Research Artikel

IDENTIFICATION OF MISCONCEPTION OF HIGH SCHOOL STUDENTS ON TEMPERATURE AND CALOR TOPIC USING FOUR-TIER DIAGNOSTIC INSTRUMENT

IDENTIFIKASI MISCONCEPTION MAHASISWA SEKOLAH TINGGI PADA TEMPERATUR DAN TOPIK KALOR MENGGUNAKAN INSTRUMEN DIAGNOSTIK EMPAT-TIER

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Abstrak

Miskonsepsi merupakan suatu konsepsi seseorang yang tidak sesuai dengan konsepsi ilmiah yang dimiliki oleh para ahli. Miskonsepsi harus dihindari dan kalau sudah terjadi perlu diremediasi karena dapat menjadi faktor penghambat dalam proses belajar siswa. Namun, miskonsepsi tidak mudah diidentifikasi, diperlukan instrumen khusus dan langkah-langkah tertentu untuk mengungkapkannya. Tujuan penelitian ini adalah untuk menggali, mengungkap, serta mendeskripsikan miskonsepsi siswa pada materi suhu dan kalor. Responden penelitian berjumlah 127 orang yang merupakan siswa dari SMA favorit di Jambi. Instrumen yang digunakan untuk pengumpulan data adalah Four-Tier Diagnostic Instrument pada materi suhu dan kalor. Analisis data dilakukan dengan cara mencari persentase jawaban benar pada setiap tingkat (tier) untuk setiap item dan persentase jawaban miskonsepsi untuk setiap kategori. Hasil penelitian menunjukkan bahwa 10 jenis miskonsepsi pada materi suhu dan kalor pada siswa telah dapat diidentifikasi dengan menggunakan sembilan buah item instrumen. Rata-rata miskonsepsi adalah sebesar 24.25%, False Positif sebesar 9,01%, False Negatif sebesar 4,72%, dan Lack of Knowledge sebesar 10,32% pada materi suhu dan kalor. persentase miskonsepsi tertinggi terletak pada miskonsepsi keenam (M6) sebesar 58,27%, yaitu "Ketika berada pada ruang yang sama suhu besi lebih rendah daripada suhu benda di sekitarnya".

Kata Kunci: *Miskonsepsi; suhu dan kalor; four-tier diagnostik instrument;*

Abstract

The misconception is a conception of someone who is not in accordance with the scientific conception possessed by experts. Misconceptions must be avoided, and if they occur, they need to be remediated because they can be a limiting factor in student learning. However, misconceptions are not easily identified; special instruments and specific steps are needed to express them. The purpose of this study is to explore, uncover, and describe students' misconceptions in temperature and heat material. The research respondents were 127 students from a favorite high school in Jambi. The instrument used for data collection was the Four-Tier Diagnostic Instrument on temperature and heat material. Data analysis was done by finding the percentage of correct answers at each level (tier) for each item and the percentage of answers to misconceptions for each category. The results showed that ten types of misconceptions in the temperature and heat material in students had been identified using nine instrument items. The average misconception is 24.25%, False Positive is 9.01%, False Negative is 4.72%, and Lack of Knowledge is 10.32% in temperature and heat material. The highest percentage of misconception lies in the sixth misconception (M6) of 58.27%, namely "When in the same room the temperature of the iron is lower than the temperature of the objects around it".

Keywords: Misconception; temperature and heat; four-tier diagnostic instrument;

INTRODUCTION

The breadth and depth of students' understanding of physical concepts can illustrate the conceptual knowledge that the student has. Conceptual knowledge is one important part that students must learn in order to solve problems (Sabella & Redish, 2007). However, in learning activities, many students believe that physics is a collection of formulas (McDermott, 1993) and tends to memorize formulas that have an impact on the low ability of students to find solutions to physics problems (May & Etkina, 2002). Students also experience difficulties in understanding physical concepts and using their reasoning abilities (Utama *et al.,*, 2018; Yediarani *et al.*, 2019) and tend to have local knowledge structures (Wadana & Maison, 2019). This is in line with the results of Mulhall and Gunstone's research (2012), which states that physics is a subject that is difficult to learn and teach. Conversely, even though physics is challenging to study, it is recognized as a choice for an appropriate career because technological advancements are supported by the mastery of science, including physics (Oon & Subramaniam, 2013).

