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Identification of Student Misconceptions on Electrical Material Using the Certainty of Response Index (CRI) Method

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Abstract

Students' ability to analyze abstract topics using their critical thinking skills depends on their understanding of the related concepts. Many science concepts are not well-developed, leading to misconceptions among many students. The mixed-methods approach in this study involved administering a diagnostic test within a quantitative framework, followed by the researcher providing assessments and justifications, along with each student's level of confidence. In the qualitative methodology, the researcher conducted interviews with several students to gather data on the underlying causes of misconceptions regarding electricity. Based on the overall results of the students' answers, the percentage of students who experienced misconceptions about the electricity material was 18% and was classified as low. Meanwhile, the results of the students' answers to each question showed that the percentage of misconceptions most frequently experienced by students was for question number four, which had a 38% response rate, with the question indicator explaining changes in electrical energy. According to one of the students' answers, they experienced misconceptions because the multiple-choice options provided incorrect answers, and the reasons for these incorrect answers were also incorrect. However, the student was confident in their answer, resulting in a CRI score greater than 2.5, which falls into the high category. Some students experience misconceptions because the concepts they receive from teachers are not fully understood, the learning methods used by teachers are not yet able to bridge students who have limitations in understanding and differences in learning styles, the use of textbooks by teachers in learning does not provide a comprehensive or complete explanation so that children feel they have a piecemeal understanding, and the learning activities carried out by teachers in developing skills and collaboration between students are not yet fully apparent.

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INTRODUCTION

Science is a branch of knowledge characterized by the study of factual natural phenomena, whether in the form of facts or events and their causal relationships (Da Silva, 2022; Lestari et al., 2024; McCain, 2015). Because science learning involves systematically exploring nature, it encompasses not only the mastery of a body of knowledge in the form of facts, concepts, or principles, but also a process of discovery. Science learning is expected to provide a platform for students to learn about themselves and the natural world around

them, thus fostering the prospect of further development in applying it in everyday life (Dewi et al., 2021; Saputro et al., 2020; Widyaningrum et al., 2022)

The implementation of the Independent Curriculum in Science and Social Studies subjects at the Elementary School level, covering grades IV, V, and VI, is combined into IPAS (Natural and Social Sciences) (Fitriyah & Wardani, 2022; Anggita et al., 2023; Mayangsari et al., 2024). These two subjects are included in the core subjects that students must obtain (Marlina, 2022; Permatasari & Marlina, 2022; Marlina & Sherli, 2022).

In elementary science education, a strong understanding of basic principles must underpin abstract concepts. Students' ability to analyze abstract topics using their critical thinking skills will depend on their understanding of the related concepts. Many science concepts are not well-developed, leading to misconceptions among students. Abbas (2016) stated that understanding abstract ideas is certainly more challenging than understanding concrete concepts. If misconceptions are not immediately identified and corrected, they will negatively impact students' understanding of subsequent concepts and make it difficult for them to learn science at higher levels (Soeharto, 2021). Misconceptions among students can have a negative impact on the learning process.

Narjaikaew (2013) stated that students will face misconceptions if they are unable to connect previous experiences with new concepts taught during science lessons. Furthermore, Aydin (2013) also stated that before teaching, teachers must be able to recognize and address their students' misconceptions. Therefore, mapping and identifying students' misconceptions regarding science learning, in particular, requires special tools. One way to determine the level of student misconceptions is by using the Certainty of Response Index (CRI) method.

The CRI method is an analytical method that presents questions and is equipped with a confidence scale in answering, so that students can provide their own answers according to their knowledge and concepts (Wulandari, 2022). This CRI method was developed by Hasan, Bagayoko, and Kelley in 1999. The CRI method is a technique for measuring a person's misconceptions by determining the level of confidence or certainty in answering each question given (Kusumawati et al., 2022). The CRI method is very easy to use in uncovering misconceptions because it includes a scale that measures respondents' confidence in answering questions. The CRI scale has different values according to its respective criteria. Based on these criteria, students can be categorized as understanding the concept, experiencing misconceptions, and not understanding the concept (Putri et al., 2021; Ulfah & Fitriyani, 2017). The advantage of this method is that it can differentiate between students who truly understand the concept, those who do not understand the concept, those who guess the answer, and those who experience misconceptions.

Based on the results of previous research, no study has focused on students' misconceptions about electrical materials using the CRI method. Thus, this study focuses on obtaining information and identifying the results of students' misconceptions about electrical materials using the CRI method through multilevel multiple-choice questions. These questions measure the level of confidence or certainty that students have in answering each question based on predetermined question indicators. The novelty in this study is connecting and complementing the results of previous research with the purpose of this study, namely, identifying students' misconceptions on electrical material using the CRI method.

