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Analysis of Misconception through CRI (Certainty of Response Index) Method among Physics Education Students

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Abstract – *This study aims to determine the level of misconceptions that occur in Cenderawasih University physics education students in the material Temperature, Heat and Waves. This research is a descriptive research conducted in physics department of Cendrawasih University by involving 22 physics education students. The data collection technique used was a test in the form of multiple choice questions of 30 items. The questions were distributed to students and then the results were analyzed by using the Certainty Of Response Index (CRI) method to be categorized into four levels, one of which is misconception category. The results of the study revealed that students experience misconception in the three materials analyzed with the average percentage of students who experienced misconception in the material of Temperature, Heat, and Waves are 20.7% (low category), and 17,61% (low category), and 32.12% (moderate category), respectively. One of the factors causing misconceptions is the lack of understanding and references from educators. Therefore, it is expected that the physics materials is delivered clearly based on the concept so that students can avoid misconceptions.*

Keywords: *certainty of response index; learning physics; misconception; understanding concepts*

I. INTRODUCTION

Physics is a science that examines a natural phenomenon along with the symptoms that occur around it which go through a series of scientific processes and the results are recognized as scientific products consisting of concepts, principles and theories (Trisnawati, 2019). Physics is very synonymous with natural phenomena, so when studying physics one has to understand the idea of a physics concepts. Each concept cannot stand alone; there is a relationship between one concept and another. Physics is important to be taught and applied in schools because it provides knowledge to students and makes a forum for the growth of scientific work skills in order to solve problems that exist in everyday life (Trisnawati, 2019). According to Ali (2019) before studying physics, students do not come to class with an empty head. The cognitive structure of students has been formed as preconceptions about events and

understanding of physics concepts. Misconceptions are students' understanding of concepts that are wrong and not in accordance with scientific concepts put forward by scientists (Yuniarti et al., 2020). This opinion is also in line with Robo et al. (2021) that misconception is a concept that is owned by someone but this concept is not in accordance with the concept recognized by experts. Febriani et al. (2022) argue that when students attend class, they are not with an empty head but have brought several ideas that were formed previously both based on the experiences of students and when they interact with the surrounding environment.

Misconceptions also occur in various scientific fields, one of which is physics. There are many misconceptions experienced by students in studying physics because a lot of abstract material makes it difficult for students to understand the correct concept. Currently there are various studies that focus on research studies on misconceptions which will certainly have a negative impact on learning. Everyone can experience misconceptions and they can also occur at various levels of education. The results of previous research shows that misconceptions that often occur in learning physics are the concept of Temperature and Heat (Febrianti et al., 2019).

Based on observations conducted to Cenderawasih University Physics Education students, there are still many students who experience misconceptions about various physics materials/concepts. One of the concepts of physics is the concept of waves. In this concept, students still believe about what they know before they learn the concept properly and correctly. The factors that cause students to experience misconceptions include student abilities, low student interest in learning, the methods applied by the teacher/lecturer in class. Sometimes misconceptions also occur in the teacher/lecturer himself. This occurs due to the lack of references from the teacher/lecturer.

Many studies have been conducted to investigate misconceptions in science lessons. For example, (Surmaini et al., 2021; Gumilar, 2016; Utami & Wulandari, 2016) investigates students' misconceptions in the field of physics. One of the students' misconceptions that he found was that the image produced by the makeup mirror was real because the image could actually be seen. Then the research conducted by Anisfaizurrahmah, (2018) on Guided Inquiry Learning Strategies for Understanding Physics Concepts of Students of SMAN 1 Pakue showed that the average score of concept understanding was in good criteria. Research conducted by Prayuda, (2021); Koto & Gusma, (2021) concerning identification of students' understanding of concepts and misconceptions using the Certainty Of Response Index (CRI) method on elasticity and hooke's law material for class XI at SMAN 4 Bantaeng shows that the participants' level of understanding of the concept of elasticity and Hooke's law of

students are in the low category and misconceptions are in the medium category.

