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To cite this article: Sindhu Madya Zakyratka Putri *et al* 2019 *J. Phys.: Conf. Ser.* **1233** 012031

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Analysis of Analytical Thinking and Misconceptions on the Concepts of Heat and Temperature on Physics Students

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Abstract. Temperature and heat are physics materials whose concepts we often encounter in everyday life. The existence of these events is to enable students to improve analytical thinking in connect phenomena that occur with the concept of physics. Analytical thinking is something that must be owned in the 21st century. Where students are required to be able to analyze, solve problems and provide appropriate solutions. This method is based on the analytical ability of students in high school. This type of research is descriptive qualitative. The research subjects were students of SMA N 1 Mojolaban with a total of 69 students who had obtained temperature and heat material. The collection data is carried out with test instruments that are made in accordance with the indicators of analytical thinking. The results of this study showed that students had low analytical thinking and misunderstanding the concept of heat temperature. Based on the profiles of students' analytical thinking cognitive processes are still low with differentiating results of 50.97%, organizing 43.24%, and attributing 32.00%.

Keyword: Analytical thinking; Concepts of heat; Temperature; Physics students.

1. Introduction

In the 21st century, offering a world of life without limits. The education sector is in a paradigm environment, where learning must be done using language [1]. Students must have the ability to apply the knowledge they have learned to face challenges outside of school. Thus, student achievement must be extended to the 21st century which will be needed for students to develop in the future. To equip students in the global era, students need analytical thinking to solve problems. Analytical thinking ability can develop problem solving skills, analyze data, and use information periodically [2]. Analytical thinking skills consist of aspects of sorting, aspects of organizing, and aspects of attributing [3].

Temperature and heat are physics learning that can be applied in everyday life. But students still have a misconception about the concept of heat transfer. Even though students are directly confronted with the concepts of temperature and heat in the school environment as well as their homes. Direct temperatures cannot be measured but can be analyzed and developed by students by interpreting the ideas they have experienced about temperature and heat in everyday life [4]. That, students have difficulty accepting different objects where objects are at the same temperature when left in the same environment for a long time [5]. Many students still face some difficulties in understanding heat and thermodynamics [6]. From



these opinions it can be concluded that students still have a lack of knowledge about the concepts of temperature and heat, even though the concept is very important, and they can be met in everyday life. Motivated from several aforementioned studies, this paper analyzes of misconceptions and analytical thinking on temperature and heat. Moreover, the place of research that will be conducted is in an area that has a gamelan and tile manufacturing industry where events from the concept of temperature and heat are always seen and experienced.

The rest of this paper is organized as follow: Section 2 describes the proposed research method. Section 3 presents the obtained results and following by discussion. Finally Section 4 concludes this work.

2. Research Method

This research is a research that uses descriptive method, which is a research method that aims to describe and interpret data that has been obtained. The thing that will be described or described in this study is an analysis of the understanding of physics concepts and students' analytical thinking on temperature and heat. The study was conducted at SMA N 1 Mojolaban with the subject of 69 students of natural science.

The research was conducted by distributing instrument tests that were prepared with analytical thinking indicators on temperature and heat material. The instrument test consists of 10 reasoned multiple-choice questions which are quoted from the papers of Helen & Manjula [7] and Almahdi Ali [5] while for analytic thinking scores with a Likert scale, the percentage of each indicator is analytical thinking. The percentage is done using the following formula:

$$\% = \frac{\text{score each indikator}}{\text{total score each indikator}} \times 100\% \quad (1)$$

The percentage of each indicator is then categorized as very high, high, medium, low, and very low. As in the Table 1 below:

Table 1. Categorization of students' analytical thinking

Percentage score (%)	Category
81-100	Very High
61-80	High
41-60	Fair
21-40	Low
0-20	Very Low

From Table 1, student test results can be used to describe analytical thinking and students' misconceptions on temperature and heat material.

3. Results and Discussion

This section presents the obtained results and following by discussion

3.1 Results

Figure 1 shows the percentage of students' analytical ways of thinking about temperature, heat transfer, and the application of the concepts of temperature and heat in everyday life. The results show that the percentage of differentiating or the way of thinking of students to distinguish concepts and interpret information and ideas from physical concepts about heat temperature of 50.97%, organizing (organizing) or the way students use concepts they already know in solving problems and in provide a reason or approach to a problem that is reasonable at 43.24% and attributing (giving attributes) or making and evaluating general conclusions based on investigation or research of 32.00%. Though students have learned the concepts of temperature and heat in the previous class, but the average percentage of all indicators of students' analytical thinking is

still low. It is seen that the aspect of differentiating students is an aspect of the highest indicator compared to other aspects of indicators. Followed by a way of thinking to use concepts in solving problems and then how to make or evaluate conclusions based on an investigation.

