

Analysis of Students' Misconceptions and Their Causes with a Four-Tier Diagnostic Test on Temperature and Heat Materials Assisted by Google Form in Islamic Junior High School Students

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Abstract.

One of the problems that often occurs in learning is misconception. Students who have it must be addressed immediately because they will hinder the learning process and can cause students to experience multiple problem. Therefore, it is necessary to analyze the misconceptions that occur first. The purpose of this study was to analyze it in the temperature and heat material that occurred along with the their causes at MTs Sains Salahuddin Wahid Tebuireng. The type of research used was descriptive quantitative. The sample in this study was taken using a purposive sampling technique, namely by considering samples that had received temperature and heat material. The number of samples in this study was 22 grade 8 students. The instrument used was a four-tier diagnostic test of temperature and heat material. The results of the study showed that many students experienced misconceptions in temperature and heat material. The most common misconceptions occurred in the concept of heat transfer, where 63.63% of students were found to assume that cold temperatures in the environment were transferred to the body. Then the next most common misconception occurs in the concept of this material, where 45.45% of students assume that temperature and heat are the same thing. The cause it happen in this material is the abstract characteristics of the material and the misconceptions that teacher have.

Keywords: Misconception, Heat and temperature, Four-tier diagnostic test

Introduction

Natural Sciences is one of the crucial subjects and can be used as a foundation for technological development. Science is always related to human activities in everyday life from simple concepts to complex concepts (Arruum & Desstya, 2024). Science can make students understand the environment in depth because in this subject, students are encouraged to want to find out (knowledge) and conduct experiments (psychomotor) (Anwari & Bachtiar, 2024). It consists of several abstract concepts that require high-level thinking skills. Science concepts can be expressed in various representations or multi-presentations, namely verbal, graphic, diagrammatic, mathematical, and tables (Aprilia & Dwandaru, 2024). Thus, it can be seen that some of these things can cause misconceptions in students.

Misconception is a form of delusion, namely knowledge that is wrong but considered true, and knowledge that is right but considered false. Misconceptions can also be referred

to as a fixed understanding, an unscientific opinion, a naive theory, a mixed conception, or a conceptual misunderstanding. In principle, in science, a misconception is something that someone knows and believes is not in accordance with what is known to be scientific truth, and most people who have misconceptions are not aware of their concepts (Devalita et al., 2021). Generally, the cause of misconceptions is that students are not mature enough when understanding a concept and can be caused by students who find learning difficult (Rahayu, 2023). In addition, the results of the evaluation by PISA (Program for International Student Assessment) from 2018 to 2022, Indonesia's ranking rose by 5 to 6 positions. However, the quality of Indonesian education is still relatively low compared to 81 countries (Nurinayah & Nur, 2023). This could be due to misconceptions. The term misconception is used in a concept that contradicts scientifically accepted theory (Makhrus & Hidayatullah, 2021). Every student must have different misconceptions (Putri, 2023). So it can be seen that misconception is a student's misunderstanding of a material which is not in accordance with what has been scientifically agreed upon.

One of the science materials that often causes misconceptions is temperature and heat (Devalita et al., 2021). Many students that can't find the difference between them (Abraham et al., 2021). This is because this material is abstract and cannot be seen directly in daily activities, resulting in different interpretations for students (Aprilia & Dwandaru, 2024). Misconceptions that occur in this material vary. Starting from the concept of temperature and heat, heat transfer, to the concept of the expansion process. This is related to the results of daily test scores of students at MTs Sains Salahuddin Wahid which show that there are still many students whose scores do not meet the criteria for achieving learning objectives, so it is necessary to investigate whether misconceptions are the cause of this.

Students who experience misconceptions must believe that the concepts they have are correct concepts (Putri, 2023). Therefore, misconceptions are urgent in education and must be addressed immediately so that there are no multiple misconceptions that can hinder the learning process in the next similar material (Laliyo, 2019). Misconceptions can certainly be detrimental to students, especially in the last decade, many have occurred in science subjects (Sukarelawan et al., 2024). However, before carrying out misconception handling, it is necessary to analyze the misconceptions that occur in students along with the causes of these misconceptions. There are various ways to identify misconceptions and their causes in students. The process of identifying misconceptions requires appropriate methods or tools so that misconceptions can be analyzed properly.

Some tools that can help in analyzing students' misconceptions include interviews and diagnostic tests. Diagnostic tests not only find students' misconceptions but also gain a deeper understanding of how students think in answering questions even if the answers are wrong (Tumanggor et al., 2020). There are various types of misconception diagnostic tests, including one-tier, two-tier, three-tier, and four-tier diagnostic tests. Of the several types of tests, the four-tier diagnostic test is a tool for analyzing misconceptions effectively and with quality to test students' misconceptions in science (Sukarelawan et al., 2024). The four-tier diagnostic test contains questions with a more specific level of answer confidence compared to other diagnostic tests (Aprianti et al., 2024). The four-tier diagnostic test provides questions to test the understanding of the concept of the material, the level of confidence in the answer, the reasons for choosing the answer, and the confidence in the chosen answer. Where the components in the four-tier diagnostic test are not fully owned by the one-tier, two-tier, and three-tier diagnostic tests. Thus, the four-tier diagnostic test is the most effective misconception measurement tool compared to other measuring tools.

