The misconception analysis of natural science students on heat and temperature material using four tier test

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Abstract. This study is to analyze the misconceptions of natural science students of State Islamic Senior High School (MAN) Banjarmasin in the heat and temperature materials. The study was conducted in all State Islamic Senior High Schools Banjarmasin, namely State Islamic Senior High School 1, 2, and 3 Banjarmasin. The instrument used in this study was a misconception test with four tier tests so that the data obtained were in the form of students’ misconception data. The analysis of the misconception uses the four tier tests. The results showed that the natural science students of State Islamic Senior High School 1 Banjarmasin experienced misconceptions on the concept of expansion, changes in form, heat capacity, and heat transfer; the natural science students of State Islamic Senior High School 2 Banjarmasin experienced misconceptions on the concept of expansion, changes of form, and Black Principle; the natural science students of State Islamic Senior High School 3 Banjarmasin experienced misconceptions on the concept of expansion, changes in form, heat capacity, Black Principle, and heat transfer.

1. Introduction
In general, concepts in physics are abstract and complex. One complex physical concept that needs to be built from students' experiences is heat and temperature [1]. Heat and temperature are taught to Senior High School/State Islamic Senior High School students majoring in natural science. The concepts that exist in the material of heat and temperature are concepts of temperature, heat, expansion and shrinkage of substances, changes in the form of substances, heat capacity, Black principle, heat transfer, convection, conduction, and radiation. For example, the concept of temperature is one abstract concept. Students cannot see the form of temperature, but can only feel, measure and calculate the amount of temperature.

The development of complex and abstract physics concepts in students must begin with the student's experience [2], because students' initial knowledge is the biggest influence on what and how students learn [3]. Students must be able to construct their initial knowledge which is connected with the knowledge gained so that new knowledge is formed. However, the concept of complex temperatures and heat makes students difficult to construct new knowledge. [4] and [5] states that students often experience gaps between abstract concepts learned in school so that they can influence their understanding of concepts. Students' difficulties in understanding the concepts well can lead to misconceptions/ misconceptions [6]. Misconception is a misunderstanding in interpreting a concept [7]. Students' misconceptions can be in the form of initial concepts, errors and incorrect relationships between concepts [8]. Misconceptions can also occur in students in understanding the concepts of heat and temperature considering the material consists of many abstract and complex concepts [9]. Heat and temperature are concepts of science that
are captured by different students [10]. This causes misconceptions in physics subjects to still be a major question in physics learning that determines the quality of student learning outcomes.

Students' misconceptions on the concept of heat and temperature are shown by the results of research conducted by several experts. Students assumed that heat was a substance that is not energy; the temperature of an object depends on its size; objects that can store heat are heat sources [9]. The results of research conducted by Stankov and Crawford [11] stated that students were wrong in transmitting heat in the environment. Students also thought that condensation only occurs in water and the temperature of a substance increases when it boils. The results of other studies, stated that students understood the relationship between heat, temperature changes, heat capacity but students were not able to imply it. Students also assumed that the temperature of the water when boiling will be different if the water mass is also different [10]. This implies that students only learn with abstract concepts without doing activities that help them to understand the concept.

The results of research on the misconceptions of heat and temperature are the basis for conducting research on misconceptions of heat and temperature in natural science students of State Islamic Senior High School in Banjarmasin. State Islamic Senior High School is a high school under the Ministry of Religion. In contrast to high schools, the implementation of learning in Islamic High School not only teaches general sciences but also deepens religious knowledge. This causes students who study at Islamic High School have higher learning burden comparing to students who study at High School. This makes natural science students in Islamic High School considered lack understanding of the concepts of heat and temperature well [12]. Therefore, it is necessary to conduct research to find out the misconceptions experienced by students in heat and temperature material. Thus, knowing the misconceptions experienced by students in heat and temperature material can be a reference in the learning process of heat temperature to achieve a good and meaningful understanding of concepts.