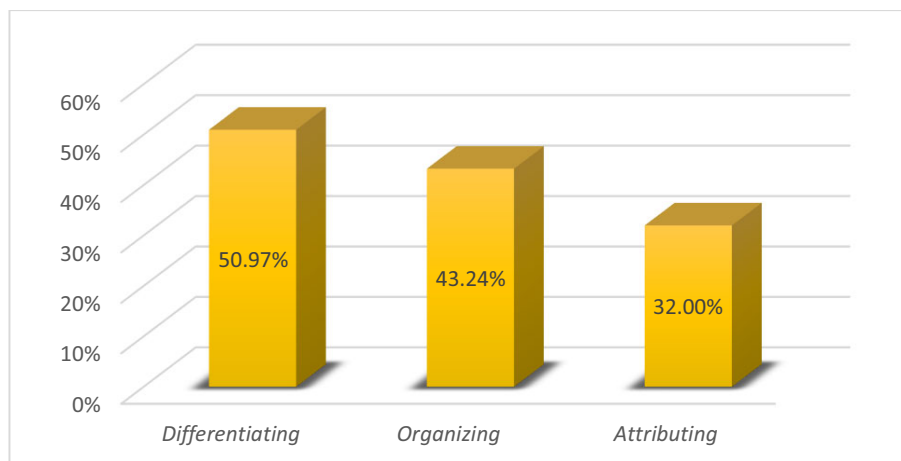


Figure 1. Percentage Of Average Students' Analytical Thinking For Each Indicator

Figure 2 shows the average percentage of students in answering each item. The average percentage of students can answer high enough for items 9 items compared to the results of students' answers on other items. However, when compared with the total ideal value that should be in value, this value is still relatively low. Problem 9 is a problem related to the concept of temperature. Meanwhile, the item that is most not answered by students is number 8, the item is a concept of heat transfer applied in everyday life.

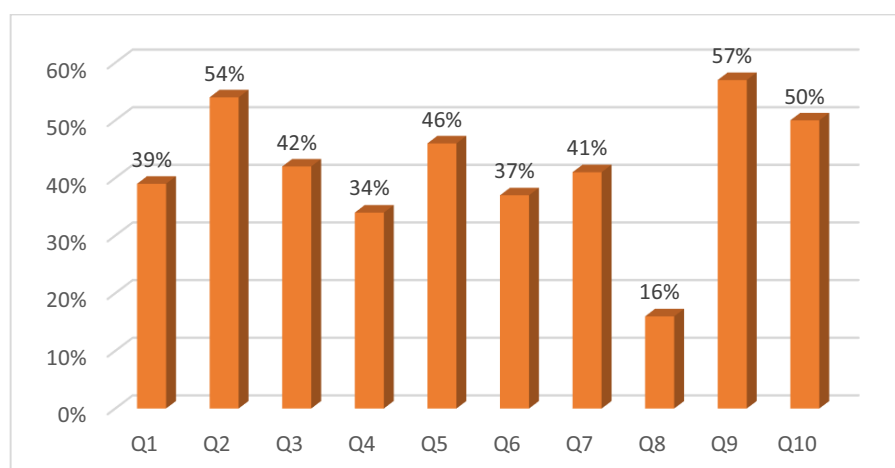


Figure 2. Average percentage of students in answering each item

Figure 3 shows that students still have an incomprehension of the concept of temperature and heat. It can be seen that students understand the highest concept in item Q9 about the definition of temperature, then

students who have the highest concept lack of understanding in item Q5 about changes in substance and students have the highest concept of misunderstanding on item Q8 about the heat of objects.

