Analysis conception of secondary student’s using four tier test on heat and temperature

A Devialita*, A Suhandi, A Samsudi, D Hendriyani, M G Purwanto, V R Riani, E Nurzakiyah, S Gitnita
Departemen Pendidikan Fisika, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudhi No. 229, Bandung 40154, Indonesia

*asridevialita@upi.edu

Abstract. The main purpose in this research is to analyse student conception about heat and temperature used four tier test question, the test consists of three question including material about temperature, temperature and heat, as well specific heat. The research has been implemented by using purposive sampling technique. The participants consisted of 67 secondary students including (23 male students and 44 female students) of senior high school in Bungo city. After the analysis obtained the largest percentage of student conception id in the category of misconception such as: (1) Objects that feel colder to the touch must be lower in temperature than objects that feel warmer to the touch; (2) Objects that have a higher temperature must have more calorific content than objects with lower temperatures; (3) Objects that are easier to increase in temperature when heated, it will be more difficult to decrease the temperature when cooled. One way to reduce student misconceptions of concept in temperature and heat material is to facilitate student learning using conceptual change model, conceptual change text or Refutation text.

1. Introduction
Meaningful and complete physics learning is a learning that fits the theory of constructivism and relies heavily on the development of relationships between new knowledge and the initial knowledge possessed by students [1]. When the initial knowledge of learners is in accordance with the new knowledge, then the process of assimilation will occur, thus strengthening the original concept of learners. However, if the initial knowledge is different from the new knowledge, it will cause cognitive conflict in students [2].

Students' lack of understanding of the concept can be caused by misconceptions. Initial conceptions that do not conform to the understanding expressed by experts are called misconceptions. Students who experience misconceptions are difficult to change from wrong to true knowledge [3]. Misconceptions might also be referred to as defined notions, non-scientific opinions, naive theories, mixed conceptions, or conceptual misunderstandings. Principally, in science these are suitcases in which something a person knows and believes does not match what is known to be scientifically correct, also most people who hold misconceptions are not alert of their concepts [4].

Misconceptions in physics learning can be limited to a variety of concepts or materials [6,7]. Research conducted [8,10] states that students still have a misunderstanding of the concept of temperature and heat. For example, the concept of thermal equilibrium still exists for students who experience misconceptions. based on the scientific conception of thermal equilibrium which when both systems are in thermal equilibrium, their temperatures are defined equally but the quantity of heat contained in both objects is not necessarily the same. The instrument used is a four-tier test which is a
development of a three-tier test instrument combined with a level of trust in the basic answer. In the process of developing four-tier test has four stages, the first stage is a knowledge test using multiple choice, the second stage is the level of trust in answering from the first stage of the form includes the choice of sure and unsure, in the third stage is the reason for choosing the answer in the first stage, and the last or fourth stage is the level of trust of students in answering questions in the third stage with a choice of sure and not sure [11].

Indonesia has a diversity of tribes and cultures, and every region in Indonesia can be the subject of research in order to know what percentage of conception level has. This ethnic and cultural diversity can also be one of the factors of misconceptions in the study subjects. Especially for learning related to the concept of physics, if the subject has a misconception must be handled immediately. The name before that we must first identify the conception of students, for example the concept of temperature and heat. Thus, the purpose of this study is to analysis the conception that students have about temperature and heat.

2. Method

2.1. Participant

Participants who involved in this research are 67 of second year’s scholars (23 male students, and 44 female students, average age around 17 years of senior high school in Bungo city). The school is in Rimbo tengah area which is in the middle of Bungo city, 244 Km from the capital of Jambi, and 1147 Km from Bandung. Figure 1a Show a map distance Bungo - Jambi and Figure 1b show a map distance Bungo - Bandung.

Figure 1a. Maps distance Bungo to Jambi (Source by Google Maps)

Figure 1b. Maps distance Bungo to Bandung (Source by Google Maps)
2.2. Instrument

The instrument used in this research is diagnostic Four Tier Test which had previously been designed and tested by Nur in his thesis. The questions distribution for student conception analysis on heat and transfer context is shown in Table 1 and the Example of four-tier test in Table 2 by [12].