Students' efforts in learning physics both through formal education and through everyday experience will produce a conception (interpretation of the concept) (Gurel *et al.*, 2015). If the conceptions possessed by students differ from the conceptions of physicists, then they can be referred to as "misconceptions" (Clement *et al.*, 1989; Gurel *et al.*, 2015).

According to Hammer (2005), misconceptions have characteristics, namely (1) is a relatively strong and stable cognitive structure, (2) is different from the concepts that scientists have, (3) influences how students understand scientific explanations, (4) must be addressed immediately, avoided, and eliminated to get the right concept. Duit *et al* (2007) state that the number of misconceptions that occur on physics topics is a problem that is often encountered in teaching physics.

One topic of physics that is closely related to the environment and the everyday life of students is temperature and heat. The temperature and heat topic is not so difficult when compared with other physical material, but it turns out that students also experience many misconceptions about the topic. The results of research conducted by Silung *et al* (2016) using a three-tier test instrument showed that 38% of students experienced misconceptions about temperature and heat topic. The same thing was also found by Alwan (2011) that more than 40% of respondents have alternative conceptions (misconceptions) on temperature and heat topic.

As explained by Hammer (2005), the identification of misconceptions is a crucial thing to do because misconceptions can be a limiting factor for students in learning physics. Incorrect concepts will be carried by students continuously so that the possibility of student learning will also be hampered by further material related to the concept due to interrelated physics material.

To diagnose misconceptions, the researcher could use various forms of tests, namely Open-ended Test, Ordinary Multiple Choice Test (MCT), Two-tier MCT, Three-tier MCT, and Four-tier MCT (Gurel et al., 2015). Gurel *et al* (2015) stated that the Four-tier MCT is the best method of all the methods available today because it can accurately measure the misconceptions owned by respondents so that the conclusions drawn are free from errors and lack of knowledge. In this study, the instrument was used in the form of a Four-tier multiple-choice test to reveal the misconceptions of high school students on temperature and heat topic.

METHOD

This study uses a quantitative descriptive research design that aims to explore, uncover, and identify misconceptions in students on the material temperature and heat. The study was conducted on 127 students of one of the favorite secondary schools in Jambi, who had studied temperature and heat material. The selection of the school as a place of research is based on several considerations. The school has an A accreditation status, has a complete learning

facility, and has students who have been selected for competence so that students are not expected to experience many misconceptions.

Data retrieval is done using an instrument developed by (Abbas, 2016) in the form of a Three-tier diagnostic test instrument. It is then modified by researchers to become a Four-tier diagnostic test by adding a level of confidence in the reasons so that each item has a composition: answer choices, confidence level on answers, choice of reasons, and level of confidence in reason (Fariyani *et al.*, 2015; Gurel *et al.*, 2015). There are advantages of the Four-tier diagnostic test compared to the Three-tier is through the four-tier diagnostic test. The researchers or teachers can: (1) differentiate the level of confidence in the answers and the level of confidence of the reasons chosen by students so that they can dig more in-depth about the power of understanding students' concepts, (2) diagnose students' more deep-rooted misconceptions, (3) determine the parts of the material that require more emphasis, (4) plan better learning to reduce students' misconceptions.