Based on the description above, the researcher is interested in conducting research to find out more about the misconceptions of fifth-grade students of Mangkang Kulon 02 Semarang Elementary School with the research title "Identifying Student Misconceptions on Electrical Material Using the Certainty of Response Index (CRI) Method."

METHODS

The research methodology used is a mixed-methods approach, namely, integrating quantitative and qualitative methods in the research process. This combination aims to produce comprehensive, valid, reliable, and comprehensive data (Creswell et al., 2007). This mixed-methods research uses an explanatory sequential design, namely a methodological framework that begins with the collection of quantitative data to identify certain trends or patterns. Next, this research continues with the collection of qualitative data to provide a deeper explanation or understanding of the quantitative results. The application of mixed methods in this study involves conducting diagnostic tests within a quantitative framework. Then the researchers respond by providing assessments and justifications accompanied by the level of confidence of each student. Meanwhile, in the qualitative methodology, the researcher conducted interviews with several students to collect data regarding the underlying causes of misconceptions in the electricity material.

The population in this study was all 26 sixth-grade students of Mangkang Kulon 02 Elementary School, Semarang. The sampling technique used was purposive sampling with online questions via Google Form, and this class was used as a single class/experimental class only, without a control class. The instrument used in this study was a three-tiered diagnostic test that incorporated open-ended reasoning and provided respondents with options to indicate their level of certainty or uncertainty. This assessment was designed to identify potential misconceptions among students. The instrument was adapted from research conducted by Ratama (2013) and has good content validity and grammatical format. The instrument is accompanied by a statement confirming that no revisions are necessary, allowing its use in its current form. The diagnostic test instrument indicators are listed in Table 1.

Table 1 Diagnostic test instrument indicators

Number	Question Indicator	Question Number
1	Mention the uses of electrical energy in everyday life	1
2	Mention the changes in electrical energy into other types of energy	2
3	Explain changes in electrical energy	3, 4
4	Explaining ways to save electrical energy in everyday life	5

Misconceptions can be identified through the implementation of a three-tier diagnostic test, which uses multiple-choice questions related to electricity in elementary school. In the three-tier diagnostic test, the multiple-choice questions are structured to cover three different levels of response. The first level consists of general multiple-choice questions. The second level relates to the reasoning behind students' choices at the first level. Finally, the third level assesses students' confidence in their responses to the previous two levels. Students' levels of conceptual understanding, as assessed by the three-tier diagnostic test, are depicted in Table 2.

Table 2 Categories of student understanding levels based on the three-level diagnostic test

Answer	Reason	Confidence	Category
Correct	Correct	Certain	Understand the Concept
Correct	Wrong	Certain	Misconceptions
Wrong	Correct	Certain	Misconceptions
Wrong	Wrong	Certain	Misconceptions
Correct	Wrong	Not sure	Don't Understand the Concept
Wrong	Correct	Not sure	Don't Understand the Concept
Correct	Correct	Not sure	Don't Understand the Concept
Wrong	Wrong	Not sure	Don't Understand the Concept

Jumini et al., (2017)

Data credibility was further tested using the CRI method, which cross-checked the data with the same source using different techniques. The level of confidence in answering the questions was assigned a scale of 1–5. The meaning of the CRI scale is shown in Table 3.

Table 3 CRI scale and its criteria

CRI	Criteria
5	Very Understanding
4	Almost Understand
3	Certain
2	Not sure
1	Some Guesswork Answers
0	Overall Answer Guesswork

Meanwhile, to determine the criteria for students in each category based on the high and low CRI scores, refer to Table 4.

Table 4 Criteria for high and low cri values

Answer Criteria	Low CRI (<2.5)	High CRI (>2.5)
Correct answer	Correct answer, but low CRI means they do not know the concept (lucky guess)	Correct answers and high CRI mean mastering the concept well (knowing the concept).
Wrong answer	Wrong answers and low CRI mean not knowing the concept.	Wrong answer, but high CRI means there is a misconception.

Source: Tayubi (2005:6)

The analysis used in this study is descriptive analysis. According to Oscar & Sumirah (2019), descriptive analysis is a statistical method used to analyze data by describing or depicting the collected data as it is, without the intention of drawing general conclusions or generalizations. The researcher took the following steps to conduct an in-depth analysis of the data obtained, namely: (1) examining student responses by correlating the multiple choice results with students' reasons and beliefs, then categorizing them based on their level of understanding as shown through a three-level diagnostic test; (2) organizing and classifying student responses related to student understanding, namely: students who understand, or do not understand, and or experience misunderstanding; (3) calculating the percentage of misunderstandings experienced by students in the answers or responses to each question they have completed according to the categories in the three-level diagnostic test; and (4) formulating conclusions based on the data and presenting them in the form of a misunderstanding profile and the corresponding percentage of misunderstandings diagnostic test techniques.

