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ANALYSIS OF MISCELLANEOUS STUDENTS' MISCONCEPTION ON TEMPERATURE AND HEAT MATERIALS USING THE CERTAINTY OF RESPONSE INDEX (CRI) METHOD

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Abstract

This study aims to analyze junior high school students' misconceptions related to temperature and heat material and to improve the quality of learning through identifying concepts that are difficult to understand. The method used is descriptive qualitative with the Certainty of Response Index (CRI) approach to measure students' level of understanding. The research sample consisted of 108 7th grade students in the Bangkalan district. The results showed that students experienced various misconceptions, especially on the concepts of temperature, heat, and heat transfer, with a significant frequency of misconceptions. These findings indicate the need for the application of more interactive and contextual learning methods, such as direct experiments and the use of visual illustrations, to improve students' understanding. The conclusion of this study emphasizes the importance of identifying misconceptions in designing effective teaching strategies, as well as the need for further research with larger samples and diverse methods to understand the factors that influence students' understanding. This study is expected to contribute to the development of curriculum and teaching methods in physics education, as well as help students understand the concepts of temperature and heat better so that they can improve their learning achievement.

Keywords*: Misconceptions, Temperature and Heat, Certainty of Response Index*

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INTRODUCTION

The importance of understanding the concept of temperature and heat in science education is very significant. First, a good understanding of temperature and heat is an important foundation in learning other physics and chemistry concepts, because these concepts often form the basis for more complex materials at higher levels of education, such as thermochemistry and thermodynamics (Rahayu et al., 2024). In addition, this journal emphasizes that many students still hold various misconceptions about temperature and heat, despite having been taught this material previously. By identifying and understanding these misconceptions, teachers can design more effective teaching strategies to help students overcome their misconceptions (Harahap & Wandini, 2023). The concepts of temperature and heat are not only important in physics but also have relevance in various other disciplines, so a correct understanding will make it easier for students to understand other materials related to energy and changes in the state of matter. Finally, the role of teachers in selecting the appropriate approach and method to teach concepts prone to misconceptions is crucial. By paying attention to students' initial understanding, teachers can create a more meaningful learning experience. Overall, a strong understanding of temperature and heat is essential to support effective science learning and to prepare students for more complex concepts in the future (Setyaningrum & Sopandi, 2021).

Student misconceptions are incorrect or mistaken understandings that students have of a concept or subject matter, which are often formed from preconceptions or initial concepts that are not in accordance with scientific understanding (Respasari et al., 2022). When students bring these incorrect preconceptions into the learning process, they tend to interpret new information in the wrong way (Sapuadi & Nasir, 2020). For example, in learning the concept of work and energy, students may misunderstand that work only occurs if there is a change in energy in an object, without understanding the context of the forces acting and the displacement that occurs. Misconceptions like this can hinder the learning process because students have difficulty understanding more complex material and relating it to other related concepts (Tiyas, Khusaini & Suwasono, 2024). Therefore, in the context of education, it is crucial for teachers to identify and address these misconceptions so that students can build a correct and in-depth understanding. With an accurate

understanding, students can apply the concept appropriately in broader situations and support the development of their critical thinking and scientific understanding (Maison, Lestari & Widaningtyas 2020).

Temperature is a measure that describes the hotness or coldness of an object or substance. Temperature is also defined as a quantity in science possessed by two or more objects that are in a state of thermal equilibrium. Hot objects have high temperatures, while cold objects have low temperatures (Salo et al., 2023). Changes in the temperature of an object to become hotter or colder are often accompanied by changes in shape or phase. For example, water can turn into ice or water vapor due to the influence of heat or cold (Wandini et al., 2022). Heat is a form of thermal energy that moves from objects with high temperatures to objects with low temperatures (Handayani et al., 2023). As energy, heat can move from one location to another and from one state to another (Nurhidayat et al., 2020). Heat plays a role in changing the state of a substance or object. Objects or substances can basically change state (solid, liquid, gas) due to heat, heat transfer occurs due to temperature differences between objects (Yolanda, 2021). Heat from an object with a higher temperature will move to an object with a lower temperature. There are three ways of heat transfer, namely conduction, convection, and radiation (Suhadi et al., 2022).