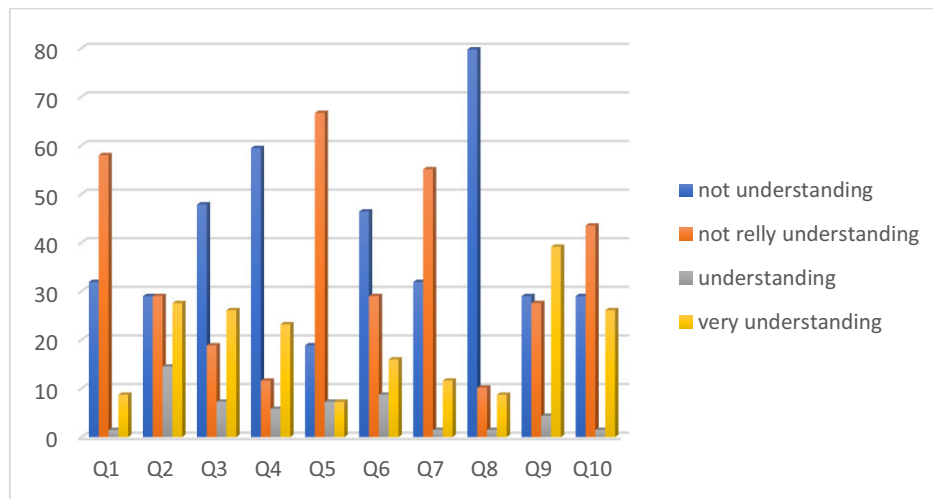


Figure 3. Percentage of students understanding each item

Table 2. The Result Students' concepts about heat transfer

Test	Result
Q4. When we walk on asphalt without using footwear during the day, we will definitely feel the heat. If you set foot on the ground, you will feel the soil is relatively cooler. Even though asphalt and soil are equally exposed to the sun. Why is that?	28.99% students answered correct, 11.6% students not really understanding and 59.4% answered incorrect.
Q5. Roni considers that when his mother cooks soup using a Pressure cooker, it cooks faster than an ordinary pot, but Roni doesn't know why it happened. Why do you think this can happen?	14.49% students answered correct, 66.7% students not really understanding and 18.8% answered incorrect.
Q8. Fishermen go to sea to catch fish at night, while during the day they return to the land carrying their catch. Why do fishermen go to sea at night and go home during the day?	10.14% students answered correct, 10.1% students not really understanding and 79.7% answered incorrect.

Q4. 71.01% students answer that the specific heat of the asphalt is larger, so that the asphalt feels hotter than the land. Even though the concept of physics is expressed in terms of the equation $Q = m \cdot c \cdot \Delta t$, if mass (m) and heat (Q) are given the same, asphalt has a greater temperature change, so that it means that asphalt has a small heat. The smaller the heat of the type of object, then the object will heat up faster and the other hand. When compared with specific heat of iron is $0.108 \text{ cal / gr } ^\circ\text{C}$ and specific heat of wood is $0.408 \text{ cal / gr } ^\circ\text{C}$, if iron and wood are both heated and heat the same, iron has a rapid temperature change and feels hotter compared to wood.

Q5. 85.51% students say that if we cook with a pressure cooker it will ripen faster because the pressure inside is bigger so that it cooks faster. Even if we cook food using pressurized cookware, it will produce hot steam which is higher temperature compared to other ordinary cooking tools. This is because it is influenced by the pressure that can make the device reach high temperatures and can make cooking quickly cooked and soft.

Q8. 89.86% students said that fishermen go to sea at night and go home during the daytime because the specific heat of the land is higher than the specific heat of the sea water making wind from land to sea at night. The reason given by students is true that at night the wind moves from land to sea so that fishermen depart at night. But students answer incorrect about the higher specific heat of land, the specific heat of the object or land is lower. The specific heat of land (solid) is smaller than the specific heat of the sea water (liquid). As a result, when heated by sunlight in the daytime, the increase in land temperature is greater than the increase in sea water temperature (although getting the same heat from sunlight). Overheated land can make the right air above it heats, so that the air has an increased temperature. Because the temperature increases, the air expands and the volume increases, resulting in reduced air density. The reduced air mass makes the air move upward, the upward air position is replaced by air from the sea, because the density of air at sea level is greater. Then the hot air that rises upwards begins to cool and glide down to replace the position of the air in the sea that moves to the land. So that during the day winds from the sea to the land and the night winds on the land to the sea, which can make it easier for fishing boats to sail [8].

Table 3. The result students' concepts

Test	Result
Q1. Think about burning matchsticks and the sea. What can you say about the concept of temperature and temperature of matchsticks and the sea?	10.15% students answered correct, 58% students not really understanding and 31.9% answered incorrect.
Q3. Riza took the metal ruler and wooden ruler left behind in the field after they practiced. He felt that the metal ruler felt hotter than a wooden ruler. Do you think the statement is true or not?	33.33% students answered correct, 18.8% students not really understanding and 47.8% answered incorrect.

Q1. Most students respond to matches having heat transfer by conduction because conduction is heat transfer through an intermediary namely wood (matchstick). Even though wood is not a heat conductor, what is means in this problem is when we light a match, we feel heat. This happens because matches are turned on and there is friction between chemicals, the fire can ignite. From the flame there is a heat emission, so that in the event of a match above there is a process of radiation (emission) where heat travels through the air, so that we can feel the heat. While the heat of sea water comes from sunlight. Where the sun rays / flows through the air. So that the heat that occurs on the beach due to the heat emission of sunlight to sea water or usually referred to as radiation heat transfer.

Q3. In item 3 which is a material with different specific heat of the objects most students answer that the iron ruler has a specific heat is greater than the wood ruler. As previously explained that the heat value of metal types is smaller because it has a large temperature, which means it can absorb and release heat faster than wood that has a large of specific heat (small temperature changes).