RESULTS AND DISCUSSION

This study was conducted by administering a diagnostic test consisting of five multiple-choice questions arranged in three levels to identify students' misconceptions about electricity. Each question posed to students aimed to elicit responses based on their existing knowledge. Students were required to provide appropriate justification for their answers, demonstrating the understanding and insights gained during the classroom learning process. There were levels of confidence in the selection of student responses. The selection

of students' confidence levels based on their understanding of the electricity material was conducted transparently.

The identification of misconceptions carried out by researchers through a three-level diagnostic test has been designed to classify students' levels of understanding into three categories: students who understand the concept, students who have misconceptions, and students who do not understand the concept. However, not all errors in student responses fall into these three categories. Students' errors may stem from a lack of understanding of the electricity material taught by the teacher. A graph of the percentage of misconceptions per student across all questions is shown in Figure 1.

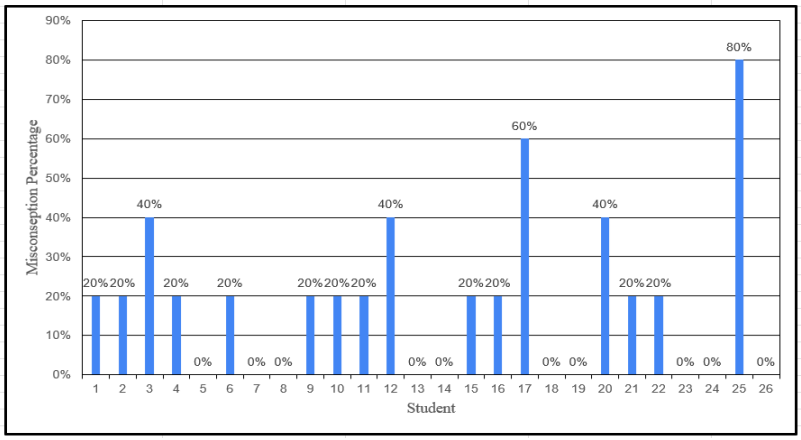

Figure 1 Graph of the percentage of misconceptions for each student on all questions

The graph of the percentage of students' misconceptions for each question is shown in Figure 2.

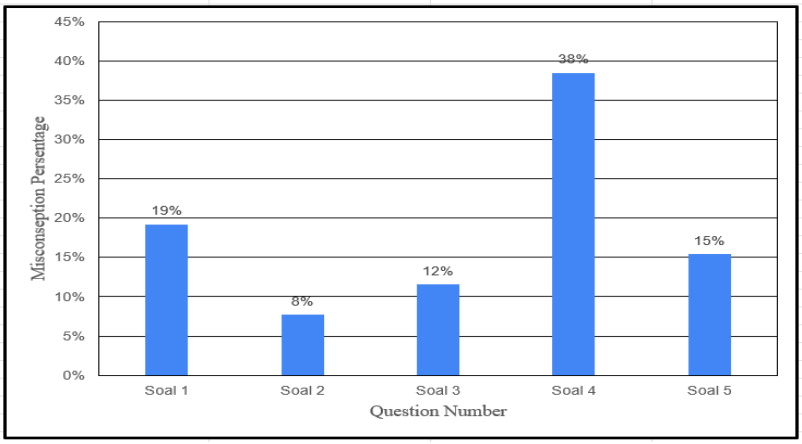

Figure 2 Graph of the percentage of student misconceptions on each question

Figure 2 shows the percentage of students who have many misconceptions about electricity. This proves that students provide examples of misunderstandings in understanding electricity in the indicator explaining ways to conserve electricity in everyday life. In this case, students' answers are incorrect, and their reasons are also inappropriate; however, they are confident in their answers, and some are even very confident, resulting in a CRI score greater than 2.5.

Multiple choice questions arranged in three levels based on the indicators of electrical material questions as a diagnostic test are explained as follows:

Level of Student Misconceptions on Electrical Material

Based on the overall student responses, 18% of students experienced misconceptions about electricity, which is considered a low percentage. Although this is considered low, teachers need to improve their teaching, as the thinking of students experiencing these misconceptions only has theoretical characteristics that differ from scientific concepts (Kambouri et al., 2016).