The topic of temperature and heat has many implications in everyday life that are very important. First, understanding heat and temperature plays a role in the use of energy in households, such as in water heaters, refrigerators, and space heaters. Knowing how a water heater works, for example, can help us set the desired temperature and save energy. In addition, in cooking activities, understanding temperature is crucial (Siregar, Nasution & Siregar, 2024). The right temperature is needed to cook food safely and effectively, where the cooking process involves the transfer of heat from the heat source to the food, which changes the temperature and state of the food. In the health sector, human body temperature is an important indicator of health. Understanding how body temperature functions and how changes in temperature can indicate the presence of disease is essential in health care, such as fever indicating that the body is fighting an infection (Oroh, Pinontoan, & Tuda, 2020). In addition, the concept of changes in state, such as ice to water or water to steam, is very relevant in everyday life, especially in the context of weather and the environment. Understanding the water cycle helps us understand the phenomena of rain and evaporation (Laliyo, 2018). Finally, in the context of comfort, understanding temperature and heat helps us regulate the temperature of a room using air conditioning or heating, thus creating a comfortable environment to live and work in. Thus, understanding temperature and heat materials allows us to better manage our daily lives and make better decisions related to energy, health, and comfort (Yolanda, 2021). Research on students' misconceptions about temperature and heat materials is crucial to improve the quality of learning. By specifically identifying concepts that are difficult for students to understand, we can design more effective learning materials and methods. In addition, the results of this study can be leveraged to create improved evaluation tools, ensuring more accurate and effective assessments, as well as provide input for improving the curriculum and teaching materials, ultimately, the main goal of this study is to help students understand the concepts of temperature and heat better so that they can improve their learning achievement.

METHOD

The study was carried out in a public and private junior high school in the Bangkalan district in November 2024. Descriptive qualitative research, which focuses on the findings of the analysis pertaining to student misconceptions, was employed. Using the Certainty of Response Index (CRI), the degree of student comprehension is assessed. A total of 108 students in grade 7 made up the sample. A total of 14 multiple-choice diagnostic text questions were completed by the students. The instrument used to measure misconceptions in this study was created by Qusthalani, Halim, and Khaldun (2015). Table 1 displays indicators of the causes of misconceptions pertaining to temperature and heat content.

Table 1. Indicators of Sources of Student Misconceptions (Qusthalani, Halim & Khaldun, 2015)

No	Source of Misconception	Question item number
1.	Concept of Temperature and Heat	1, 6, 7, 9, 10, 12, 13, 14
2.	Concept of Heat Transfer and Temperature Transfer	2, 3, 4, 5
3.	Concept of Thermal Properties of Materials	8, 11

A Certainty of Response Index (CRI) table, ranging from 0 to 5, is included with the questions that students are asked in order to assess their comprehension of the material. Table 2 displays the Certainty of Response Index (CRI) requirements. which Hasan, Bagayoko, and Kelly (1999) developed.

Table 2. CRI Criteria (Hasan, Bagayoko, & Kelly, 1999)

CRI	Criteria
0	*Totally guessed answer*
1	*Almost guess*
2	*Not sure*
3	*Sure*
4	*Almost certain*
5	*Certain*

The results obtained were then analyzed to identify the level of understanding of the students. The level of understanding can be measured through table 3. which has been developed by Hakim, Liliasari & Kadarohman, (2012), in which contains the level of understanding of CRI, namely Lack of the concept knowledge (TTK), Misconception (Mis), Guessing (M), Uncertain about the answer (TKDJ), and Having the Right Concept (MKB).

