K-12 students’ misconception ability on global warming: a case study

S Satriadi*, W Liliawati, I Hasanah and A Samsudin
Program Magister Pendidikan Fisika, Universitas Pendidikan Indonesia, Bandung, Indonesia

*Corresponding author’s email: satriadi.saat@upi.edu

Abstract. A case study is a research design to identify misconception about high school students on global warming. Diagnosing misconception process is important factor to help teachers overcome their learning problems. The participants are 100 students with 43 males and 57 females of the third grade students of senior high schools in Bandung. The data has been collected by distributing diagnostic test items in the form of three tier test. The study indicates that there are several misconceptions related to global warming such as (1) Global warming is caused by ozone layer depletion, (2) The greenhouse effect is not a natural but man-made phenomenon, (3) Carbon dioxide (CO₂) which has been erode the ozone layer in the stratosphere, (4) Greenhouse gases increase due to the depletion of the ozone layer, and (5) The ozone layer is the layer involved in the process of the greenhouse effect. In conclusion, the results of this study established that the diagnostic test is able to analyse the students’ misconceptions as well as categorize the level of students understanding toward the global warming; understand the concepts, misconceptions, or don’t understand concepts.

1. Introduction
In the learning process students are always absorbed to be gifted to understand the learning material besides possible. The fact is, it does not always absorb information completely, there are often problems encountered. These problems are encountered when students experience difficulties and problems in learning, especially in physics subjects which contain many scientific and abstract concepts and are often considered difficult to learn [1-2]. When learning physics, it will not be separated from the essential concepts that occur in physics learning, so that students’ concept understanding is very significant in physics learning. Based on the involvement at this time the understanding of students’ concepts in physics is still a problem, where the understanding of physics learning unstated by students is a misunderstanding [3-5]. So, there are times when what students understand about a scientific concept is often different from the concept espoused by physicists in general [5-7]. The incompatibility of understanding the concept is often referred to as misconceptions or alternative concepts.

The reasons of misconceptions can be derived from students, textbooks, and the context used and especially teachers [3, 8-10]. Misconception is a partition for students in reconstructing their knowledge and influencing the understanding of students’ scientific concepts [5], therefore it is important to identify misconceptions in students for more effective learning [11-12]. Identification of misconceptions is carried out on concepts that have the potential to experience misconceptions, one of which is physics learning in the material of global warming which is included in the conservation issues around us.
Students’ knowledge of the environment as well as changes in atmospheric composition, global warming, the effects of greenhouse, ozone depletion, and acid rain still experience misconceptions [13].

In place of Arslan [13] with a three-tier diagnostic test, there are misconceptions regularly found in the assessable of global warming, including: (1) Global warming caused by depletion of the ozone layer; (2) Global warming will cause skin cancer; (3) Acid rain is a result of global warming; (4) Global warming can be reduced by limiting on chemical waste released into rivers; (5) The greenhouse effect is a phenomenon that is truly dangerous to humans; and (6) Using public transportation reduces the depletion of the ozone layer.

2. Methods

2.1 Participants
The participants of this study were 100 of K-12 students; 43 males and 57 females aged around 16-17 years in 3 high schools in Bandung. Most of them are from rich family, they had access to obtain information since they had complete learning sources such as subject guide books as well as the current technologies which can be used to search any information from the internet.

2.2 Instrument
The instrument has 7 questions; every question included three levels to assess students’ understanding towards global warming. The first level was about the content, which comprised of multiple-choice questions in three choices. The second level, the researchers presented several reasons for the answers given to the first level response. Then, the third one was about the level of students’ confidence in answering the first and second level questions. The rubric sample for the Three-tier Diagnostic Test is shown in Figure 2. This test had been validated by experts and has a reliability of 0.89 in the high category. Test results were analysed by calculating the average score obtained.
5.1. The increasing amount of greenhouse gases will make the earth's temperature will continue to increase. The correct statement about the greenhouse effect is:
   a. The greenhouse effect is a natural phenomenon
   b. The greenhouse effect is not a natural phenomenon
   c. The greenhouse effect has no effect on humans

5.2. Which is the reason for your answer to the previous question?
   a. The greenhouse effect does not occur naturally but is man-made
   b. The greenhouse effect just happens not to involve living things
   c. The greenhouse effect occurs naturally involving all substances in nature
   d. 

5.3. Are you sure of the answer you gave from the two questions above?
   1. Sure
   2. Not sure

Figure 2. Three tier of global warming test.