To find out students' misconceptions about heat and temperature material, a special test of misconception is needed. The use of misconception diagnosis tests must be able to distinguish between students who understand the concept well, do not know the concept or students who experience the misconceptions. Four-level multiple choice test (four tier test) overcomes the weaknesses of misconception test. At the four tier tests, includes a confidence rating of each answer and students' reason so that the accuracy of this test is higher than other tests in identifying students' misconceptions. Four tier tests consist of four levels: choice of answers, multiple choice answer beliefs, reasons, and reason beliefs [13]. Four tier tests can be used to identify students who understand concepts, experience misconceptions, errors and students who do not know the concept [14], [6]. Thus, the four-tier test is effective for identifying students who experience misconceptions, who understand concepts and who does not understand concepts of heat and temperature. The review then becomes a basis for carrying out research to find out the misconceptions of Natural Sciences students in State Islamic Senior High School Banjarmasin on heat and temperature material using the four-tier test.

2. Methods
This study uses a qualitative descriptive approach to identify misconceptions of natural science students of State Islamic Senior High School 1, 2, and 3 Banjarmasin in heat and temperature. The instrument used in this study was a four-tier misconception test developed by the researcher so that the data obtained were students' misconceptions. The development of heat and temperature is based on the concepts and indicators developed and adapted to the upper middle Physics syllabus. The results of instrument validation by experts showed that the heat and temperature test questions were relatively high with a figure of 96.6%. Instrument testing was conducted on the students of Tadris Physics/ Physics Education Antasari State Islamic University Banjarmasin. The results of testing the validation of test questions showed that Tier 1 and 3 questions were valid and classified as reliable with Cronbach's Alpha value of 0.760. Data analysis techniques in determining student misconceptions follow the four tier test answer pattern criteria developed by Kaltakci, et al [15]. If the student gives false answer in tier 1, sure in tier 2, wrong reason in tier 3 and sure in tier 4, so they experienced misconceptions.
3. Results and Discussion

3.1. The State Islamic Senior High School 1 Banjarmasin Natural Science students’ Misconception on Heat and Temperature Material

Natural science students of State Islamic Senior High School 1 Banjarmasin who answer four tier question about heat and temperature there are 37 students. The following is the analysis result of students’ State Islamic Senior High School 1 Banjarmasin answer.

![Figure 1. The result of State Islamic Senior High School 1 Banjarmasin students’ answer](image)

According to the Figure 1, the natural science students of State Islamic Senior High School 1 Banjarmasin experienced the misconception 40.54% on heat and temperature concepts. The result of research showed that the natural science students of State Islamic Senior High School 1 Banjarmasin experienced the misconception quite high on question number 4 (67.57%); question number 6 (59.46%); question number 7 (40.54%); question number 8 (54.05%); question number 10 (56.76%); question number 11 (62.16%); question number 12 (45.95%); question number 18 (67.57%); question number 19 (62.16%), question number 20 (51.35%); and question number 21 (40.54%).

Many students understand the wrong concepts in heat and temperature material. Question number 4 about water molecules problem at 50°C. 22 students were sure to answer that the water molecules began to evaporate. With the reason students were also sure to answer that at this temperature water molecules have a certain speed and there is no force Pull between molecules so that they quickly leave the surface. However, in theory at 50°C, water molecules have the same velocity and there is an attraction between molecules so that no water molecules leave the surface.

Question number 6 contains the bimetal length increase. 22 students considered that the increase in the length of the metal depends only on the coefficient of expansion, not depending on the amount of temperature given. This is not in accordance with the theory that the expanding bimetal depends on the coefficient of expansion and temperature changes. In question number 7, 15 students were sure to answer if the coefficient of expansion is a large length, a small temperature change, then the increase in length of the stem is large because the increase in length is directly proportional to the coefficient of expansion and inversely proportional to changes in temperature. Whereas in theory the heat and temperature, the length of the stem will increase if the temperature changes and expansion coefficient are also large.

Question number 8 is about the graph of temperature changes in hot wax liquid. Many students believe that temperature changes will occur. However, in theory the change in form does not occur when there is a change in temperature. When there is no change in temperature, the substance will be in two forms. In question number 11, students considered heat capacity depends on the size of the object. Students believed that the larger the size of the object, the greater the heat capacity. For question number 12 is about the comparison of the heat capacity of aluminum and water. Students believed that the temperature of the water is lower than aluminum because of the form of liquid water and solid aluminum.
In question number 18 about heat transfer. According to the analysis result of students’ answers, as many as 25 students assumed that convection does not occur in water so it does not move heat to the metal gauze, then the ice does not melt. While numbers 19, 20 and 21 are about applying heat transfer. In these questions, it was found that students still had the wrong assumptions about convection, conduction and radiation. For example, such as number 19, students assumed that someone can feel the warmth of the heating because there is convection in surrounding air. Students have not been able to understand well about convection, conduction and radiation.