3.2. Discussion

Based on the 2013 curriculum that is applied in Indonesia, has specific aims and objectives which lead to the demands of the 21st Century that is capable of carrying out all the work to think analysis or decision making rather than mechanistic thinking (routine), so that learning is expected to be oriented to the scientific approach, that is observing, questioning, experimenting, associating, and communicating [9]. In other words, learning that directs students to analytic thinking is one way to realize skills in the 21st century. Analytical thinking is a powerful thinking tool to understand the parts of the situation, which are defined as: (1) the ability to research and unravel facts and thoughts into strengths and weaknesses; (2) develop the capacity to think wisely, smartly, solve problems, analyze data, remember and use information. Analysis skills as a high level of cognitive ability will be owned by students if students have the ability to know, understand, and applying [10]. Which has three aspects of cognitive thinking that is aspects of sorting, aspects of organizing, and aspects of attributing [3].

These analytical thinking skills can be used by students in analyzing. The concept of heat and temperature is one of the most widely used concepts in our daily lives. For example, shaking hands in a different environment, a bonfire activity when scouting, while walking on asphalt and cooking. So that the concepts of temperature and heat can be used in improving students' analytical thinking. The research was conducted by distributing instrument tests that were prepared with analytical thinking indicators on temperature and heat material. The item composition of heat transfer, heat conductivity and equilibrium, concept heat and temperature in daily lives.

Based on the research that has been done, how to think students are still at the level of medium and low, because they are difficult to understand and apply the concept of physics to the phenomena they face in the surrounding environment. Students still has misconceptions about heat transfer, which causes heat transfer to be the surrounding air, they cannot explain the difference in heat type and heat capacity contained in objects. Some students are still unable to read temperature and heat, cannot mention some of the examples they experience every day. Some of the students are unable to use and interpret the concept of temperature equilibrium from a graph. Many students could not predict the final temperature when two samples at different temperatures are mixed. However, most of them understand that the final temperature cannot be higher than the temperature of two samples before mixing [5].

Maybe this is because students in previous learning do not give a deep impression so that the concept cannot be remembered. This research was carried out further by conducting interviews with students to find out more clearly why students could not answer the items correctly. Students have difficulty answering items because they are difficult to understand the language of the problem or because the concepts of temperature and heat, they still do not understand. Based on the interviews that have been carried out, it turns out students say that, they have no difficulty understanding the problem but are confused and lack understanding of the concept of temperature and heat. When asked more deeply, they answered that physics learning is usually done in class by solving physical problems mathematically rather than discussing everyday concepts. Teachers more often explain the heat temperature equation and solve the problem than do the practicum or observation regarding daily events related to heat temperature.

In addition, based on observations from SMA N 1 Mojolaban close to the tile and gamelan industry. Which industry has many concepts of heat and temperature. For example, the concept of heat transfer in the form of conduction, radiation, convection, expansion, changes in the form of substances and so forth. That way the teacher should be able to utilize local wisdom around the school to do more interesting learning and can give a deep impression to students. Interesting learning can improve students' memory of a concept that occurs around them. Hence, students need learning that builds and improves concepts so that students are able to reason and think analytically.

Based on the results of the study, the researchers gave suggestions to improve analytical thinking and make students understand the concepts of physics, especially temperature and heat. Learning is needed using the project method. The concept and characteristics of project-based learning is an innovative learning model or approach, which emphasizes contextual learning through complex activities. The focus of learning lies in the core concepts and principles of a study discipline, involving students in investigating problem solving and other meaningful task activities, giving learners the opportunity to work autonomously constructing their own knowledge, and culminating in producing tangible products [11].

Misconceptions that students have on the concept of temperature and heat can be reduced by means of learning using a scientific approach. In research conducted by Nuryanto shows that learning with an effective scientific approach reduces misconceptions [12]. Also explained from Marry, research to support students' independent learning in problem-based learning and projects. The study explains that this approach allows students to think about their thinking, provides an opportunity to stimulate ideas among students, and allows teachers to identify and overcome misconceptions that students might have [13]. Learning with a scientific approach can reduce student misconceptions as measured by the student understanding scale rubric. Rubrics that are made in accordance with the concept of temperature and heat material and adjusted to the analytical thinking indicators.

4. Conclusion

This paper has analyzed of analytical thinking and misconceptions on the concepts of heat and temperature on physics students. Based on the results of research from analytical thinking and understanding of the concepts of temperature and heat in SMA N 1 Mojolaban. Based on the profile of students' analytical thinking cognitive processes are still low with differentiating results of 50.97%, organizing 43.24%, and attributing 32.00%. Most students are still low in analytical thinking and still have a poor understanding of the concepts of temperature and heat. Especially in heat transfer and the concept of specific heat of a material. From these results, we need a way to improve students' analytical thinking and conceptual understanding.

Acknowledgments

The author would like to thank the students and teachers in the research class at SMA N 1 Mojolaban High School, who have helped the authors in the study, and the authors for Prof. Cari and Prof. Widha, and patiently in guiding researchers.

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