In addition to adding a level (tier) so that it becomes four-tiered, the instrument was also modified. The researcher had been adding, removing, and revising some items. To increase the validity and reliability of the instrument, researchers conducted trials. The instrument test was conducted on 234 students of Jambi City 1 High School. After testing, the validity and reliability obtained nine items of valid questions, which are then used to retrieve data. The data obtained were then analyzed to get the percentage of correct answers, the percentage of misconceptions, and the percentage of lack of knowledge, including false positives and false negatives. To get the percentage of correct scores for each item, the researcher use the equation:

$$X = \frac{\sum SB}{\sum Student} \times 100\%$$

The X value indicates the percentage of the correct score of each item, and SB is the True Score of the item according to level (tier). For example for the first level (first-tier) if the answer

is correct SB = 1 and if wrong has given a zero score; for the first and third level (first and second tier) if the answer is correct and the reason is true SB = 1, otherwise it is given a zero score. Decision making (Scientific Conception, Lack of Knowledge, False Positive, False Negative, or Misconception) of students' concepts is carried out using the criteria as in Table 1.

Table 1. Table of Guidelines for Criteria for Decision Making (Gurel *et al.*, 2015)

1st tier	2nd tier	3rd tier	4th tier	The decision for the four-tier test
Correct	Sure	Correct	Sure	SC
Correct	Sure	Correct	Not	LK
Correct	Not sure	Correct	sure	LK
Correct	Not sure	Correct	Sure Not sure	LK
Correct	Sure	Wrong	Sure	FP
Correct	Sure	Wrong	Not	LK
Correct	Not sure	Wrong	sure	LK
Correct	Not sure	Wrong	Sure Not sure	LK
Wrong	Sure	Correct	Sure	FN
Wrong	Sure	Correct	Not	LK
Wrong	Not sure	Correct	sure	LK
Wrong	Not sure	Correct	Sure Not sure	LK
Wrong	Sure	Wrong	Sure	MSC
Wrong	Sure	Wrong	Not	LK
Wrong	Not sure	Wrong	sure	LK
Wrong	Not sure	Wrong	Sure Not sure	LK

SC: Scientific Conception; LK: Lack of Knowledge; FP: False Positive; FN: False Negative; MSC: Misconception

RESULT AND DISCUSSION

The instrument trials conducted on 234 students of Jambi City 1 High School as respondents revealed that eight students did not give complete answers to all tiers, so the data analyzed only came from 226 respondents. This instrument trial was used to determine the

construct validity of each item based on loading values using factor analysis (Brown, 2006; Pallant, 2011) and determine the reliability of the instrument based on Cronbach's alpha values. The validity values of the instruments can be seen in Table 2.

Based on the data in Table 2., it appears that five items have a loading value above 0.3, which is in one factor (component), and four items also have a loading value above 0.3, which supports the second factor. One item (i.e., item 10) loading in two components, this item is deleted so that the construct validity increases. Three items have loading values below 0.3 (not shown), namely item 2, item 3, and item 7. These three items are not used in data collection because they are invalid. Based on these results, it was decided that the instrument used for research data collection consisted of nine items.

Tabel 2. Instruments validity

Item	Component	
	1	2
Item 5	.775	
Item 6	.763	
Item 4	.585	
Item 11	.387	
Item 13	.341	
Item 2		
Item 9		.648
Item 12		.620
Item 1		.531
Item 8		.412
Item 3		
Item 7		

Then the instrument reliability testing of each of these factors was carried out. The results obtained are 0.58 and 0.27. This reliability is relatively low. According to Brown (2006) and Kaltakci-Gurel et al., (2017), factor reliability is a measure of internal consistency, namely how strong the relationship of items in a group. Weak relationships indicate that the items are more independent of each other. This also shows the multidimensionality of the instrument.

Based on the results of research on the description of misconceptions of class XII MIA students on the temperature and heat topic, it is

obtained percentage graphs for overall correct answers and misconceptions.

Percentage of Correct Answers

After scoring at the first level, the second and third levels, and also at all levels, the percentage of correct answers obtained by students on the material temperature and heat. The scoring method is the same as that of Kaltakci-Gurel et al (2017) and Maison et al (2020). The results of the percentage of students' answers are displayed in the form of diagrams, such as Figure 1.