3.2. The State Islamic Senior High School 2 Banjarmasin Natural Science Students’ Misconception on Heat and temperature Material

Natural science students of State Islamic Senior High School 2 Banjarmasin who answer four tier question about heat and temperature there are 32 students. The following is the analysis result of students’ State Islamic Senior High School 2 Banjarmasin answer.

![Figure 2. The result of State Islamic Senior High School 2 Banjarmasin students’ answer](image)

According to the Figure 2, the natural science students State Islamic Senior High School 2 Banjarmasin experienced the misconception 25.15% on heat and temperature concepts. The result of research showed that the natural science students State Islamic Senior High School 2 Banjarmasin experienced the misconception quite high on question number 1 (46.88%); question number 2 (43.75%); question number 6 (43.75%); question number 8 (46.88%); and question number 15 (37.50%).

The misconception in question number 1, occurs due to students’ assumptions about the expansion of air molecules. Students assumed that the air molecules in the heated metal box expand. Whereas when expansion occurs, air molecules move quickly and make the container (box) expand. Question number 2 is still about the concept of expansion. In this question, students experienced misconceptions because students assumed that when objects (metal rods) are heated there will be shrinkage. In theory, an increase in temperature can cause expansion of an object. The analysis of the answers on number 6 and 8 same with the answer of students State Islamic Senior High School 1 Banjarmasin. Question number 15 concerning Black Principle, where the principle is that the heat received is the same as the heat received. In this question there is a misconception because many students assumed that the temperature of the water mixture is 45°C because the temperature of the water mixture is the amount of hot and cold-water temperature, then divided by two.

3.3. The State Islamic Senior High School 3 Banjarmasin Natural Science Students’ Misconception on Heat and temperature Material

Natural science students of State Islamic Senior High School 3 Banjarmasin who answer four tier question about heat and temperature there are 38 students. The following is the analysis result of students’ State Islamic Senior High School 3 Banjarmasin answer.
Figure 3. The result of students’ State Islamic Senior High School 3 Banjarmasin Answer

According to the Figure 3, the natural science students State Islamic Senior High School 3 Banjarmasin experienced the misconception 41.85% on heat and temperature concepts. The result of research showed that the natural science students of State Islamic Senior High School 3 Banjarmasin experienced the misconception quite high on question number 1 (57.89%); question number 2 (44.74%); question number 4 (50.00%); question number 6 (57.89%); question number 8 (52.63%); question number 10 (52.63%); question number 11 (57.89%); question number 15 (47.37%); question number 16 (44.74%); question number 17 (39.47%); question number 18 (60.53%); question number 19 (55.26%); and question number 20 (52.63%).

In general, the students’ answer in questions 1, 2, 4, 6, 8, 10, 11, 15, 18 and 19 have the same analysis as the previous discussion on State Islamic Senior High School 1 and 2 Banjarmasin. Therefore, in this section will discuss the misconceptions of natural science students State Islamic Senior High School 3 Banjarmasin on the answers of questions number 16, 17, and 20. These three questions are about heat transfer. In question number 16, most students assumed that conduction on lead wire occurs faster than the process of convection in water. This is not in accordance with the theory, that the process of convection in water is faster and can melt ice. In question number 17, students misunderstood about a conductor power of an object. Students were not able to determine and sort the conductor power of an object. For question number 20, students considered the under part of hand feels hot when holding a metal rod due to conduction from metal and convection from the air which makes body warm. Students mistakenly transmit heat in the environment. Students consider the temperature of an object to depend on its size [9] [16]. Thus, a quality learning process is needed in order to become meaningful learning for students.

4. Conclusion
Based on the explanation of the discussion, it can be concluded that the natural science students Islamic Senior High School in Banjarmasin experienced misconceptions as follows: At 50°C, water molecules have a certain velocity and there is no attraction between molecules so that the molecules quickly leave the surface; the expansion of the length of an object is only affected by the long expansion coefficient; when the temperature changes, there is also a change in shape of object; the larger the size of the object, the greater the heat capacity; convection does not occur in water; and warm air from heating is heat transfer by convection; the heated air molecule will experience expansion; a heated object will experience shrinkage; the temperature of the mixture of water is the amount of temperature of hot and cold water, then divided by two; and metal conduction is faster than water convection.

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