Wahyuni (2018) & Resbiantoro et al. (2022) conducted research on Students' Conceptions and Misconceptions, Student Teacher Candidates, and Teachers on the Topic of Light in Physics Learning. The results of his research show that there are many misconceptions related to the concept of light and geometric optics being studied. However, based on some of the previous analyzes/researchers that have been stated above, limitations were found, namely: 1) Many previous studies focused only on examining temperature and heat. 2) Previous research used diagnostic tests in general, and 3) Previous research was only limited to capturing conceptions and misconceptions without addressing these misconceptions, even though further analysis was needed from the results of the research found regarding the misconceptions that occurred and then providing solutions to overcome them. Based on the three limitations that have been described, it is necessary to conduct a study that analyzes students' misconceptions further so that we can find out the level of misconceptions of these students. Misconceptions in students can also be identified using several methods; one of which is using the Certainty of Response 5 Index (CRI) method (Manalu et al., 2019). The Certainty of Response Index (CRI) method can be a solution in overcoming problems about the tendency of being unsure of students answers. This method also allows students to state reasons for the answers they choose so that teachers can find out the misconceptions based on the reasons (Manalu et al., 2019).

This study aims to determine the level of misconceptions that occur in Cenderawasih University physics education students in Temperature, Heat and Waves material. After conducting further analysis on students, will their level of misconceptions decrease in the material on Temperature, Heat and Waves?

II. METHODS

This type of research is a descriptive analysis research. It is a kind of research where the researcher makes a systematic, factual and actual description or picture of facts (Sugiyono, 2013). The research was conducted in Cenderawasih University involving 22 physics education students: 8 men and 14 women. The instrument used in this study was in the form of a multiple choice test with 30 questions and 4 choices (options). The questions were distributed to students and then the results were analyzed by taking into account the CRI method. The data analysis steps carried out in this study are (Entino et al., 2022):

1. Determine the CRI value based on the scale (Table 1)

Table 1. The CRI value based on the scale

CRI	Criteria
5	Certain
4	Almost Certain
3	Sure
2	Not Sure
1	Almost Guessed
0	Totally Guessed Answer

2. Determine the category of understanding level based on the choice of answers and scores CRI (Table 2).

Table 2. Category of level of understanding based on the choice of answers and scores CRI

Answer criteria	Low CRI <2,5	High CRI ≥ 2,5
Correct answer	Correct answer but low CRI means you don't know the concept	Correct answer and high CRI means you know the concept well
Wrong answer	Wrong answer and low CRI means you don't know the concept	Wrong answer but high CRI means there is a misconception

Source: (A'yun, 2018)

3. Analyze students answers to determine the level of understanding whether it is understanding the concept well, understanding the concept but not being sure, misconceptions, or not knowing the concept. Percentage calculations were carried out for the four assessment results in each level by using the equation: P=f/N×100% (1). Then the reference for determining the answer category uses the Certainty of Response Index (CRI)

Information:

P = group percentage number
F = number of students in each group
N= total number of students who are research subjects

4. Recapitulate the percentage of the average level of understanding of all students in answering questions along with their level of confidence using the equation:

$$\% = \frac{Amount\ Student\ Answers}{Amount\ All\ Student} \quad (1)$$

and where the percentage categories can be grouped as in table 3 below.

Table 3. Percentage categories

Precentage	Categori
0% - 30%	Low
31% - 61%	Moderate
61% - 100%	High

Source: (Entino et al., 2022)

III. RESULTS AND DISCUSSION

Based on the test results of students using the Certainty of Response Index (CRI) with multiple choice questions, the percentage of students' understanding was grouped into the category of understanding concepts well, understanding concepts but not sure, misconceptions and not understanding concepts. The questions distributed to students were 30 items. Before they worked on them, the researcher first explained the procedure for working on the questions according to the CRI method. After students understood what had been explained, they then worked on it. The results can be seen in the following table:

Table 4. Data on percentage of understanding of each indicator and question item for the material of temperature and heat

No	Material	Question number	Understanding the concept	Understand but not sure	Misconcep-tion	Do not understand the concept
1	Temperature	2	40.91	22.73	18.18	18.18
		3	45.45	36.36	0.00	18.18
		4	22.73	27.27	31.82	18.18
		7	27.27	22.73	13.64	36.36
		10	18.18	27.27	27.27	27.27
		12	22.73	31.82	9.09	36.36
		13	59.09	22.73	18.18	0.00
		15	31.82	13.64	22.73	31.82
	Average		**33.52**	**25.57**	**17.61**	**23.30**
2	Heat	1	22.73	31.82	22.73	22.73
		5	40.91	27.27	31.82	0.00
		6	54.55	18.18	22.73	4.55
		8	50.00	18.18	18.18	13.64
		9	36.36	27.27	22.73	13.64
		11	31.82	22.73	18.18	27.27
		14	36.36	13.64	36.36	13.64
	Average		**35.90**	**24.33**	**20.07**	**19.07**