Table 1. Potential misconceptions and the alternative sets measuring the concerning misconceptions [13]

| Misconceptions                                                                 | Alternative set |
|-------------------------------------------------------------------------------|----------------|
| Global warming is caused by depletion of the ozone layer                       | 1.1.a 1.2.b 1.3.a |
| Global warming is caused by climate change that occurs                         | 1.1.c 1.2.c 1.3.a |
| Paper recycling is not an effective solution to reduce global warming          | 2.1.a 2.2.b 2.3.a |
| Changing the source of electrical energy into renewable energy cannot help reduce | 2.1.b 2.2.c 2.3.a |
| Global warming                                                                  |                |
| The greenhouse effect is not a natural phenomenon                               | 3.1.b 3.2.a 3.3.a |
| The greenhouse effect has no effect on humans                                  | 3.1.c 3.2.b 3.3.a |
| Carbon dioxide (CO₂) gas is the only gas that can increase greenhouse gases     | 4.1.b 4.2.a 4.3.a |
| Increased greenhouse gases are caused by depletion of the ozone layer          | 4.1.c 4.2.c 4.3.a |
| Depletion of the ozone layer causes the earth's temperature to increase        | 5.1.a 5.2.a 5.3.a |
| Carbon dioxide (CO₂) which has eroded the ozone layer in the stratosphere      | 6.1.a 6.2.c 6.3.a |
| Depletion of the ozone layer caused by carbon monoxide (CO)                    | 6.1.c 6.2.b 6.3.a |
| The ozone layer protects the earth from acid rain                              | 7.1.a 7.2.a 7.3.a |
| The ozone layer is a layer involved in the process of the greenhouse effect    | 7.1.c 7.2.b 7.3.a |

2.3 Research Design
A single case study was used as a method in this study, fixed design. This design used more than one type of analysis such as quantitative or qualitative as well as the number of methods that can be useful in sub-units [14]. The research school was chosen based on the school and students' quality; average level. This aimed to make the results able to be used as representation and provide a general description. The research was conducted by taking data to identify students' misconceptions through the provision of Three-tier Diagnostic Test on one-time global warming material. Data collection time is on 15-31 August 2018. This test required two hours of study, 45 minutes per hour. This test was distributed to the students who had previously learned about the concepts. Then the results were displayed statistically and then analysed.

2.4 Data Analysis
After taking the steps that must be taken in the process of data processing regarding the state of student conception, then the researcher obtained the process first by classifying the students' answers to the Concept Understanding criteria, Not Understanding Concepts and Misconceptions. Generally drawn in table:
Table 2. Level analysis category based on level 1, 2 and 3

| Category               | Level Tier (Tier I) | Option | Level Tier (Tier II) | Reason | Level of Confidence (Tier III) |
|------------------------|---------------------|--------|----------------------|--------|------------------------------|
| Understand Concept     | Correct             | Correct| Sure                 |        |                              |
| Don't understand the concept | Correct             | Correct| Not Sure             |        |                              |
|                        | Incorrect           | Incorrect| Not Sure             |        |                              |
| Misconception          | Correct             | Incorrect| Sure                 |        |                              |
|                        | Incorrect           | Correct| Sure                 |        |                              |
|                        | Incorrect           | Incorrect| Not Sure             |        |                              |

The consortium with student misconceptions is based on the percentage calculation of students' misconceptions with the frequency distribution equation [15].

\[
\text{Mean} = \frac{\sum fx}{N} \tag{1}
\]

\[
\text{SD} = \left( \frac{\sum fx^2}{N} - \left( \frac{\sum fx}{N} \right)^2 \right)^{1/2} \tag{2}
\]

Information:
\(\sum fx\) = Number of frequencies multiplied by \(x\)
\(N\) = Many research samples
SD. = Standard Deviation

3. Result and Discussion

3.1. Identification of student conceptions individually

The grades Three-tier Diagnostic Test can be identified with percentage on concept understanding that is understanding the concept, not understanding the concepts and misconceptions revealed in figure.

![Figure 3. Recapitulation of students’ understanding of concepts.](image)

Based on students' understanding concepts percentage, the highest misconceptions occurred in students’ number 8, 52, and 55 with 83.33%, while understanding the highest concept occurred in
student number 64 with 66.66% and did not understand the concept the highest occurred in student numbers 27 and 67 with 91.66%.

