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# Using a Three-level Diagnostic Test Instrument to Detect Student Misconception: A Case of the Concept of Heat

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**Abstract.** This study aims to: (1) determine the level of misconceptions of male students in grade VII of a State Junior High School in Lamongan Regency on the subject of heat case physics by using a three-level test. (2) Knowing the level of misconceptions of class VII junior high school students in Lamongan Regency on the subject of heat case physics by using a three-level test. (3) Knowing the level of misconceptions of seventh grade junior high school students in Lamongan Regency on the whole science subject by using a three-level test. This research is a qualitative descriptive study. The sample of this study consisted of 300 seventh grade students in 10 different schools in Lamongan Regency, with 163 female students and 137 male students. The research instrument used was a diagnostic instrument and interview guide. The three-tier diagnostic instrument consisted of 20 questions. Each question consists of three levels, namely the first level is the usual choice of answers, the second level is the choice of reasons, and the third level is the level of confidence in the answers and reasons. Based on the results of the study, it was shown that: (1) The level of misconceptions of male students in grade VII of SMP Negeri in Lamongan Regency on the subject of heat case physics using a three-level test was included in the high category of 67%. (2) The level of misconceptions of seventh grade junior high school students in Lamongan Regency on the subject of heat case physics using a three-level test is in the high category of 64%. (3) The level of misconceptions of seventh grade junior high school students in Lamongan Regency in all subjects of hot case science using a three-level test is in the high category of 66%.

## INTRODUCTION

Physics is a branch of natural science that includes facts, principles, laws, postulates, theories, and scientific methodologies. Physics is a subject in the science family that is very closely related to everyday life [1] Physics is part of the natural sciences taught in junior high schools (SMP). According to Amnirullah [2] physics is learning that prioritizes mastery of concepts. Mastery of concepts shows students master physics materials well. Understanding of physics concepts is very important in learning physics because by mastering the concepts of knowledge students will tend to last a long time even though the material has been taught for a long time. However, physics educators often find that students have misconceptions, namely conceptions that are different from the concepts believed by experts. According to Suparno [3] a misconception or a wrong concept refers to a concept that is not in accordance with the scientific understanding or students' misconceptions.

One of the common misconceptions about physics for junior high school students is on the material of temperature and heat. This is in accordance with the results of Sozbilir's research in [4] that when the ice cube melts, many students assume that the temperature of the ice cube changes, while the correct concept is that the temperature of the ice does not change but causes the ice to melt due to latent heat. Misconception analysis is a basic thing to know before discussing efforts to overcome misconceptions, because with this analysis it will be useful to distinguish which students know the concept and which students have misconceptions so that they know how to overcome them. One way that is considered effective in distinguishing students' misconceptions is a diagnostic test for misconceptions in

written form. The misconception diagnostic test is intended to determine the learning difficulties experienced by students related to the existence of misconceptions.

Identifying misconceptions using the three tier test diagnostic instrument is predicted to be able to distinguish students' misconceptions more accurately than the one tier or two tier diagnostic test, because it is able to distinguish students who lack knowledge based on students' beliefs when answering questions on one tier and two tier [6]. Because this level of belief also affects the calculation of misconceptions and concepts mastered by students. The three tier test will allow teachers and students to distinguish misconceptions so as to provide an overview to the teacher about students' mastery of the material that has been delivered, and students will correct their misconceptions with scientific conceptions or change the wrong concept to the right concept. [7] [4] also added that using the three tier test instrument also makes it easier for teachers to detect misconceptions experienced by students, so that teachers can then overcome misconceptions experienced by students by improving learning. Based on the description above, the objectives of this study are as follows: 1) To determine the level of misconceptions of male students in grade VII SMP in Lamongan Regency in the subject of heat case physics by using a three tier test. 2) To find out the level of misconceptions of female students in grade VII SMP in Lamongan Regency in the subject of heat case physics by using a three tier test. 3) To find out the level of misconceptions of seventh grade junior high school students in Lamongan Regency on the overall heat case science subject by using the three tier test.