Based on the graph in the figure, it can be seen that the percentage of correct answers at the first level (first-tier) for each item is higher than the other forms. This is because, at the first level, students only choose the answers without including the reasons for the answers chosen. This form is like a regular multiple-choice problem (one-tier), whereas for the first and third levels, such as two-tier questions where in addition to the answers also included reasons for choosing answers. The percentage is lower because the correct answer is not necessarily accompanied by the right reason it could be due to guessing the answer and pure coincidence. Scoring for all levels (four-tier) not only pays attention to students' answers and reasons but also includes confidence in both of them. The percentage is even lower compared to the percentage of the first level, and also the percentage of the first and third levels, such as Figure 1.
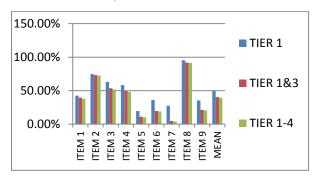

Figure 1. Graph of Correct Answer Percentage

The highest percentage of correct answers for all levels is in item 8, which is 91.34%, meaning that item 8 is a problem that is relatively easy for students to understand. The lowest

percentage of correct answers is in item 7, which is 3.94%, which means that the concepts in this problem are relatively difficult to understand by students.

Percentage of Misconception Responses

Misconception data analysis is done in the same way as the correct answer, but the scoring is adjusted to the alternative table of misconception distribution (Table 4). Students who answered according to the answers in the table were given a score of "1". Students who answered not according to the answers in the table were given a score of "0". Data analysis was not carried out by scoring in each question as in the correct answer, but scoring was carried out on each type of misconception (Kaltakci-Gurel *et al.*, 2017; Peşman & Eryılmaz, 2010).

Table 4. Description of Misconceptions and Alternative Answers

M#	Description of Misconception	Item
M1.	When there is a change in the state of matter, the temperature of the object can change.	1.1.a; 1.2.a; 1.3.a;1.4.a
M2.	The distribution of matter of different sizes results in each part having a different temperature.	2.1.a; 2.2.a; 2.3.b; 2.4.a 2.1.a; 2.2.a; 2.3.c; 2.4.a 2.1.c; 2.2.a; 2.3.b; 2.4.a 3.1.b; 3.2.a; 3.3.b; 3.4.a 3.1.b; 3.2.a; 3.3.c; 3.4.a 4.1.a; 4.2.a; 4.3.c; 4.4.a 4.1.c; 4.2.a; 4.3.b; 4.4.a
M3.	The mass of an object changes when the object changes in temperature.	5.1.b; 5.2.a; 5.3.a; 5.4.a 5.1.c; 5.2.a; 5.3.e; 5.4.a
M4.	Heat can flow if there is a difference in the amount of heat.	6.1.a; 6.2.a; 6.3.a; 6.4.a 6.1.b; 6.2.a; 6.3.a; 6.4.a

M#	Description of Misconception	Item
M5.	The temperature of the object does not affect heat transfer.	6.1.c; 6.2.a; 6.3.c; 6.4.a
M6.	When in the same room, the temperature of the iron is lower than the temperature of the surrounding objects.	7.1.a; 7.2.a; 7.3.a; 7.4.a 7.1.a; 7.2.a; 7.3.c; 7.4.a 7.1.a; 7.2.a; 7.3.d; 7.4.a
M7.	Color does not affect the absorption of heat in objects.	8.1.c; 8.2.a; 8.3.e; 8.4.a
M8	Brightly colored objects absorb more heat.	8.1.b; 8.2.a; 8.3.c; 8.4.a
M9.	When the sky is clear at night, the temperature is higher than when it is cloudy.	9.1.a; 9.2.a; 9.3.b; 9.4.a
M10.	The temperature is not affected by clear or dark skies.	9.1.c; 9.2.a; 9.3.a; 9.4.a 9.1.c; 9.2.a; 9.3.b; 9.4.a

Table 4. contains the types of misconceptions and item items that measure the misconceptions. The next step is analyzing the data and the results obtained. They are presented in the form of a percentage of students' misconceptions in diagrams, such as Figure 2.
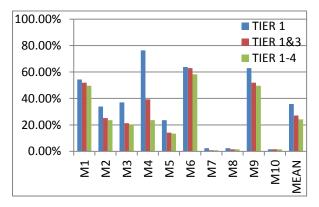

Figure 2. Diagram Percentage of Student Misconceptions

Based on the graph, it can be seen that the average percentage of misconceptions at the first level is also higher than the others. This shows that students' wrong answers cannot be

categorized immediately that the student experiences misconceptions. Incorrect answers can be caused by students who do not have knowledge (lack of knowledge).