After knowing the misconceptions that occur, it is necessary to analyze the causes of the misconceptions. The causes of misconceptions that occur in students can vary (Aprianti et al., 2024). There are several factors that cause misconceptions, namely student

preconceptions, associative thinking, humanistic thinking, incomplete reasoning, wrong intuition, cognitive development that experiences obstacles, student abilities, student learning motivation (Makhrus & Hidayatullah, 2021). The method generally used to identify the causes of misconceptions is by conducting direct interviews with students and teachers who have carried out learning on the material where misconceptions occur.

In analyzing misconceptions using a four-tier diagnostic test and analyzing the causes of misconceptions, it takes a lot of precision and time to correct them. Thus, there needs to be a site that can be used for a four-tier diagnostic test and analysis of its causes. One such site is Google Form (Heryadi, 2021). In addition, current technology has played an important role in improving the education system in various fields. So that the use of the site also supports the implementation of technology in learning (Turmuzi et al., 2024). Google form is part of the google site that has a template that can be used and understood easily. The implementation of the four-tier diagnostic test into google form can be seen in excel form so that teachers can easily correct the answers without requiring a long duration of time.

The novelty of this study is that this study was conducted in a pesantren-based school in Jombang, namely MTS Sains Shalahuddin Wahid. So that in this study will be analyzed the misconceptions that occur in students and their causes and their relationship to the pesantren environment. this is what makes this study unique. In addition, data was taken using a google form without printed paper so that data can be processed more easily. Previous relevant research is research conducted by Fadhillah et al. (2022) but the study did not use google form and this research didn't take at pesantren. In addition, research conducted by Maryam (2020) stated that there was a misconception of the concept after analyzing misconceptions of the material using google form. However, this study was not used in analyzing misconceptions on temperature and heat material and this research didn't take at pesantren.

Although many studies have been conducted on student misconceptions in physics learning, this study offers a new perspective by combining a four-tier diagnostic test with the google form platform to identify and analyze student misconceptions on temperature and heat material and their causes in more depth. This study aims to identify and analyze misconceptions held by students at Islamic Junior High School using a four-tier diagnostic test administered through google forms. By understanding the root causes of these misconceptions, we hope to provide valuable insights for educators to address these issues effectively.

Methods

This research is a quantitative research with a case study type conducted at MTs Sains Salahuddin Wahid Tebuireng. The sample selection technique in this study used the purposive sampling technique, namely sampling because of a consideration (Sugiyono, 2017) where the sample was selected based on students who had received temperature and heat material and teachers who had given this material. The material was obtained in class 2 of the even semester, so the sample used was 22 students in class 8. The data collection tool in this study used a four-tier diagnostic test instrument which was used to analyze students who experienced misconceptions on this material.

This four tier diagnostic test is the test that have modified from questions developed by Berg (1991) on misconceptions. The test instrument consists of 5 questions and interviews with students and teachers, each consisting of 5 questions. As the name implies, each question in this test instrument has four levels of questions. The first level is a conceptual question, the second level is the respondent's level of confidence in answering the first level question, the third level is the choice of reasons for the answer to the first level question, and the fourth level is the respondent's level of confidence in the third level question. The cognitive levels used are levels C3 (application) to C4 (analysis). The material

in the test instrument is temperature and heat material consisting of the concept of temperature and heat, the expansion process, and heat transfer. In addition, this study also used interviews with teachers and students who had completed the diagnostic test.

Data analysis techniques in this study were used to analyze misconceptions that occurred based on students' answers to the four tier diagnostic test. This is done by analyzing the combination of each student's answers. According to Gurel (2015), students who experience misconceptions are participants who answer. The data analysis technique is based on the combination of student answers on the four-tier diagnostic test. This is shown in Table 1.

Table 1. Misconception Analysis Techniques

No	Answer Combination				Category
	Answer	belief	Reason	Belief	
1	True	Yes	False	Yes	Misconception
2	True	No	False	Yes	
3	False	Yes	False	Yes	
4	False	No	False	Yes	
5	True	Yes	True	No	Partially understand
6	True	Yes	False	No	
7	True	No	True	Yes	
8	True	No	True	No	
9	True	No	False	No	Mistake
10	False	Yes	True	No	
11	False	Yes	False	No	
12	False	No	True	No	
13	False	No	True	No	Understand the concept
14	False	Yes	True	Yes	
15	False	No	True	Yes	
16	True	Yes	True	Yes	

(Source: Gurel, 2015)

In order for the data analysis not to be too broad, the temperature and heat material is focused on the material of the concept of temperature and heat, the expansion process, and heat transfer. The indicators of questions and cognitive levels of the four-tier diagnostic test can be seen in the following table.