## METHODS

The type of research used in this research is descriptive research with a qualitative approach. Descriptive qualitative research was conducted by describing and analyzing the results obtained during the research. Data collection techniques through tests using diagnostic instruments in the form of three tier tests and open interviews. Diagnostic result data is expressed in the form of percentage of students' conception categories. The sample of this research is students who have received the material temperature and heat, class VII students. The sample consisted of 300 students from 10 different schools in the city of Lamongan, with 163 female students and 137 male students.

The research instruments used were diagnostic instruments and interview guidelines. The diagnostic instrument was developed based on the misconceptions on the concepts of temperature and heat referred to from several related journals. Each item contains one misconception. The interview guide was developed according to the results of the diagnosis of misconceptions. The interview questions are the same as those on the diagnostic instrument. The three-tier diagnostic instrument consists of 20 questions. Each question consists of three levels, namely the first level is the usual choice of answers, the second level is the choice of reasons, and the third level is the level of confidence in the answers and reasons. Eight possible combinations of student answers and guidelines for categorizing answers for the three-tier concept mastery question can be seen in Table 1.

**TABLE 1.** Shows the three-tiered test's answer categories. [5]

<b>Tier 1</b>	<b>Tier 2</b>	<b>Tier 3</b>	<b>Type</b>
Correct	Correct	Confident	Mastering the Concept (MK)
Correct	Incorrect	Confident	Misconception (MS)
Incorrect	Correct	Confident	Misconception (MS)
Incorrect	Incorrect	Confident	Misconception (MS)
Correct	Correct	Having doubts	No Preconceptions, Just Guessing (MB)
Correct	Incorrect	Having doubts	Do not understand the idea (TT)
Incorrect	Correct	Having doubts	Do not understand the idea (TT)
Incorrect	Incorrect	Having doubts	Do not understand the idea (TT)

## RESULTS AND DISCUSSION

### 1. Percentage of Male Students' Misconceptions

The results of the recapitulation of the percentage of male students' misconceptions on all questions are presented in table. This result aims to see the overall picture of the percentage of male students' misconceptions from all questions. The following is a recapitulation of the percentage of male students' misconceptions on all questions shown in Table 2.

**TABLE 2.** Percentage of Male Students' Misconceptions on All Questions

Understanding Level	Amount	Percentage	Category
Misconception	1837	67%	High

From the table, it can be seen that in all the questions that have been done, overall on all the items of male students who were identified as having misconceptions had a percentage of 67%.

**TABLE 3.** Percentage of male students' misconceptions on each item

No	Concept	The number of students	Percentage (%)	Category
1	The heat used to raise the temperature	80	58	Medium
2	Effect of temperature on object size	93	67	High
3	The effect of specific heat on changes in the temperature of an object	96	70	High
4	Expansion of solids	87	63	High
5	Thermometer observation	75	54	Medium
6	The relation of heat to the temperature of an object	96	70	High
7	The connection between mass and heat	90	66	High
8	Specific heat	95	69	High
9	The connection between a substance's heat and density	98	72	High
10	The connection between heat and temperature fluctuations is depicted graphically	105	77	High
11	Expand long	96	70	High
12	Change of state from solid to liquid	70	51	Medium
13	Evaporation	92	67	Medium
14	Condense	85	62	Medium
15	Phase change graph of a substance	85	62	Tinggi
16	Conduction	90	66	High
17	Convection	112	82	High
18	Radiation	108	78	High
19	Heat exchange	98	72	High
20	Asas black	86	63	High