The data in the table above is the work of physics education students who have been processed/analyzed using equation (1) above. From the table above it can be seen that in the Temperature material, the items the students could *understand* the most was item number 13 with a percentage of 59.09%, followed by number 3 with a percentage of 45.45% and number 2 with a percentage of 40.91%. Then for the category of *understands but is unsure*, the highest score went to number 3 with a percentage of 36.36%, followed by number 12 with a percentage of 31.82%, numbers 4 and 10 with a percentage of each 27.27 %. The questions which resulted in a high level of *misconceptions* are number 4 with a percentage of 31.82%, number 10 with a percentage of 27.27%, and number 15 with a percentage of 22.73%. Finally, the items students *don't understand* at all are number 7 with a percentage of 36.36%, number 12 with a percentage of 36.36%, number 15 with a percentage of 31.82%, and number 10 with a percentage of 27.27%.

In the Heat material, the items that obtained the highest *understanding* of the students was number 6 with a percentage of 54.55%, number 8 with a percentage of

50.00%, and number 5 with a percentage of 40.91%. For the category understands but is not sure, number 1 was on top with a percentage of 31.82%, followed by number 5 with a percentage of 27.27%, and number 9 with percentage of 27.27%.

Futhermore, *misconceptions* occurs in number 14 with a percentage of 36.36%, number 5 with a percentage of 31.82%, and number 1 with a percentage of 22.73%. Lastly, for the category *don't understand the concept* the highest score was obtained by number 11 with a percentage of 27.27%, number 1 with a percentage of 22.73, and number 8 with a percentage of 13.64%.

For the wave material, there are 15 questions in the form of multiple choices. These questions were also analyzed using equation (1) so that the level of misconceptions obtained can be seen in the table below:

Table 5. Data on the percentage of understanding of each indicator and question item for wave material

No	Material	Question number	Understanding the concept	Understand but not sure	Misconcep-tion	Do not understand the concept
3	**Wave**	16	18.18	27.27	31.82	22.73
		17	31.82	27.27	36.36	4.55
		18	36.36	27.27	18.18	18.18
		19	18.18	22.73	36.36	22.73
		20	27.27	18.18	22.73	31.82
		21	13.64	27.27	36.36	22.73
		22	31.82	9.09	40.91	18.18
		23	45.45	9.09	27.27	18.18
		24	22.73	36.36	9.09	31.82
		25	18.18	27.27	18.18	36.36
		26	27.27	40.91	31.82	0.00
		27	31.82	27.27	40.91	0.00
		28	13.64	22.73	54.55	9.09
		29	27.27	22.73	50.00	0.00
		30	18.18	45.45	27.27	9.09
Average			**25.45**	**26.06**	**32.12**	**17.48**
Average percentage overall			**30.84**	**25.17**	**26.24**	**17.76**

The data in the table above is the results of students' understanding test which have been analyzed using equation (1). From the table above, it can be seen that the highest level in the concept *understanding* category is in number 23 with a percentage of 45.45%,

number 18 with a percentage of 36.36%, and numbers 20, 26, 29 with a percentage of 27.27% each. For the *understand but not sure* category, number 30 obtained the highest score with a percentage of 45.45%, number 26 40.91%, and number 24 with a percentage of 36.36.

Meanwhile, in the *misconception* category, a high level of misconception is found in question number 28 with a percentage of 54.55%, number 29 with a percentage of 50.00%, and numbers 22, 27 with a percentage of 40, 91 % each. Finally, the question who has the on top in *don't understand the concept* category are number 25 with a percentage of 36.36%, number 20 and 24 with a percentage of 31.82% each, and number 16, 19, 21, with a percentage of 22.73 %

After the data were analyzed using equation (1), it can be found that the average score of students' misconceptions in the material of Temperature, Heat, and Waves are 17.61% (low category), 20.07% (low category), and 32.12% (moderate category), respectively. More details can be seen in the diagram below:

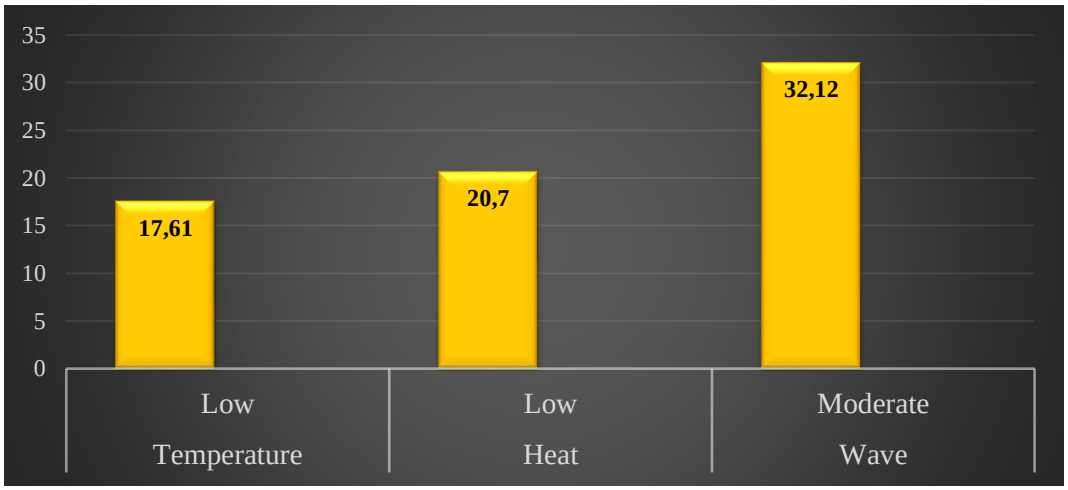

Figure 1. Level of students' misconceptions about temperature, heat and waves

The diagram above shows that the highest level of student misconceptions is in the wave material.

Discussion

In the physics concept of temperature there are 8 questions given to students and the questions are in the form of multiple choices. After the questions were analyzed, there were 3 questions that had a high level of misconceptions, namely questions number 4, 10 and number 15. Question number 4 discussed the tools used to measure body temperature. The answer choices are: a. Hands, b. Thermometer; c. Hand; d. Barometer and E. Hydrometer. From these questions, there were 22.73% of students who understood the concept, 27.27% who understood the concept but were unsure, 32.82% who had misconceptions and 18.18% who did not understand the concept. It is clear that the

level/percentage of misconceptions is the highest. The correct answer to this question is option b. However, most of the students answered a, namely hands, because of their inaccurate prior knowledge. Just touching the body does not tell how many degrees a person's body temperature is.

The second level of misconception is found in question number 10 where the question asks if the stove fire is enlarged when the water superimposed on it is boiling, then a. fixed water temperature; b. the speed of boiling water increases; c. water temperature increases; d. constant boiling rate of water and e. burning water. The percentage level of this question is that those who understand the concept are around 18.18%, those who understand but are not sure are 27.27%, those who experience misconceptions are 27.27 and those who do not understand the concept are 27.27%. Whereas the correct answer to the question is a. the water temperature remains the same, but most of the students answered c, namely the water temperature increased. Even though if the stove fire is enlarged right when the water is boiling, then the temperature remains. When boiling occurs the process of changing from liquid to gas. At the time of boiling, the temperature of the liquid cannot increase anymore because the heat supplied will be used to change the state of the liquid to gas and over time the water superimposed on the fire will run out/shrink due to evaporation.

For question number 15, the presentation was 31.82% who understood the concept, 13.64% who understood but were still unsure, 22.73% experienced misconceptions and 31.82% did not understand the concept. This question discusses the temperature of a substance when measured with a Fahrenheit thermometer shows the number 62 °F. If the temperature of the object is measured with a Celsius thermometer it shows the number a. 16.7 °C; b. 22.2 °C; c. 34.2 °C; d. 52.2 °C; and e. 54.0 °C. the correct answer to the question is option a, namely a. 16.7 °C. where first we have to know the ratio of the thermometer scale, namely: C: R: F = 5: 4: 9 so to change this value from a Fahrenheit thermometer to a Celsius thermometer, we use a ratio of 5/9 x °F - 32 so the answer is a. However, some students choose option e because they are confused with the equation where they use the equation 9/5 x °F-32 so the result is 54.0 °C.

In the Heat material, the highest level of misconception was in question number 14, with a percentage of 36.36%, and number 5, with a percentage of 31.82%. For those who understand the concept category there are number 6 with a percentage of 54.55% and number 8 with a percentage of 50%, then for the category that understands but is not sure, it is at number 1 which is 31.82%, and number 5 around 27.27%, then those who do not understand the concept are at number 1 which is 22.73% and number 11 which is 27.27%.

Furthermore, question number 14 asks about the transfer of energy by sunlight, what it is called: a. Conduction; b. Radiation; c. Isolation; d. Convection; and e. Indirect. From

these questions, most students experience misconceptions. This is because they find it difficult to distinguish between isolation and radiation because many of them answered isolation, even though isolation and radiation have a much different meaning or meaning where isolation can be interpreted as something that separates itself from the others, while radiation is heat transfer that by direct sunlight.

