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Identification of Prospective Physics Teacher's Misconceptions of Temperature and Heat Concept Using the Three Tier Test

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Abstract: This study aims to identify the misconception profile of prospective physics teachers (respondents) on the material of temperature and heat. This research is quantitative descriptive research. As many as 25 prospective physics teachers as respondents in this study. The research data was taken using a three-tier test instrument in the form of multiple-choice questions with open reasons. The results showed that as many as 58.73% of respondents experienced misconceptions and only 30.82% of respondents understood the concept. Most of the misconceptions occur in the concept of thermal equilibrium. As many as 61.90% of respondents experienced misconceptions about this concept. In addition, many misconceptions occur in differentiating the concepts of temperature, heat, and thermal energy. A total of 59.53% of respondents experienced misconceptions about this concept. the average respondent has not understood the substance of the difference between the concepts of temperature, heat, and thermal energy. Many of them equate to the concept of heat and thermal energy of an object. respondents also do not seem to be very able to distinguish the boundaries between the concept of temperature and the concept of thermal energy.

Keywords: Misconception; Prospective physics teacher; Temperature; Heat; Three-tier test

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Introduction

Physics is a part of natural science that studies natural phenomena and their causes. In physics, these natural phenomena are outlined in the form of concepts, principles, laws, postulates, and theories to be easily understood by humans (Kaniawati, 2017). The concept is a term used to represent a particular object, phenomenon, event, or situation (Suparno & Paul, 2005). Through concepts, experts express their thoughts by using one term to represent or explain a state or an event that occurs in the universe. The concept of heat (Q) for example is used to represent the process of transferring energy from objects with high temperatures to objects with lower temperatures. Likewise, the concept of temperature (T) is used to represent the size or degree of hotness or coldness of an object.

Concepts are a fundamental element in studying physics because they are the basis for the formation of law, theory, principle, and/or postulate. In other words, principles, laws, theories, and postulates are formed from the relationship of two or more concepts. For example, Boyle's Law explains the relationship between the concept of pressure (P) and the concept of the

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volume of a gas (V) in an enclosed space where the temperature variable (T) is kept constant. Charles' law describes the regular relationship between the volume of a gas (V) and the temperature of a gas (T) at constant pressure (P). Likewise, principles, principles are built on the basis of the relationship between two or more concepts. For example, the principle of floating, floating, and sinking in a fluid material is built on the regularity of the relationship between the concept of the density of the liquid and the density of the object to be immersed in the liquid. For example, in principle, if the density of the object is greater than the density of the liquid (($\rho_{object} > \rho_{fluid}$)), the object will sink if it is immersed in the liquid. Likewise, if the density of the object is smaller than the density of the liquid ($\rho_{object} < \rho_{fluid}$) then the object will float. Thus, in learning physics, the basic concepts of students should be really considered by the teacher when teaching in class because of this conception. will be used as a basis for building more complex knowledge.

Conception is a picture or a person's understanding of a certain concept. This conception is inherent in the cognitive structure of each individual so it is subjective. The subjective referred to here is that it is very likely to differ from one individual to another. For example, the conception or view of the concept of heat. Some people think that heat is a form of energy possessed by objects that have a temperature. On the other hand, there are also those who think that heat is the amount of energy transferred from an object with a higher temperature to an object with a lower temperature. It is possible that there are also those who understand the concept of heat with a different understanding from the two understandings above. Therefore, because of its subjective nature, it is possible for a person's conception to be right or wrong. A conception is said to be true if it is in line with or equal to the conception held by the experts. If a person's conception is not in line with or is not the same as the conception of the experts, then there are at least two possibilities that may occur, namely; the person does not understand the concept or even experiences misconceptions.

The misconception is a term to indicate a difference in thinking between a person's concept and a concept that has been defined by experts. The term misconception is used to describe a situation where a person's conception is not true (wrong) or not in accordance with the general truth based on empirical evidence but the person believes that the concept is true. Of course, this situation will affect the process of assimilation or integration of new concepts or information with old concepts that already exist before. Therefore, misconceptions in students need to be handled properly and at the right time (Ni'mah, et al. 2019).