Tabel 3. Category of Student Concept Understanding (Hakim, Liliasari & Kadarohman, 2012)

First tier **(Answer)**	***Second tier*** **(Reason)**	**CRI Value**	**Description**	**Kode**
Incorrect	**Incorrect**	<2,5	Lack of the concept knowledge	TTK
Incorrect	**Correct**	<2,5	Lack of the concept knowledge	TTK
Incorrect	**Incorrect**	>2,5	Misconception	Mis
Incorrect	**Correct**	>2,5	Misconception	Mis
Correct	**Incorrect**	<2,5	Guessing	M
Correct	**Correct**	<2,5	Uncertain about the answer	TKDJ
Correct	**Incorrect**	>2,5	Misconception	Mis
Correct	**Correct**	>2,5	Having the Right Concept	MKB

Based on the category of students' conceptual understanding with CRI criteria, the results obtained are grouped into several categories of the percentage level of misconceptions. The categories of the percentage level of misconceptions can be seen in Table 4. which was developed by Ramadhani, (2015).

Table 4. Category Percentage Level of Misconception

Level of Misconception	**Category**
$x \leq 27\%$	Low
$27\% < x < 73\%$	Medium
$x \geq 73\%$	High

RESULT AND DISCUSSION

The results obtained from the research conducted in grade 7 totaling 108 students with 14 questions, are presented in the form of a table with several criteria that have been selected according to the calculation of CRI. The number of frequencies and percentages of forms of misconceptions for each question item that has been obtained can be seen in table 5. The data analysis results for questions 1 through 14 in Table 5 indicate that the MIS group consistently dominated the frequency of responses. With the largest domination observed in questions number 6 (57.41%) and 12 (47.22%), the proportion of replies for this group varied from 29.63% to 57.41%. This data indicates that compared to other categories, the MIS group has a higher level of comprehension or involvement. According to the proportion of

questions 1 through 14, the degree of misperception falls into the medium percentage range. This achievement might suggest that the MIS group's learning approach or plan is working.

Table 5. Number of Frequency and Percentage of Misconception Forms for Each Question Item

No.	TTK		MIS		M		TKDJ		MKB	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
1	52	48,15	48	44,44	0	0	5	4,63	3	2,78
2	47	43,52	48	44,44	2	1,85	8	7,41	0	0
3	31	28,7	45	41,67	19	17,59	4	3,7	8	7,41
4	38	35,19	50	46,3	10	9,26	3	2,7	7	6,48
5	46	42,59	51	47,22	6	5,56	0	0	5	4,63
6	41	37,96	62	57,41	1	0,93	0	0	3	2,78
7	53	49,07	47	43,52	2	1,85	1	0,93	4	3,7
8	58	53,7	36	33,33	8	7,41	0	0	5	4,63
9	56	51,85	32	29,63	10	9,26	0	0	9	8,33
10	45	41,67	60	55,56	2	1,85	0	0	0	0
11	34	31,48	35	32,41	14	12,96	15	13,89	10	9,26
12	37	34,26	34	31,48	11	10,19	8	7,41	18	16,67
13	38	35,19	41	37,96	11	10,19	6	5,56	5	4,63
14	34	31,48	51	47,22	7	6,48	1	0,93	5	4,63

In the meantime, the TTK category made a substantial contribution to a number of questions, particularly questions 8 and 9, which each had a 51.85% percentage. TTK's contribution, however, did not exhibit the same level of consistency as MIS. Conversely, the M, TKDJ, and MKB categories demonstrated very poor contributions, with the majority of their percentages falling below 10%, while several queries yielded no responses at all. According to Khoerunnisa and Aqwal (2020), the persistent dominance of MIS suggests that this group has a higher potential to serve as a reference when assessing and enhancing learning methodologies for other groups. To lessen the disparity in question-answering skills between groups, it is critical to identify the MIS group's success factors (Sari et al., 2024).

According to data analysis, there are a number of reasons why students have misunderstandings, with the MIS (Misconception) and TTK (Difficulty in Understanding Concepts) categories dominating the frequency of answers. According to Maisyarah, Vilmala, and Agusminarti (2024), the primary cause is a lack of profound comprehension of concepts. Students frequently exhibit a superficial or incorrect grasp of fundamental ideas, which may be brought on by unclear

comprehension during the learning process. As evidenced by the extremely high number of responses from the MIS category in questions 6 and 12, this leads to students' inability to compile new information using what they already know. According to Azmi et al. (2024), students' inability to put theory to practice is also a result of their lack of practical experience. Insufficient hands-on experience, such experiments or practical applications of physics principles, can make it difficult to comprehend how the concept works in a real-world setting. This is shown in questions 8 and 9, which demonstrate the dominance of TTK (Keliata & Choirunnisa, 2023).