As for question number 5, which discusses 2 kg of water with a temperature of 40 °C, it will be heated to a temperature of 70 °C. If it is known that the specific heat of water is 4.186 j/kg °C, how much heat is absorbed by the water is a. 2.51 J; b. 25.11 J; c. 251160 J; 251.16 J; and e. 2511.60 J. The correct answer to the question is c, which is 251160 J where it is known: m = 2 kg; c = 4.186 j/kg °C; ΔT = (70 – 40) °C = 30 °C and what is being asked: Q = ? so the answer is Q = mcΔT Q = 2 x 4.186 j/kg °C x 30 °C Q = 251,160 J. However, some students choose option d, which is 251.16, even though it is in the form of kilo joules, not joules. So here, they still lack understanding regarding unit conversions. Because what they partially understand is that kj and j are the same in the sense that they don't pay much attention to the final units of their work. Even though the final result or the unit used at the end is very influential on the final result obtained.

This is in line with the research conducted by Febrianti et al. (2019); Nasir et al. (2021) & Yeberti et al. (2020) regarding the analysis of misconceptions about temperature and heat in Tanjung Raja 3 Public High School students. The results of his research show that students' conceptual understanding of SMA Negeri 3 Tanjung Raja uses the TTCI instrument based on graphical representations based on the category of understanding concepts, namely understanding concepts of 5.92%, understanding concepts but not sure of 0.89%, misconceptions of 57.85%, and do not understand the concept of 35.34%. The highest percentage of conceptual understanding is in the category of misconceptions. The average percentage of SMA Negeri 3 Tanjung Raja students who experienced the highest misconception was in the concept of temperature which was divided equally by 71.88% and the lowest misconception was in the concept of changes in length with changes in temperature of 47.92%. Research conducted by Asmin & Rosdianti (2021) shows that the percentage of students' misconceptions is 69% for temperature material and 63.79% for heat material. These two researchers showed that there were misconceptions about each material. Misconceptions are also understanding concepts that are not in accordance with scientific explanations received by experts in the field (Suparno., 2013).

Meanwhile, the research conducted by Prayuda (2021) found that there were misconceptions among the students in understanding materials. The conclusion of this study was that in dynamic fluid material,

especially the continuity principle sub-material, a misconception was identified using the four-tier diagnostic test instrument by 28% due to students' understanding who thinks that in a small pipe, the fluid has a large speed because of the large fluid pressure and also research conducted by Khoiri et al. (2017) with the title Identification of Misconceptions Class X High School Physics Textbooks on the Subject of Kinematics of Straight Motion shows that Intan Pariwara's textbook has misconceptions on the aspect of writing formulas with a percentage of 66.67% and aspects of writing symbols with a percentage of 40%. Meanwhile, the Phibeta Aneka Gama textbook had misconceptions about the aspect of writing formulas with a percentage of 22.22% and the aspect of writing symbols with a percentage of 10%. This shows that the misconceptions that occur are not only in physics material but in the process of making teaching materials as well.

In Wave material, students are given 15 multiple choice questions where the highest level of *misconceptions* is found in question number 28 with a percentage of 54.55% and number 29 with a percentage of 50%. The category of *understand the concept*, the highest went to number 23 with a percentage of 45.45% and number 18 with a percentage of 36.36%, then for the category *understands but is not sure*, it is number 30, namely 45.45%, and number 26 with a percentage of 40.91%. Finally for *who do not understand the concept* category, number 25 with a percentage of 36.36% obtained the highest score, followed by number 20 and 24 with a percentage of 31.82% each.

For question number 28, which discusses propagating waves, which require an intermediary medium, it is called a wave. mechanic; b. electromagnetic; c. Transverse; d. Longitudinal; and e. Walk. For this question, the correct answer is a, which is a mechanical wave where a mechanical wave is a wave which in its propagation requires a medium, which distributes energy for the purposes of the process of propagating a wave. Sound is an example of a mechanical wave that propagates through changes in air pressure in space (the tightness of air molecules). Without air, sound cannot travel. On the beach you can see waves, which are mechanical waves that require water as a medium. Other examples include waves on a rope or spring. However, most students answer that is a transverse wave even though the definition of a transverse wave itself is a type of wave whose motion is directed based on the direction of vibration and the direction of propagation. The main feature of transverse waves is that the media particles move perpendicular to the direction of propagation of the wave. Basically, waves based on the direction of vibration and propagation are divided into two types, namely transverse waves and longitudinal waves.