Misconceptions often occur in students both at school and at the college level. Based on the results of research conducted by Wulandari, et. al., (2018), as many as 81% of junior high school (SMA) students have misconceptions about the concepts of temperature and heat. In addition, research conducted by Nursyamsi, et.al., (2018) showed that as many as 29.52% had misconceptions and 63.56% did not understand the concept. Based on the identification results of previous research, it was found that there were several forms of misconceptions experienced by students in the matter of temperature and heat, including students who assumed that hot and cold could move, and on the concept of temperature students assumed that cold objects did not contain heat. There are several reasons that cause these problems, namely the temperature material is an abstract material, the concept of heat has many influencing factors and each factor should not be omitted, and students often bring their understanding in everyday life contrary to the concept of temperature and heat understood by experts (Mustofa, 2021). The problems above are the difficulties experienced by students in general regarding the concepts of temperature and heat. The tendency of students to memorize the concept of heat transfer without being accompanied by concrete examples causes the potential for misconceptions to increase (Praptama, et al. 2021).

In cognitivist learning theory, the conception that exists in the cognitive structure of each individual is known as schemata. Schemata are initial knowledge that exists in the cognitive structure of each individual which is then used as a rationale for understanding new knowledge. Sekmata that exists in each individual (student) is very instrumental in understanding and mastering the learning provided by teachers in schools or lecturers in universities. In other words, students who have little prior knowledge will find it difficult to make knowledge connections so it takes longer than students who have sufficient prior knowledge. Moreover, if the schemata in the cognitive structure of students are not under the general truth stated by the experts, it will have an impact on the truth of the association and accommodation of information. The student's conception of physics as a teacher candidate which often contradicts the scientist's conception can cause difficulties for students later to be able to apply the concept to the learning process (Wahyudi & Maharta, 2013).

Therefore, before designing a lesson plan, a teacher should know the data on the ability or initial conception of students to be able to adjust the treatment that will be given to them. To obtain an overview or description of the student's prior knowledge, it is necessary to conduct a preliminary study regarding this matter. Therefore, in this study, the researcher conducted a preliminary study to determine the profile of the initial conception (understanding the concept, not understanding the concept, and misconceptions) of prospective physics teacher students. To be a basis or reference in preparing learning programs and giving treatment to prospective physics teacher students.

Method

This research is descriptive research with a quantitative approach. Descriptive research is research with the main objective of making a systematic and accurate description or description of the symptoms, phenomena, or facts being studied without any special treatment on the research subject (Muliawan, 2014). The instrument used in this study used the Three Tier Test. The three-tier test used in this study was in the form of a multiple-choice test with open reasons and equipped with a level of confidence. The reason for the second level is made open so that prospective physics teachers are freer to express their conceptions. While the confidence questions at the third level in this instrument were used to measure students' confidence in their answers at the first and second levels. The level of confidence can be considered a form of internal confidence in the accuracy of choosing answers

The data obtained were then classified and then analyzed by calculating the percentage of the number of prospective teachers who experienced misconceptions, understood concepts, and did not understand concepts. The guidelines for classifying the conceptions of prospective physics teachers in this study refer to table 1 below (Arslan, et al. 2012).

Table 1. Conception categories of prospective physics teachers using the Three Tier Test

Answers to questions			Category
First Level	Second Level	Third Level	
True	True	Sure	Understand the Concept
True	False	Sure	Misconception
False	True	Sure	Misconception
False	False	Sure	Misconception
True	True	Not Sure	Guess
True	False	Not Sure	Don't Understand Concept
False	True	Not Sure	Don't Understand Concept
False	False	Not Sure	Don't Understand Concept

Results and Discussion

In this study, the conception of prospective physics teachers is classified into 4 (four) categories, namely; understanding concepts, misconceptions, misconceptions, guessing, and not understanding concepts. The following is the data on the conception category of prospective physics teachers on the material of temperature and heat.