Table 2. Four-tier Diagnostic Test Indicators

No	Concept	Misconception	The Right Concept
1	The concept of temperature and heat	Temperature and heat are the same thing (Kapul et al., 2023)	Temperature and heat are two different things, Temperature and heat are two different things. Temperature is a unit that cannot be moved, while heat can move from one place to another (Wahidah et al., 2017)
2		Cold temperatures in the environment are transferred to the body (Wahidah et al., 2017)	Heat flows from high temperature to low temperature (Wulandari, 2019)
3	Expansion process	The mass of an expanding object increases in size. Expansion is caused by	Metal consists of particles that are arranged very closely together and the position of the particles

		an increase in the number of particles (Wahidah et al., 2017)	will change when exposed to heat (Wahidah et al., 2017)
4		Expansion is not affected by the coefficient of expansion (Wahidah et al., 2017)	The coefficient of linear expansion of metal affects the expansion of the metal object. The greater the coefficient of linear expansion of the object, the easier and faster the metal will expand (Wahida et al., 2017)
5	Heat transfer	The high specific heat of a substance will speed up the temperature change of the substance (Wahidah et al., 2017)	The specific heat of a substance is inversely proportional to the change in temperature (Wahidah et al., 2017)

In addition to analyzing data from the results of the four-tier diagnostic test, an analysis of the interview results was also conducted. The interview results were analyzed by identifying answers and connecting the answers of teachers, students, and data from the four-tier diagnostic test.

Results and Discussion

In this study, respondents were tested with a four-tier diagnostic test to determine the misconceptions that occurred. The results of the analysis are based on a combination of answers and reasons and students' beliefs in answering questions on the material of temperature and heat. Some categories of student conception profiles include misconceptions, partial understanding, errors, and conceptual understanding. The results of students' answers can be seen in the following figure.

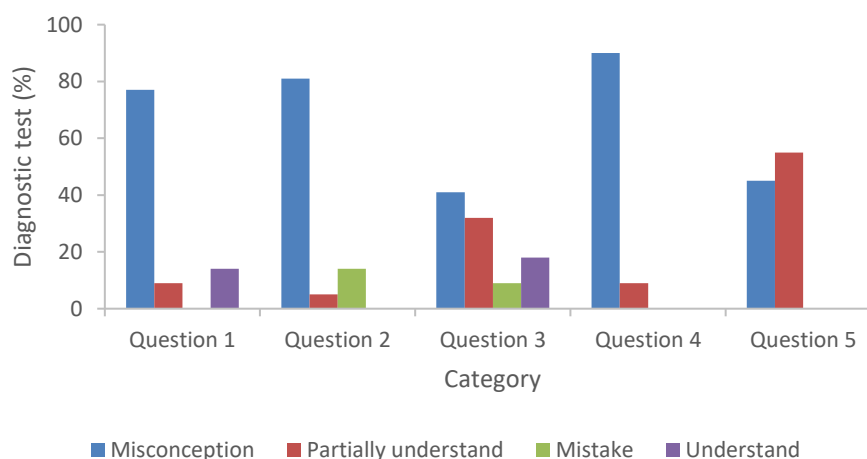


Figure 1. Results of diagnostic test analysis

Based on the Figure, it is known that there are misconceptions in the five questions in the four-tier diagnostic test. In the first and second questions about the concept of temperature and heat, 77.27% of students had misconceptions about the difference between temperature and heat, and 81.81% of students had misconceptions about heat

transfer. Then in the third and fourth questions about the expansion process, 40.90% of students had misconceptions about what happens to the particles of an object during the heating process, and 90.91% of students had misconceptions about the relationship between the expansion coefficient and the expansion process. In the fifth question about the effect of heat, 54.54% of students had misconceptions about the relationship between specific heat and temperature changes. The results of this study are in accordance with previous studies that there are still many students who experience misconceptions in the material on temperature and heat

Various misconceptions that occur in students from the diagnostic test can be seen in the following Table 3.