**Table 1.** The questions’ distribution for four-tier test

| No | Concept          | Misconception                                                                 | Question Number |
|----|------------------|-------------------------------------------------------------------------------|-----------------|
| 1  | Temperature      | Objects that feel colder to the touch must be lower in temperature than objects that feel warmer to the touch. | 1               |
| 2  | Heat & Temperature | Objects that have a higher temperature must have more calorific content than objects with lower temperatures | 2               |
| 3  | Specific Heat    | Objects that are easier to increase in temperature when heated, it will be more difficult to decrease the temperature when cooled | 3               |
|    |                  | **Total**                                                                    | **3**           |

**Table 2.** The Example of the four-tier test used is:

**Tier 1**

When heated simultaneously with the same heater, water and cooking oil of the same mass, it turns out that cooking oil rises faster than water. If now cooking oil and water have the same mass and the same starting temperature is simultaneously cooled, then which do you think will drop faster temperature?

A. Water will drop faster  
B. Cooking oil will drop faster  
C. The temperature of cooking oil and water will drop equally quickly

**Tier 2**

Are you sure of the answers you give Tier 1?

A. Sure  
B. Not Sure

**Tier 3**

The right explanation for your choice of answers in Tier 1 is ....

A. The speed of the decrease in the temperature of the object is proportional to the mass and temperature initially. Because the initial temperature and mass are the same then the decrease in the temperature of cooking oil and water will be equally fast.  
B. The amount of physics that characterizes the rapid slowness of the temperature of objects rises when heated is a type of heat. Things that rise faster when heated will also drop in temperature when cooled.  
C. The amount of physics that characterizes the rapid slowness of the temperature of objects rises when heated is a type of heat. Things that rise faster when heated will be slower to drop the temperature when cooled.

**Tier 4**

Are you sure of the answers you give Tier 3?

A. Sure  
B. Not Sure
2.3. *Technique* of Analyses Data

Data about the state of conception obtained by the literature that is used as the basis for the study include research by [13-15]. Gurek's research became the basis of decision-making in the four tier tests used in this study. The criteria for retrieving desperation can be illustrated in the Table 3.

| Table 3. The Criteria Conception Four tier test by [15] |
|--------------------------------------------------------|
| Level of Conception | Coding | Tier 1 | Tier 2 | Tier 3 | Tier 4 |
|----------------------|--------|--------|--------|--------|--------|
| Scientific Knowledge | SK     | ○      | sure   | ○      | Sure   |
| Misconception        | M      | ×      | Sure   | ×      | Sure   |
| Lack of Knowledge    | LK     | ○      | sure   | ○      | not sure |
|                      |        | □      | not sure | □      | not sure |
|                      |        | □      | not sure | □      | not sure |
|                      |        | □      | not sure | □      | not sure |
|                      |        | □      | not sure | □      | not sure |
|                      |        | □      | not sure | □      | not sure |
|                      |        | □      | not sure | □      | not sure |
|                      |        | □      | not sure | □      | not sure |
|                      |        | □      | not sure | □      | not sure |
|                      |        | □      | not sure | □      | not sure |

*○*: Correct, ×: Incorrect

After the student’s answer is entered by conception level category in Tabel 3 then the result of the student’s answered are processed using equation 1 by [16].

\[
P = \frac{F}{N} \times 100 \% \]

\(P\) = Percentage of student answers per item

\(F\) = The frequency of student’s answer to each question

\(N\) = Number of students

100\% = Constant number

The calculation of the percentage value of each item of the next question will be described in the form of a table or diagram, which is the purpose of which is to see an overview of the students' conception of the school on the concept of temperature and heat.

3. Result and Discussion

After conducting the test to know the conception of students calm the concept of temperature and heat in the form of diagnostic *four tier test*, then from the results of the answers students can be grouped into three categories namely Scientific Knowledge (SK), Misconception (M), and Lack of Knowledge (LK). The results of the analysis in percentage form can be seen in Figure 2 and the number of students who understand the concept of each question can be seen in Figure 3.
Figure 2. Percentage of student conception level per question (M) is Misconception, (LK) is Lack of Knowledge, is (SK) is Scientific Knowledge.