For question number 29 the question given: Based on the propagation medium, the wave is divided into 2, namely: a. Transverse and longitudinal waves; b. Mechanical and

electromagnetic waves; c. Stationary waves and traveling waves; d. Mechanical and stationary waves; e. transverse and mechanical waves. The correct answer is; b. Mechanical and electromagnetic waves. Where is the wave according to whether there is a medium for its propagation. There are two types of waves, namely electromagnetic waves and mechanical waves. Electromagnetic waves are waves that do not need a medium to propagate. Examples of electromagnetic waves include light waves and radio waves. While mechanical waves are waves that need a medium to propagate. Examples of mechanical waves are water waves, string waves and sound waves. So here there is a misconception because what they understand is that waves based on the direction of propagation are transverse waves and longitudinal waves. When in fact the two waves are waves that are grouped based on the direction of vibration.

There are several researchers who support this findings for instance that conducted by Safriana & Fatmi (2018) entitled Analysis of Mechanics Material Misconceptions in Student Teacher Candidates Through Force Concept Inventory and Certainty of Response Index which revealed that there are several physics materials that are analyzed and many misconceptions occur, including the concept of mechanics. Those who experience the highest misconceptions are self-centered frames of reference (97.43%), heavy objects fall more quickly (89.30%), the mass of objects can cause objects to stop moving (80.44%), the movement of objects is a representation of a force that working on objects (70.45%), impetus comes from blows (63.34%).

Another research was conducted by Aulia at al. (2018) entitled Analysis of Middle School Students' Misconceptions on Physics Materials and shows that misconceptions about the concepts of vibration and waves are found at 7.40%.

Of every physics concept discussed in this study, each student had a level of misconception except for the first matter is temperature related and is on question number 3, where the question discussed the definition of temperature. And the highest percentage of misconceptions is in the concept of waves. Misconceptions occur due to wrong intuition where ideas about a concept are spontaneous before learning it and only follow feelings. 2) There is erroneous reasoning because the information or data obtained is incomplete or incorrect, resulting in incomplete knowledge. 3) The initial concept that was understood while in school could make him experience mistakes. The level of confidence that what is done is right, it will be done with confidence even though what is done is wrong. 4) The low ability of students dominates the causes of misconceptions. With low ability, it results in wrong answers Wiyoko & Hidayat (2020) Other causes of misconceptions also come from the students themselves, teaching methods, textbooks used in class, and also from teachers or lecturers who teach in class

(Entino et al., 2022; Hull et al., 2022; Chen et al., 2023).

The implication of the results of this study is that researchers already know the level of misconceptions that occur in the material Temperature, Heat and Waves. Where of the three materials, waves are the material that has the highest level of misconceptions. Therefore this is used as a reference for the teacher/ lecturer in learning, so that the teacher/lecturer can plan and carry out learning so that students do not experience misconceptions anymore and also the teacher/lecturer needs to emphasize learning on fundamental concepts so that the concepts can be well understood by students.

IV. CONCLUSION AND SUGGESTION

The conclusion that can be drawn from this study is that of the three physics concepts analyzed, the average percentage of students who understands the concepts of Temperature, Heat, and Waves are 33.52%, 35.90 and 30.84%, respectively; while that in the category of Understanding Concepts but is Not Sure are 25.57%, 24.33% and 25.17%, respectively. Furthermore, the percentage of students who Do Not Understand the Concept, for the material of Temperature, Heat, and Waves are 23.30%, 19.07% and 17.76%, respectively. Finally, the average percentage of students who experienced misconception in the material of Temperature, Heat, and Waves are 20.7% (low category), and 17,61% (low category), and 32.12% (moderate category), respectively. This happens because some good things come from within the student, as well as from outside/comes from the lecturer or the environment. Therefore, in the subject of Temperature and Heat, the researcher tries to keep the level of misconceptions that occur lower than the material on Waves. That is one way to get used to them so as not to draw conclusions about something before studying the concept properly and correctly. And also by using interesting methods during the learning process so that they have interest and motivation when learning.

One of the factors causing misconceptions is the lack of understanding and references from educators. Therefore, it is expected that lecture material is conveyed clearly and precisely in accordance with the concept so that students do not have misconceptions regarding the material being discussed. Because sometimes what is explained is not relevant with the existing concept. and it is also hoped that educators will choose the right learning model and method in accordance with the character of the students who will be taught so that they can encourage students to have high motivation and enthusiasm in receiving the lessons delivered.

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