3.2. Identify students' conceptions of each question

| Category                | Number | Question |
|-------------------------|--------|----------|
| Understand Concept      | 32     | 1        |
|                         | 40     | 2        |
|                         | 4      | 3        |
|                         | 9      | 4        |
|                         | 7      | 5        |
|                         | 33     | 6        |
|                         | 17     | 7        |
| Misconception           | 54     | 1        |
|                         | 35     | 2        |
|                         | 75     | 3        |
|                         | 70     | 4        |
|                         | 67     | 5        |
|                         | 40     | 6        |
|                         | 67     | 7        |
| Don't understand concept| 14     | 1        |
|                         | 25     | 2        |
|                         | 21     | 3        |
|                         | 21     | 4        |
|                         | 26     | 5        |
|                         | 27     | 6        |
|                         | 16     | 7        |

The results about data, there are several questions still have an equally high percentage of misconceptions, including questions 1, question number 3, question number 4, question number 5 and question number 7.

![Figure 4. Questions with high misconceptions.](image)

Question number 1 showed that the misconceptions experienced by students were still high at 54%. It means that there were 54 of 100 students who had misconceptions toward the cause of the global warming. The question was about the analysis of the factors that cause global warming. Of the 54 students, 75.6% identified misconceptions that global warming was caused by the depletion of the ozone layer, while 24.4% identified a misconception that global warming was caused by climate change.

Regarding the question number 3, it was found that the misconceptions experienced by students as much as 75%. It indicated that there were 75 students who fell into the misconception category of a total of 100 students. This question was created to identify the correct facts about the greenhouse effect. Of the 75 students, 80% identified misconceptions that the greenhouse effect is not a natural phenomenon but man-made and 20% of these students had misconception that it occurred because of the natural effects.

In term of question number 4, the students experienced misconceptions as much as 70%, this study showed that there were 70 students who fell into the misconception category of a total of 100 students. Analysis of the causes of an increase in greenhouse gases (greenhouse) was the indicator of this question. Of the 70 students, there were 57.1% identified misconceptions that increased greenhouse gases were caused by depletion of the ozone layer and 42.9% of these students had misconceptions about the carbon dioxide which can cause the increasing of the global warming.

Related to the question number 6, there were 40% of these students who had misconceptions. It implied that there were 40 students included in the misconception category of a total of 100 students. The question indicator was about the analysis of the ozone smear depletion causes. Of the 40 students, 65% identified misconceptions that carbon dioxide (CO₂) had eroded the ozone layer in the stratosphere. Meanwhile, 35% of these students thought that the depletion of the ozone layer was caused by carbon monoxide (CO).
The last highest misconception was the question number 7, there were 67% of the students who experienced misconceptions. It concluded that there were 67 students included in the misconception category of a total of 100 students. The indicator of this question was about an explaining the role of the ozone layer for the earth and the creatures in it. Of the 67 students, there were 65.7% identified misconceptions that the ozone layer worked as a protector of UV light. Thus, it can regulate climate change and control the phenomena of the greenhouse effect. While around 34.3% of these students who thought that the ozone layer protected the earth from the acid rain.

4. Conclusion
Misconception becomes an obstacle in learning because of stable understanding, resistance to difficulties. There needs to be anticipation to overcome the misconceptions experienced by students. Some activities that can be done to overcome misconceptions are using misconceptions, learning together with communicating with the teacher, and helping to reconstruct their knowledge [16]. Improvements to previous misconceptions must be revealed first, where and what happens, can provide information to the teacher in the right process in learning to suspend errors that occur in students on global material.

Based on the results of this field studies, it can be summarized that misconceptions occur throughout the students with the highest misconceptions occur with a percentage of 83.33%, while students with the highest conceptual understanding occur with a percentage of 66.66% and do not understand the highest concept of students occurs with a percentage 91.66%. Then other results show that there were some misconceptions regarding the global warming: (1) Global warming is caused by ozone layer depletion, (2) The greenhouse effect is not a natural but man-made phenomenon, (3) Carbon dioxide (CO2) which has been erode the ozone layer in the stratosphere, (4) Greenhouse gases increase due to the reduction of the ozone layer, and (5) The ozone layer is the layer involved in the process of the greenhouse effect. In conclusion, the results of this study established that the diagnostic test is able to analyse the students’ misconceptions as well as categorize the level of students understanding toward the global warming; understand the concepts, misconceptions, or don’t understand concepts.

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