Based on Figure 2. The percentage of students in question number 1 about Temperature who experienced Misconceptions (63%), question number 2 about Temperature and Heat students who experienced Misconceptions (58%), question number 3 about Specific Heat students who experienced Misconceptions (55%). Based on Figure 3 number of students who experienced Misconceptions (M) in question number 1 (42) of question number 2 (39), and question number 3 (37). From these three questions, it can be seen that the misconceptions experienced by students on the concept of temperature and heat can be categorized as high. The misconceptions of students found can be seen in Table 4.
### Table 4. Misconceptions of students on the concept of temperature and heat

| No | Content          | Scientific Concept                                                                 | Misconception                                                                 |
|----|------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| 1  | Temperature      | The feeling of warmth or cold when touching an object does not necessarily describe a higher or lower temperature. | Objects that feel colder to the touch must be lower in temperature than objects that feel warmer to the touch. |
| 2  | Temperature and Heat | The temperature of an object is not necessarily comparable to the calorific content it has. | Objects that have a higher temperature must have more calorific content than objects with lower temperatures. |
| 3  | Specific Heat    | Based on the concept of Specific heat, then the object that is easier to increase the temperature when heated, it will be easier to decrease the temperature when cooled. | Objects that are easier to increase in temperature when heated, it will be more difficult to decrease the temperature when cooled. |

The cause of students' misconceptions is that they still have difficulty changing their understanding, they tend to remember and memorize the information they have obtained before. This is in line with the results of research that states that misconceptions can be resistant which means that the idea of students who are misconceptions is quite difficult to convert into scientific conception even though they have been confronted or confronted with logical reasoning through both experiments and direct observations to show where the student's concept errors are located [17]. The results of other studies also show that students build more knowledge precisely with their experience and apply more logic but are not motivated by a complete knowledge of the concept of physics [18].

### 4. Conclusion

The student conception in senior high school about temperature and heat content is still diverse, based on the results of the study using four tier tests, of which as many as 63% of students still experience misconceptions of Temperature content, 58% of Temperature and Heat content and 55% of heat type content. One way to improve or reduce student misconceptions of a particular concept in temperature and heat material is to facilitate student learning using Reputation text and also the results of this research can be a supporting material in identifying conceptions about temperature and heat.

### 5. Acknowledgments

A very big thank you is given to the lecturer who guided me, class A of 2019 physics education, all students who took the test who took the test, and the teacher who gave permission so that this research could be carried out.

### 6. Reference

[1] Limon M 2001 *Lear. Instruc.* **11** 357
[2] Chan C, Burtis J, & Bereiter C 1997 *Cognit. Instruc.* **15** 1
[3] Samsudin A, Suhandi A, Rusdiana D, Kaniaiwati I and Coștu B, 2015 *International Journal of Industrial Electronics and Electrical Engineering* **3** 12 74
[4] Alwan A A 2011 *Procedia - Social and Behavioral Sciences* **12** 600
[5] Samsudin A, Suhandi A, Rusdiana D, Kaniaiwati I and Coștu B, 2016 *Asia-Pacific Forum on Science Learning & Teaching, 17* 1
[6] Suprapto 2020 *Philos. Sci. Educ* **1** 2
[7] Utari G P and Liliawati W 2019 *Seminar Nasional Fisika* **1** 1 86
[8] Lestari and Suharto 2014 *Unnes Phys. Educ. J.* **3** 2
[9] Sri N 2016 *J. Pedidikan fisika teknologi.* **2** 3
[10] Caleon I S and Subramaniam R 2010 *Research in Science Education, 40* 3 313
[11] Syamsiah E N 2020. Remediasi Miskonsepsi Siswa melalui Pengajaran Remedial menggunakan Computer Assisted Conceptual Change Oriented Text (CA-CCOText) terkait Konsep-Konsep pada Materi Suhu dan Kalor (Doctoral dissertation, Universitas Pendidikan Indonesia).

[12] Caleon I S & Subramaniam R 2009 Research in Science Education. 40 313

[13] Kaltakci-Gurel D, Eryilmaz A and McDermott L C 2017 Research in science & Technological education, 35 2 238

[14] Gurel D K, Eryilmaz, A, & McDermott L. C 2015 Eurasia J. Math. Sci. Technol. Educ. 11 5

[15] Alawiyah N S2017 J. Ilmiah Mahasiswa (JIMP) Pendidikan Fisika 2 2.

[16] Ibrahim M 2012 Konsep, “Miskonsepsi dan Cara Pembelajarannya,” (Surabaya: Unesa University Press)

[17] Wahidah N S, Kusairi S and Zulaikah S,2017 J. Pendidik. Fis. Teknol 2 3.