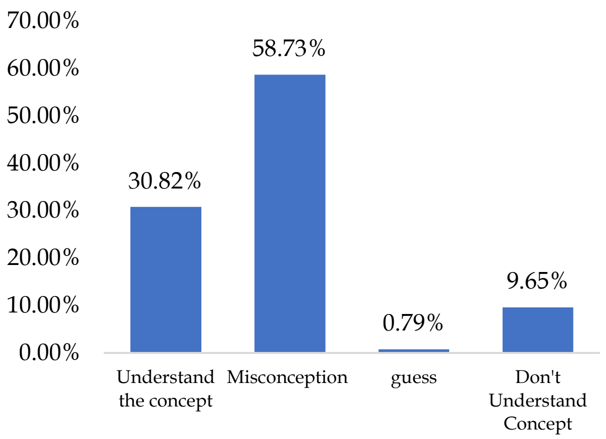

Figure 1. Conception of prospective physics teachers on the material of temperature and heat

The data in the table above shows that the number of students who understand the concept is 30.82%. That is, there are still 69.18% of prospective physics teachers who do not understand the concept and the concept is different from the conception of the experts.

On average, students know how the concepts that explain temperature and heat matter. However, the misconceptions experienced by prospective physics teacher students may also have an influence on the understanding of concepts that will be accepted by students when they teach later. In the matter of temperature and heat, there are several misconceptions experienced by prospective physics teacher students, especially in explaining the effect of the volume of objects on the heat transfer process. In addition, prospective physics teacher students have misconceptions about the effect of heat on a substance and also lack an understanding of the influence of the environment on specific heat and heat capacity.

Table 2. the conception of prospective physics teachers in each sub-discussion of temperature and heat

Konsep	Understand the concept	Misconception	Guess	Don't Understand Concept
Thermal Equilibrium	34.92%	61.90%	0.00%	3.17%
Differences in Temperature, Heat, and Thermal Energy	27.38%	59.53%	2.38%	10.72%
Specific heat	33.37%	47.62%	0.00%	19.00%
Heat capacity	28.57%	59.52%	0.00%	11.90%
The effect of heat on changes in temperature and shape of an object	42.86%	40.48%	0.00%	16.67%
Rata-rata	30.82%	58.73%	0.79%	9.65%

The data above shows that as many as 61.90% of prospective physics teachers have misconceptions about the concept of thermal equilibrium. There are 3 (three) similar problems given to students to identify students' conceptions of this thermal equilibrium concept.

- Two ice cubes taken from the same refrigerator are placed on a table. The first ice has a larger volume than the second ice.
- Two iron balls are immersed in boiling water for a long time. The mass of iron ball A is greater than the mass of iron ball B.
- Metals A and B are made of the same type of metal heated simultaneously for a long time but the two metals do not melt (change form). Metal A has a larger surface area than metal B.

From the three cases, students were instructed to determine the temperature ratio between the two objects being compared for each given problem. For the first problem, as many as 66.67% of students answered that ice that has a larger volume will have a greater temperature. Likewise, for the second and third problems, most of the students answered that the metal which has a larger mass or surface area will have a greater temperature. On average, students assume that the greater the mass or size of a substance, the more heat is absorbed by the substance when heated so that the temperature of the substance is higher than the temperature of a substance with a smaller mass and size.

In general, the findings of misconceptions experienced by students for the sub-discussion of thermal equilibrium are almost the same as the assumption that the increase in temperature depends on the type, size, and mass of the substance (object) even though the objects are heated for a long time (Subekti & Sunarti 2016). Students may not use their understanding of the concept of equilibrium in this case. Students often assume that equilibrium is only possible when two objects are in contact or mixed (Witanecahya, et. al., 2014). In addition, the researcher saw that students did not understand the difference in the concepts of temperature, heat, and thermal energy. Students assume that the more heat that is absorbed by an object it shows that the temperature of the object will be greater. This is reinforced by the answers of several students who said that holding a metal that has a larger surface size certainly feels hotter than holding a smaller metal even though both metals are heated at the same time. This answer strengthens the research hypothesis which states that students do not seem to understand the different concepts of temperature, heat, and thermal energy.