The data obtained from the percentage of male students' misconceptions on all questions based on (Table 2), it is known that of all 91 male students, the percentage of misconceptions is included in the high category. The data obtained on the percentage of male students' misconceptions in each item can be seen in (Table 3), identified students experiencing the highest misconceptions on item number 10, which is identifying the heat transfer process with the percentage of misconceptions included in the high category. The lowest misconception occurs in item number 17, which is to distinguish heat transfer by conduction, convection and radiation with the percentage of misconceptions included in the medium category. The items with the highest percentage can be seen in table 3. Question indicator number 10 is Identifying the heat transfer process. In this problem, a misconception is identified that temperature flows from hot objects to cold objects. This is the most common misconception experienced by male students, namely 81% of the total sample. Students assume that boiled eggs become cold because the temperature flows into the water, when in fact it is not temperature but heat that flows from an object with a higher temperature to an object with a lower temperature, causing the egg to cool. Misconceptions occur because students answer incorrectly on the questions given but have a high level of confidence, in line with the results of research [6] that misconceptions occur because students answer incorrectly on the questions given but have a high level of confidence in their answers.

## 2. Percentage of female students' misconceptions

The results of the recapitulation of the percentage of students' misconceptions on all questions are presented in the form of Table below:

**TABLE 4.** Percentage of female students' misconceptions on all questions

Understanding Level	Amount	Percentage (%)	Category
Misconception	2106	64	High

From the table, it can be seen that in all the questions that have been done, overall on all the items female students identified as having misconceptions have a percentage of 64%.

**TABLE 5.** Percentage of female students' misconceptions

No	Concept	The number of students	Percentage (%)	Category
1	The heat used to raise the temperature	129	79	High
2	Effect of temperature on object size	103	63	High
3	The effect of specific heat on changes in the temperature of an object	131	80	High
4	Expansion of solids	123	75	High
5	Thermometer observation	102	63	High
6	The relation of heat to the temperature of an object	99	60	Medium
7	The connection between mass and heat	95	58	Medium
8	Specific heat	104	64	High
9	The connection between a substance's heat and density	94	58	Medium
10	The connection between heat and temperature fluctuations is depicted graphically	115	71	High
11	Expand long	120	73	High
12	Change of state from solid to liquid	88	53	Medium
13	Evaporation	102	62	High
14	Condense	107	66	High
15	Phase change graph of a substance	127	78	High
16	Conduction	88	53	Medium
17	Convection	94	57	Medium
18	Radiation	89	55	Medium
19	Heat exchange	103	63	High
20	Asas black	93	57	High

Obtaining data on the percentage of female students' misconceptions on all questions based on (Table 4), it is known that of all 138 female students, the percentage of identified misconceptions is included in the high category. The data obtained on the percentage of female students' misconceptions in each item can be seen in (Table 5), it is identified that students experience the highest misconceptions in item number 1, which is explaining the concept of temperature with a percentage included in the high category. The lowest misconception occurs in item number 15, which is identifying heat due to changes in temperature when objects come into contact with the percentage of misconceptions included in the medium category. The items with the highest percentage can be seen in table 5. The indicator for question number 10 is explaining the concept of temperature. In this problem, a misconception is identified that the temperature of hot water is determined by the amount of hot water. This is the most common misconception experienced by female students, which is 80% of the total sample. Students assume the more hot water, the higher the water temperature, when in fact the temperature of the water in a small glass is the same as the temperature of the water in a large teapot, because the temperature of an object does not depend on how much or how little an object is. Misconceptions occur because students answer incorrectly on the questions given but have a high level of confidence, in line with the results of research [6] that misconceptions occur because students answer incorrectly on the questions given but have a high level of confidence in their answers.

### 3. Percentage of Misconceptions of All Students

The results of the recapitulation of the percentage of students' misconceptions on all questions are presented in the form of Table 6.

The data obtained from the percentage of misconceptions of all students based on Table 6, it is known that students who have had the experience of learning the material of temperature and heat and were tested with Three tier Test questions indicate that students still experience many misconceptions as indicated by the high percentage of students' misconceptions. Based on the results of the recapitulation of the percentage of misconceptions of all students on all questions, the percentage of students' misconceptions as a whole was identified as being in the high category. Based on the results of the recapitulation of the percentage of misconceptions in each item, it shows that students experience misconceptions in each item with a different category. The data acquisition of the percentage of misconceptions for all students in each item can be seen in Table 6, it is identified that students experience the highest misconceptions in item number 1, which is explaining the concept of temperature with the percentage of misconceptions included in the high category. The lowest misconception occurs in item number 15, which is identifying heat due to changes in temperature when objects come into contact with the percentage of misconceptions included in the low category. There are 14 items that have a high percentage of misconceptions. Question number 1 is to explain the concept of