Meanwhile, the results of students' answers to each question showed that the percentage of misconceptions most frequently experienced by students was question number four, at 38%, with the question indicator explaining changes in electrical energy. The following is question number four, along with the answer from one of the students who experienced the misconception.

Question: Electric charges flow or move their electrons in one direction or back and forth in a conductor, or what is commonly called electric current. The collection of electrons continuously flows from one point to another, so that the electric current is similar to the flow of a river. This statement is the definition of ....

A. direct current
B. static electricity
C. dynamic electricity
D. complementary electricity

Answer: A. direct current
The reason you chose this answer: because electricity flows in one direction.
Your belief in choosing this answer:

A. Very Uncertain
B. Not Certain
C. Not Quite Certain
D. Certain
E. Very Certain

Answer: D. Certain

According to the answer of one of the students, he had a misconception because the multiple-choice option was incorrect, both in the answer and the reason, yet the student was confident in his response. Consequently, the CRI they obtained was greater than 2.5, falling into the high category.

Many students make incorrect answers, use incorrect reasoning, and hold strong beliefs because they already have their own ideas in their answers. Therefore, it can be said that many students in a class already have their own ideas before they face a subject, which are called preconceptions (Modell et al., 2005). Many of these preconceptions are incorrect, often hindering the development of scientific concepts (Bangun et al., 2019). Therefore, teachers need to improve their teaching of electricity.

Factors Causing Student Misunderstanding

Consistent with the findings of Tayubi (2005) and Fakhriyah (2021), misconceptions can arise from experiences through daily interactions with the natural environment. The students' residential areas are industrial areas, so their daily interactions are very limited. Furthermore, parents are often busy working in factories, resulting in a lack of attention and limited opportunities for instilling experiences in their children. Students learn on their own, without explanation or guidance, in learning about the environment, leading to the formation of preconceptions.

These learning experiences can lead to the formation of inaccurate intuitions in students' minds. Students' preconceptions, many of which are erroneous, often hinder the development of scientific concepts (Bangun et al., 2019). Misconceptions arise among students who engage with abstract conceptual material that lacks concrete reality, resulting in a lack of clarity in their understanding of the concepts (Haryono et al., 2021; Khandagale & Shinde, 2021).

Research conducted by researchers is always accompanied by limitations and challenges that can hinder the achievement of optimal results. However, these limitations and challenges can be anticipated by the researchers themselves. A limitation of this study was that the online test, administered via Google Forms, did not impose a time limit on response collection. This lack of time limits allowed students to submit answers that may not accurately reflect their understanding, as they could search for answers online or collaborate with other peers during the assessment.

The challenges and shortcomings encountered by the researchers included the inadequate internet connection at the school, which couldn't be used directly by multiple devices. Therefore, the researchers had to inform students that they would need to provide their own internet quota for online tests. This was considered a burden for some parents, who are from the lower-middle class.

In this study, researchers found that several students experienced misconceptions due to their tendency to hesitate when answering questions. Furthermore, they didn't fully understand the concepts they received from their teachers, leading them to present ideas haphazardly or with little relevance in their answers.

Furthermore, the teaching methods employed by teachers are unable to accommodate students with limited understanding and differing learning styles. The teachers' use of textbooks in their lessons does not provide comprehensive or complete explanations, leaving students with a fragmented understanding.

The learning activities carried out by teachers to foster skills and collaboration among students are not fully visible. As a result, some students work individually within their groups. As a result, the division of tasks within the group tends to be ineffective, and they end up blaming each other if their group's work fails to achieve its goals.

CONCLUSION

The level of students' misconceptions about electricity material is relatively low, with an average percentage of 18%, based on the results of a study conducted through data collection at SD Negeri Mangkang Kulon 02 Semarang with analysis using the Certainty of Response Index (CRI). Although it is classified as low, it is still necessary to carry out follow-up and reflection on learning so that grade 6 students do not experience misconceptions about electricity material in the following academic year. In this study, after identification, several factors caused students' misconceptions about learning electricity material, including students' preconceptions or initial concepts or understandings that students had before receiving electricity material learning, the effectiveness of the learning methods used during the learning process, and the strategies used by teachers in conveying and explaining to their students when learning electricity material were still less than optimal. The results of this study are expected to be a reference material for further research aimed at overcoming and improving students' understanding of misconceptions, especially in learning electrical material.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest in this research.

AUTHOR CONTRIBUTIONS STATEMENT

All authors have contributed to the conceptualization, methodology, formal analysis, investigation, and writing of this article.

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