Overall, the highest percentage of misconception lies in the sixth misconception (M6) of 58.27%, which is "When in the same room the temperature of the iron is lower than the temperature of the surrounding objects". This sixth misconception is measured by item 7. Students assume that in a closed room, the temperature of the iron is lower than the temperature of other objects around it, and in an open room, the temperature of the iron is higher than the temperature of other objects in the vicinity. Students do not understand that the temperature of the iron and the surrounding objects are the same when in the same room (thermal equilibrium).

The next misconception that mostly happens to students is M1 (49.61%); namely, students have the concept that "when the process of changing the shape of the object changes temperature". If the water is heated continuously, then according to students, the temperature will rise until the water runs out. Likewise, with M9 (49.61%), the students were convinced by the concept that "when the sky is clear at night, the temperature is higher than when it is cloudy". This concept might arise based on students' experiences during the day, the clouds block the sun's heat from reaching the earth's surface, so the earth feels less hot. Even though at night, the process is different, the presence of clouds will prevent the release of heat from the earth so that the earth feels warmer than during the clear sky.

The lowest percentage of misconception is in the seventh misconception (M7), which is "Color does not affect the absorption of heat in objects". This seventh misconception is measured by item no.8. The percentage of misconceptions on this concept is not too large (only 0.79%). However, there are still some students who have incorrect concepts; that color does not affect heat absorption. This concept is not correct because dark colors tend to absorb more heat than bright colors.

In addition to identifying correct answers and misconceptions, an analysis of false positives, false negatives, and lack of knowledge is carried out. The percentages for positive errors, negative errors, and lack of knowledge can be seen in Table 5.

False positives can be assessed by students who answered right, but the reasons were wrong. False negatives can be assessed from students who have wrong answers, but the reasons are correct. Lack of knowledge is assessed from the lack of confidence in the answers and or reasons were given by students.

Based on the table, it can be seen that the highest percentage of positive errors is in item 7, while the percentage of positive errors that are low is in item 2. For the highest negative error is in item 6, while the lowest negative error is in item 8, amounting to 0% means that there are no students who give valid reasons for wrong answers. Furthermore, in the Lack of Knowledge category/lack of knowledge, the highest percentage is in item 5, while the lowest percentage is in item 8.

Tabel 5. Percentage of False Positive, False Negative, and Lack of Knowledge

Kategori	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Mean
% False Positive	2.36	1.57	7.09	7.09	7.87	14.96	22.83	3.15	14.17	9.01
% False Negative	1.57	0.79	0.79	6.30	6.30	14.17	1.57	0.00	11.02	4.72
% Lack of Knowledge	4.72	4.72	5.51	6.30	12.60	11.02	5.51	0.79	3.15	10.32

CONCLUSION

Based on the results of research that has been done, it can be concluded that students are still experiencing misconceptions about the material temperature and heat. This can be seen from the results of research conducted using the test instrument in the form of a four-tier multiple choice question (four-tier diagnostic test). The results of the data analysis show that the average percentage of correct answers is 39.46%, and the average percentage of students' misconceptions is 24.25%. Students' highest misconception is in the concept of conduction, which is in item 7. The item items that have the highest percentage of misconceptions are items with the lowest percentage of correct answers and vice versa. The lowest student misconception is in the concept of radiation, which is in item 8. The items with the lowest percentage of misconceptions are items with the highest percentage of correct answers.

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