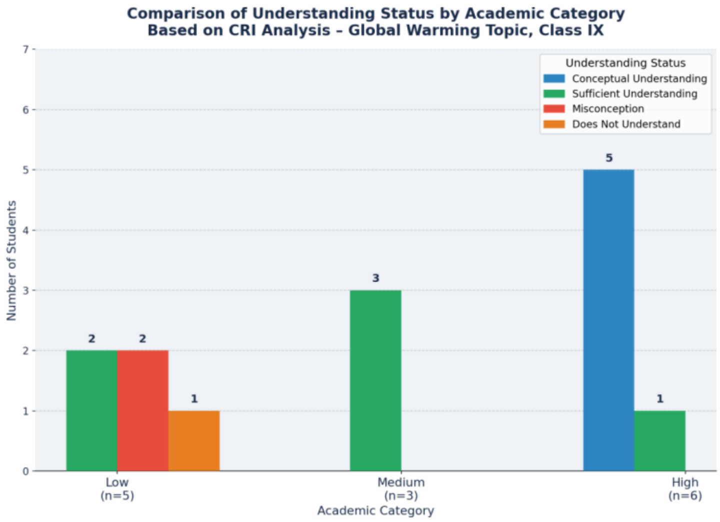

Figure 4. Comparison of Understanding Status Based on Academic Category

Analysis based on academic category produced the pattern presented in Table 5. The most significant finding is the distribution of misconceptions concentrated in the Low category (2 cases of dominant misconceptions out of 5 students = 40%), compared to the Medium category (0%) and the High category (0% dominant misconceptions).

Table 5. Distribution of Conclusions per Academic Category

Category (n)	Conceptual Understanding	Sufficient Understanding	Misconception	Does Not Understand
Low (n=5)	0 (0%)	2 (40%)	2 (40%)	1 (20%)
Medium (n=3)	0 (0%)	3 (100%)	0 (0%)	0 (0%)
High (n=6)	5 (83.3%)	1 (16.7%)	0 (0%)	0 (0%)
Total (n=14)	**5 (35.7%)**	**6 (42.9%)**	**2 (14.3%)**	**1 (7.1%)**

Table 5 shows a clear correlation between academic category and CRI understanding profile. The High category was dominated by Conceptual Understanding

(83.3%), while the Low category showed the highest heterogeneity, with cases of misconception and incomplete understanding. This finding is generally consistent with Suharsono et al. (2022), who found a positive correlation between academic achievement and conceptual accuracy in science subjects.

However, an important exception deserves attention: two Low-category students (S7 and S13) actually had the highest average CRI (4.7), equal to that of High-category students, but with a very high dominance of misconceptions. This phenomenon is referred to as the "knowledge-confidence paradox," in which confidence not matched by knowledge accuracy results in deep-rooted misconceptions (Choi et al., 2022). These students likely obtained incorrect information from inaccurate sources (social media, everyday conversation) and believed it to be scientific truth.

Conversely, the Medium category was entirely at the Sufficient Understanding level (100%), with no cases of dominant misconception. This indicates that medium-level students balance caution in responding (reflected in non-extreme CRI values) with adequate concept mastery. This pattern is consistent with the findings of Herlanti et al. (2020), who showed that students with medium academic ability tend to be more "calibrated" in their confidence compared to students with extreme abilities.

Implications for the Development of ESD-Oriented Science Learning

The identified misconception profile has direct implications for designing science learning oriented toward Education for Sustainable Development (ESD). Based on the CRI data obtained, at least three main strategies need to be integrated into instruction.

First, apply CRI-based diagnosis before instruction (pre-instruction CRI) to map specific misconception points that need to be addressed. Data from this study show that misconceptions were concentrated in agricultural GHG contribution, deforestation, mitigation-adaptation terminology, and coral reefs. These topics need special emphasis in instructional design (Marlina et al., 2021).

Second, use the Problem-Based Learning (PBL) model in early sessions to confront misconceptions by presenting authentic problems based on local data. Well-structured confrontational experiences have proven effective in initiating conceptual change among students with deep-rooted misconceptions (Rousell & Cutter-Mackenzie-Knowles, 2020; Suryani et al., 2025). In the context of SMPN Satu Atap 5 Hanau, authentic problems can take the form of climate-change data that directly affect the Kalimantan region, such as forest fires, floods, and coastal abrasion.

Third, implementing the Project-Based Learning (PjBL) model in subsequent sessions encourages students to design and carry out real action projects grounded in accurate understanding. Integrating ESD into PjBL has proven effective in developing students' SA through direct experience of contributing to environmental sustainability (Kelfina et al., 2025; UNESCO, 2021). Action projects may include producing educational media on climate-change mitigation for the community, tree planting, or waste management based on circular-economy principles.

Based on the item-level misconception analysis, further diagnostic interviews are recommended for 13 of the 14 students who showed misconceptions on at least one item. These interviews are important for exploring the structure and sources of misconceptions in greater depth, so that remediation can be designed more precisely. The findings of this study also confirm that the CRI instrument should not only be used as a research tool, but also integrated as a routine diagnostic assessment practice in school science instruction (Herlanti et al., 2020; Suharsono et al., 2022).

CONCLUSION

The distribution of students' understanding showed 35.7% Conceptual Understanding, 42.9% Sufficient Understanding, 14.3% dominant Misconception, and 7.1% Does Not Understand—with 23.9% of all responses identified as misconceptions. Second, the highest misconceptions were found in agriculture's contribution to GHG (item 6: 42.9%), deforestation (item 7: 35.7%), impact on coral reefs (item 11: 35.7%), and adaptation terminology (item 17: 35.7%). Third, academic category strongly correlated with CRI understanding profile: High-category students were dominated by Conceptual Understanding, and Medium-category students were entirely at the Sufficient Understanding level. In contrast, Low-category students showed higher patterns of misconception and incomplete understanding. Taken together, these findings confirm the urgency of developing ESD-oriented science learning that is responsive to students' specific misconception profiles in remote schools.

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