temperature, question number 2 is to compare the temperature of a certain object, question number 3 is to identify the effect of specific heat on changes in object temperature, question number 5 is to identify the expansion of solids in everyday life, question number 6 is to identify the factors that affect heat transfer, question number 8 is Comparing an object that receives heat, question number 9 is Identifying the heat transfer process, question number 10 is Identifying the heat transfer process, question number 11 is Comparing the specific heat of an object, question number 12 namely Identifying changes in the state of matter, Question number 13 is describing the process of changing the state of matter, Question number 16 is Analyzing the effect of heat on changes in the shape of objects, Question number 18 is Identifying heat transfer by conduction in everyday life, Question number 20 is Identifying heat transfer radiation in daily life -day. There are 6 items that have a percentage of misconceptions in the medium category. Question number 2 is to identify the expansion of solids, Question number 7 is to identify the effects of heat changes, Question number 14 is to give an example of a change of state that releases heat, Question number 15 is to identify heat due to changes in temperature when objects come into contact, Question number 17 is to differentiate heat transfer by conduction, convection and radiation, Problem number 19 is to identify heat transfer by convection in everyday life. The items with the highest percentage can be seen in Table 6.

**TABLE 6.** Percentage of students' overall misconceptions

No	Concept	The number of students	Percentage	Category
1	The heat used to raise the temperature	209	70	High
2	Effect of temperature on object size	196	65	High
3	The effect of specific heat on changes in the temperature of an object	227	75	High
4	Expansion of solids	210	70	High
5	Thermometer observation	177	59	Medium
6	The relation of heat to the temperature of an object	195	65	High
7	The connection between mass and heat	185	61	High
8	Specific heat	199	66	High
9	The connection between a substance's heat and density	192	64	High
10	The connection between heat and temperature fluctuations is depicted graphically	220	73	High
11	Expand long	216	72	High
12	Change of state from solid to liquid	158	53	Medium
13	Evaporation	194	65	High
14	Condense	192	64	High
15	Phase change graph of a substance	212	71	High
16	Conduction	178	59	Medium
17	Convection	206	69	High
18	Radiation	197	66	High
19	Heat exchange	201	67	High
20	Asas black	179	60	High

Indicator question number 10 is to explain the concept of temperature. In this problem, a misconception is identified that the temperature of hot water is determined by the amount of hot water. This is the misconception that most students experience as a whole, namely 79% of the total sample. Students assume the more hot water, the higher the water temperature, when in fact the temperature of the water in a small glass is the same as the temperature of the water in a large teapot, because the temperature of an object does not depend on how much or how little an object is. From the results of the data analysis above, it can be seen that misconceptions occur in each item. Overall the level of students' misconceptions on the material of temperature and heat is included in the high category. This is in accordance with the results of research [15] that concepts related to the concepts of temperature and heat are concepts that are quite difficult for students to understand, so misconceptions often occur. This is also in line with the results of research [12] that misconceptions occur because students answer incorrectly on the questions given but have a high level of confidence in their answers.

## CONCLUSION

Based on the results of research and discussions that have been carried out, it is concluded that from the 20 questions given, junior high school students in Lamongan have misconceptions on all questions with a percentage of misconceptions of 49.19%. Meanwhile, the percentage of understanding the concept is 32.02%, the guess category is 11.76% and the category does not know the concept with a percentage of 7.02%. The highest misconception is in the

concept of question number 17 about convection with a misconception percentage of 80.03% and in the concept of question number 19 about heat exchange with a misconception percentage of 92.24%. This shows that the misunderstanding of concepts experienced by students is quite high, therefore there is a need for remediation of physics concepts, especially the material of temperature and heat.

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