Table 3. Various Types of Student Misconceptions

Concept	Misconception	Total
Temperature and heat are two different things. When two objects have different temperatures, heat will flow.	Temperature will flow when there are two objects with different temperatures brought close together	8
	Temperature and heat will flow when there are two objects with different temperatures brought close together	10
	Specific heat will flow when there are two objects with different temperatures brought close together	1
Heat moves from objects with high temperatures to objects with low temperatures.	When the air is cold, the cold temperature in the environment is transferred to the body.	14
	When the air is cold, heat is transferred from the environment to the body.	4
During the expansion process, the particles of the object will move further apart.	When the iron ball expands, the volume of the iron ball decreases because the particles decrease.	10
	When the iron ball expands, the volume of the iron ball increases because its particles increase.	2
	When the iron ball expands, the volume of the iron ball remains the same because its particles do not change.	7
The coefficient of expansion is directly proportional to the increase in length	The coefficient of linear expansion has no relationship with the increase in length.	7
	The coefficient of expansion is inversely proportional to the increase in length	2
	The higher the specific heat of a substance, the less it can absorb heat.	6

Specific heat is inversely proportional to temperature change	The higher the specific heat of a substance, the smaller its ability to absorb heat.	4
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Based on Table 3, it can be seen that the biggest misconception that occurs in students is in the concept of heat transfer which states that when in cold air, the cold temperature in the environment will be transferred to the body. This shows that students experience misconceptions that temperature moves from one object to another, as well as the process of moving from a low-temperature object to a high-temperature object. This is relevant to research conducted by Setyaningrum & Sopandi, (2021) which states that the most common misconceptions about heat transfer, where the transfer process is from a low-temperature object to a high-temperature object. In addition, the results of interviews with science teachers at MTs Sains Tebuireng also stated that many students experience misconceptions about the difference between temperature and heat, the relationship between temperature and heat, and particle transfer in the concept of heat transfer. From several statements, it was found that misconceptions about temperature and heat material were often found in the concept of heat transfer.

The biggest misconception after the concept of heat transfer is that temperature and heat are the same thing and the misconception that when expansion occurs, the volume and particles of an object decrease. Many students assume that temperature and heat are the same things that can move from one object to another. This is in line with research conducted by Fadhilah et al. (2022) which states that many students still understand that temperature and heat are the same thing. In addition, research conducted by Kotsis et al. (2023) states that students ranging from elementary school, middle school, and university levels, still find many misconceptions in these two things. In his research, he stated that many students need clarification on the concept of heat and temperature and need help explaining the difference between heat and temperature.

Another study conducted by Zayyinah et al. (2022) also stated that there are still many misconceptions in the concept of expansion according to Table 3. Many students understand that there is a change in the number of particles during expansion, even though this statement is wrong. In addition, research conducted by Jumadi et al. (2023) stated that the concept of expansion is a difficult concept compared to other concepts in the chapter. Where in his research, students considered that out of 4 questions about expansion given, there were 3 questions that fell into the difficult category. So that is what allows misconceptions to occur in the expansion material.

After the misconceptions that occur are found, it is necessary to explore the causes of these misconceptions. Based on interviews with students and teachers, it was found that the main cause of these misconceptions is the abstract nature of the material on temperature and heat for students. Most of them are less able to illustrate what happens when heat moves. The results of the interviews are relevant to the results of previous research conducted by Permatasari (2022) and research conducted by Surya et al. (2023) which stated that misconceptions that occur in students are mostly caused by the abstract concept of the material received.

However, apart from that, teachers also mentioned in interviews that there were errors in the textbooks read by students which caused misconceptions in students. This is also relevant to research conducted by Budiwati et al. (2023) and research conducted by Saputri et al. (2023) which showed that many misconceptions were caused by books. Some books explain material too broadly, triggering misconceptions in students. But, after analyzing it more deeply, there were no errors in the textbook, so the teacher himself also experienced misconceptions. This is relevant to the results of research conducted by (Desstya et al., 2020) which stated that there were still misconceptions in science subject

teachers. Thus, it also makes students have misconceptions. Another thing that makes students less able to understand this concept is because of the limited use of technology in their educational units, so that students cannot imagine the concept in interactive media such as virtual laboratories. This is relevant to research by Faroqi et al. (2024) which states that the biggest challenge in learning in Islamic boarding schools is the limited use of technology.

Conclusion

Based on the results and discussions that have been carried out, it can be seen that at MTs Sains Salahuddin Wahid there are still many students who experience misconceptions in the material of temperature and heat. The biggest misconception occurs in the concept of heat transfer, where as many as 45.45% of believe that in cold environmental conditions, the air there is transferred to the body. This shows that students understand that heat moves from lower temperatures to the higher. this happens in this material because the abstractness of this material by students and the existence of conceptual errors stated in the textbook. However, after being investigated, it was not the textbook that contained errors, but the science teacher who also have misconceptions. Because in the tect book is not found the error. In addition, in the Islamic boarding school environment there are also limitations in using computers so that learning is mostly conventional so that students also find it more difficult to accept the material, especially since the material requires adequate learning media such as virtual labs, to represent materials that cannot be seen in real life. From the results of this study, it is recommended that science teachers always pay attention to misconceptions that occur in students so that the science learning process is not hampered, so that learning is needed that can make students understand the concept of the material being studied.

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