Furthermore, to identify students' conceptions of the concepts of temperature, heat, and thermal energy. Students are given three questions, one of which is; Hot water in glass x is divided into two different quantities. A total of 1⁄3 parts in glass A and 2⁄3 in glass B. If the influence of the environment is ignored, then the ratio of the temperature and heat of the two parts of the liquid is?

Most students have misconceptions in this case. On average, they assume that the temperature of the liquid in glass B is higher than the temperature of the liquid in class A. They assume that the heat of an object is influenced by the mass of the object ($Q = m\ c\ T$) so that the heat carried by the liquid in glass B is greater than the heat energy of the liquid in glass A. This answer certainly shows that students do not understand the difference between the concept of heat and the concept of thermal energy. Students assume that heat is a form of energy possessed by objects with a high temperature or temperature. Furthermore, when students were asked about the ratio of the heat possessed by two similar objects that have the same mass but different temperatures. The average student states that objects with higher temperatures have higher heat as well. Such a conception shows that heat has the same definition as thermal energy.

For the concept of specific heat, as many as 47.62% of students experienced misconceptions. The average student assumes that specific heat represents a measure of the speed of an object in absorbing and releasing heat. That is, the greater the specific heat of an object, the faster the object absorbs or releases heat from its environment so that the temperature of the object changes more quickly. In a study conducted by Tanahoung, et.al., (2010), 75% of high school students experienced misconceptions. On average, students assume that specific heat is the value of heat energy which indicates the ability of a material to capture heat.

In other words, the greater the specific heat of an object, the greater the ability of that object to capture heat. The form of students' misconceptions in the research conducted by Tanahoung, et. al., (2010) is the same as the misconception experienced by prospective physics teachers in this study but with a smaller percentage. In addition, the results of this study are also in line with the results of research conducted by Nursyamsi, et.al., (2018) which showed that 36.02% of students had misconceptions about the concept of specific heat. Likewise, for the concept of heat capacity, the data in the table above shows that as many as 59.52% of students experience misconceptions.

In addition, misconceptions also occur in students when determining the effect of heat on changes in temperature and the shape of an object. As many as 58.73% of students experienced misconceptions in this sub-discussion. Wulandari, et. al, (2018) found that as many as 49.00% of students experienced misconceptions in determining the effect of heat on changes in temperature and the shape of an object. The average student who experiences misconceptions assumes that, when water at a temperature of 100^0C is heated, the water temperature will continue to increase until it turns into steam. In addition, students also assume that to change form from liquid to gas, the substance must release heat. This is in line with the results of research by Nursyamsi, et.al., (2018) which states that students who experience misconceptions assume that when an object changes form from liquid to gas, it indicates the object releases heat.

Conclusion

The results showed that as many as 58.73% of prospective physics teachers had misconceptions and only 30.82% of them understood the concept. Most of the misconceptions occur in the concept of thermal equilibrium. As many as 61.90% of prospective physics teachers have misconceptions about this concept. In addition, many misconceptions occur in differentiating the concepts of temperature, heat, and thermal energy. As many as 59.53% of prospective physics teachers have misconceptions about this concept. The results of this study show that there are still many students who have misconceptions about the concepts of temperature and heat. In this study, the sub-discussion that became the focus of the researcher's study was limited to the sub-discussion of temperature and heat. Therefore, the researcher suggests for further research to identify students' misconceptions in other sub-discussions. In addition, the researcher hopes that this research can be used as a basis for lecturers in choosing and determining the right treatment when teaching in class.

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