Table 5 shows the number of frequencies and percentages of misconceptions for each question item based on the indicators of the students' misconception source questions that were created, while Table 6 shows the results of misconceptions based on the indicators or each concept. According to table 6's data analysis, each sub-concept has a number of misconceptions. The MIS category's "Concept of Temperature and Heat" has the highest average frequency of 43.4%, suggesting that students frequently have basic misconceptions about these concepts. TKDJ (2.31%) and MKB (5.44%) are two other categories that have a significantly lower degree of misperception. "Concept of Heat Transfer and Temperature Transfer" shows similar trends, with the MIS category dominating with a frequency of 44.91% and the M category following at 8.56%. Students' ignorance of the connection between temperature variations and energy transfer is evident from this instance.

Table 6. Percentage of Misconceptions of Each Concept

No	Concept	Question Number	TTK %	MIS %	M %	TKDJ %	MKB %
1	Concept of Temperature and Heat	1, 6, 7, 9, 10, 12, 13, 14	41,2	43,4	5,09	2,31	5,44
2.	Concept of Heat Transfer and Temperature Transfer	2, 3, 4, 5	37,5	44,91	8,56	3,47	4,17
3.	Concept of Thermal Properties of Materials	8, 11	42,59	32,87	10,19	7,41	6,94

However, in the "Thermal Properties of Materials Concept," the TTK group had the highest frequency of misperception (42.59%), indicating that students struggle to fully comprehend the idea of thermal properties of materials. A noteworthy percentage of 36.35% was also reported by the MIS category. In terms of misconceptions in all subconcepts, the MIS category is the primary cause, with a percentage above 40%, particularly in the "Concept of Temperature and Heat" and "Concept of Heat Transfer." This percentage indicates that the degree of misperception for subconcepts 1 through 3 falls into the medium percentage range. This suggests that in order to decrease misconceptions, a more efficient teaching strategy is required (Putri et al., 2024). This strategy can take the shape of direct experimentation, context-based learning, or the use of visual aids that highlight the causal relationship between ideas (Maslani, 2024). The MIS category should receive the majority of attention in order to enhance students' comprehension of these fundamental physics ideas.

According to the data gathered, there are a number of interconnected reasons why students may have misconceptions about the notions of temperature and heat, heat transport, and thermal material qualities (Asmin & Rosdianti, 2021). First, the primary cause is a misinterpretation of fundamental terminology. Heat and temperature are often confused by many students, who are unable to tell the difference between the two (Rokhim, Rahayu & Dasna, 2023). For instance, people might not realize that energy is being absorbed or released during the change process and instead assume that an object's temperature would continue to fluctuate. Furthermore, this misperception is also

influenced by incorrect everyday experiences (Saputra, Marsha & Kustiyah, 2024). While temperature is more closely linked to the average kinetic energy of the particles in an object, students may believe that mass has a direct impact on temperature (Mahardika et al., 2023). Overall, the results of the students' answers that have been obtained are then averaged and presented in the form of a percentage diagram for each category. The diagram can be seen in Figure 1.

Figure 1. Percentage of Each Category of Misconception

Based on the study's categories of misconceptions, this figure shows the proportion of students' responses. Students' responses to questions pertaining to the ideas of temperature, heat, and energy transmission are displayed by category. The analysis's findings indicate that, with a percentage of 42.33%, the students in the Misconception category (MIS) had a notable dominance in response frequency. Students struggle to grasp these ideas, as evidenced by the largest percentage of answers. This demonstrates the pressing need to enhance students' comprehension using more contextualized and participatory teaching strategies. Consequently, the findings of this diagram offer a clear picture of the students who continue to have misconceptions, and they may serve as the foundation for future learning tactics that are more successful.

It was discovered from observations of 108 seventh graders at Bangkalan junior high schools and MTs that the kids themselves are the cause of these misunderstandings. When students answer a question incorrectly, it might lead to misconceptions since it shows that they have not properly analyzed the subject. Students who choose a reason incorrectly have the lowest misconception, while those who choose an answer and its justifications have the highest misconception. The study's findings suggest that although students may provide the right response, they may not comprehend the rationale behind it (Nasir, 2020).

This misunderstanding is also largely caused by ineffective learning practices. Students are more prone to make mistakes if the teaching strategy emphasizes memorizing over comprehension of the material. The significantly reduced contributions from Categories M, TKDJ, and MKB would indicate that the instructional techniques used were less successful in inspiring or actively involving the students. Furthermore, if the questions are poorly crafted to gauge thorough conceptual knowledge, assessment restrictions may also have an impact on the outcomes. Lastly, student performance may also be impacted by psychological issues including low self-esteem or an inability to adjust to pressure during tests. Students who are anxious or insecure often provide responses based more on conjecture than on true comprehension. All things considered, the reasons behind these misunderstandings point to the necessity of assessing and refining instructional strategies as well as more interactive and contextual learning approaches (Mu'aziyah & Isnawati, 2023) in order to enhance students' comprehension of physics ideas (Rachmawati & Supardi, 2021).

The lack of context in physics learning is also a significant cause of these misconceptions (Aziza, et al., 2023). Students often learn these concepts in isolation without understanding the underlying cause-and-effect relationships. For example, they may not be aware of how heat transfer occurs through conduction, convection, and radiation and how each of these processes contributes to temperature changes (Sofianto & Irawati, 2020). Without a clear understanding of the interactions between these concepts, students tend to have difficulty when faced with real-world situations involving energy transfer (Maison, Lestari & Widaningtyas, 2020). Therefore, it is important to implement more interactive and contextual learning methods, such as hands-on experiments and the use of visual illustrations, to help students learn theory with practice). (Kairuddin, et al., 2024) By focusing on the dominant categories of misconceptions, especially in terms of temperature and heat and energy transfer, we can improve students' in-depth understanding of these basic physics concepts (Ariani & Mahtari, 2023).

CONCLUSION AND RECOMMENDATION

A. Conclusion

This study successfully identified and analyzed misconceptions experienced by 7th grade students related to the concepts of temperature, heat, and heat transfer. The results showed that students often experienced fundamental misunderstandings, especially in the Misconceptions (MIS) category, which reached an average frequency of above 40% for several subconcepts. The largest misconceptions occurred in the concepts of temperature and heat, as well as heat transfer, which indicates the need for a more effective learning approach. Therefore, the application of interactive and contextual learning methods, such as direct experiments and the use of visual illustrations, is expected to improve students' understanding of these basic physics concepts and reduce the level of misconceptions that exist.

This study also has several limitations. First, this study was only conducted in one location, namely in Bangkalan district, so the results may not be generalizable to a wider population. Second, the number of samples used was 108 students, which may not be representative enough to describe the entire population of students at the junior high school level. In addition, the instrument used to measure misconceptions was limited to multiple-choice questions, which may not fully cover the complexity of students' understanding. Therefore, further research with larger samples and more diverse methods is needed to obtain a more comprehensive picture of misconceptions in physics learning.

B. Recommendation

It is recommended for further research, that researchers conduct broader studies involving various locations and student populations from various educational backgrounds. This is important to obtain more representative data and better generalizations regarding misconceptions in physics learning. In addition, the use of diverse research methods, such as quantitative and qualitative approaches, can provide a deeper understanding of the factors that influence students' misconceptions. Research can also explore the use of educational technology, such as interactive learning applications and simulations, to improve students' understanding of physics concepts. In addition, it is important to involve teachers in the research process to gain their perspectives on the challenges faced in teaching complex concepts. Thus, the results of this study are expected to provide significant contributions to the development of more effective curricula and teaching methods in physics education.

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