

Exploring students' misconceptions using three-tier diagnostic test as the preliminary analysis for e-modules development on global warming and environmental pollution

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Article Information	Abstract
Keyword: Misconception; Three-tier; Global warming; E-module development Kata Kunci: Miskonsepsi; Three-tier; Pemanasan global; Pengembangan e-modul History: Received : 08/04/2025 Revised : 09/06/2025 Accepted : 14/06/2025 Published : 18/06/2025	Misconceptions are challenges in education. Misconceptions can occur in science learning topics, one of which is the topic of global warming and environmental pollution. Misconception analysis is conducted as one of the diagnostic tests to analyze misconceptions in students and as an early stage of developing teaching materials. This study aims to provide an overview of student misconceptions that occur in the material of global warming and environmental pollution. This research uses a quantitative descriptive method with the data from multiple-choice answers using the three-tier diagnostic test misconception question and the results were grouped using a three-level misconception categorization. The sample in this study amounted to 96 students, with global warming and environmental pollution as the focused topics. The results showed that 57.9% of students' answers were misconceptions, 30.1% of students' answers were scientific knowledge, 2.7% of students' answers were lucky guesses, and 9.3% of students' answers were lack of knowledge. The larger number of misconception categories indicates that students still do not correctly understand the concepts of global warming and environmental pollution. Students who are included in the misconception category appear to have believed in the wrong knowledge about global warming and environmental pollution. This belief in erroneous knowledge is a challenge for educators to correct students' misconceptions. Thus, the results of this misconception analysis can be an important asset for the development of e-modules to reduce the level of students' global warming and environmental pollution misconceptions. <i>Abstrak. Miskonsepsi merupakan tantangan dalam pendidikan. Miskonsepsi dapat terjadi pada topik pembelajaran sains, salah satunya adalah topik pemanasan global dan pencemaran lingkungan. Analisis miskonsepsi dilakukan sebagai salah satu tes diagnostik untuk menganalisis miskonsepsi pada siswa dan sebagai tahapan awal pengembangan bahan ajar. Tujuan dari penelitian ini adalah untuk memberikan gambaran mengenai miskonsepsi siswa yang terjadi pada materi pemanasan global dan pencemaran lingkungan. Penelitian ini menggunakan metode deskriptif kuantitatif dengan data yang digunakan adalah hasil jawaban pilihan ganda menggunakan instrumen tes diagnostik tiga-tingkatan dan hasilnya dikelompokkan menggunakan kategorisasi tiga-tingkatan. Sampel pada penelitian ini berjumlah 96 siswa, dengan materi pemanasan global dan pencemaran lingkungan sebagai topik yang difokuskan. Hasil penelitian ini menunjukkan bahwa sebanyak 57,9% jawaban siswa mengalami miskonsepsi, 30,1% jawaban siswa merupakan scientific knowledge, 2,7% jawaban siswa merupakan lucky guess, dan 9,3% jawaban siswa merupakan lack of knowlegde. Jumlah kategori miskonsepsi yang lebih banyak menunjukkan bahwa siswa masih belum memahami dengan benar konsep-konsep pada materi pemanasan global dan pencemaran lingkungan. Siswa yang termasuk dalam kategori miskonsepsi rupanya telah meyakini pengetahuan yang salah terhadap pemanasan global dan pencemaran lingkungan. Keyakinan terhadap pengetahuan yang keliru ini merupakan tantangan bagi pendidik untuk meluruskan kesalahpahaman siswa. Dengan demikian, hasil dari analisis miskonsepsi ini dapat menjadi modal penting bagi pengembangan e-modul guna menurunkan tingkat miskonsepsi pemanasan global dan pencemaran lingkungan siswa.</i>

A. Introduction

The true knowledge of a concept material is important for students to achieve achievement in learning (Förtsch et al., 2020). The new knowledge gained by students will influence the knowledge they already have (Vosniadou et al., 2008). The good understanding of true concept knowledge can be a strong foundation for developing other skills that support learning. Some studies have shown that with correct conceptual, students can more easily develop critical thinking and problem-solving skills (Amanda et al., 2022). In addition, student with good conceptual knowledge will find it easier to think creatively (Liu, 2016).

Students' knowledge of biological material is often misunderstood, or misinterpreted. Misconceptions are understandings, beliefs, and ideas that are believed to be true but contradict the true understanding of generally accepted experts (Dellantonio & Pastore, 2021; Malaterre et al., 2023). Misconceptions can occur in any biological material (Fuchs et al., 2021), especially in materials related to the analysis of concepts in biology (Coley & Tanner, 2012). Misconceptions can occur due to the receipt of incorrect information and integration or perceptions that are not the same as the existing scientific principles (Duda et al., 2020; Kumandaş et al., 2019). The existence of misconceptions in students is an important problem if left unchecked because it can hinder learning (Kinchin, 2019) and lead to unwise judgment in students' lives (Asberger et al., 2021). Thus, misconceptions on biological concepts mean an understanding of a concept that is believed true, but contradicts existing principles or theories.

Biology is one of the subjects in which misconceptions often occur (Kadirhanogullari & Kose, 2024), including the concepts of global warming and environmental pollution. Global warming and environmental pollution were very close to human life. Misconceptions about the concept of global warming often occur, especially regarding the understanding, causes, and effects of global warming related to the greenhouse effect (Aksoy & Erten, 2022). Misunderstanding the causes and effects of global warming makes it a widely held belief that can undermine effective policies for tackling the problem of global warming (Fleming et al., 2021). This can also affect students' daily lives in their activities. The problems and impacts of misconceptions about global warming are similar to those of environmental pollution (Miller, 2020).

Misconceptions are challenges in education. Misconceptions are often unconsciously taught by teachers to students (Kinchin, 2019). Study has shown that teachers are the cause of misconceptions of biology concepts, one of which is evolution (Yates & Marek, 2014). Teacher training and personal experience are among the causes of teacher-caused misconceptions (Guerra-Reyes et al., 2024). The

emergence of student misconceptions about a particular concept can also be caused by previous learning experiences, information from books, and information from the Internet (Prayitno & Hidayati, 2022). In addition, students' personal thoughts contribute to the emergence of misconceptions about a particular material (Sari & Mufit, 2023). To overcome misconceptions that occur in students, teachers ideally, carry out diagnostic analysis activities to record students' misconceptions about the biological material to be taught (Ristanto et al., 2023). Therefore, in the next learning activity, the data that the teacher has held can be a reference to correct existing misconceptions.

Misconception analysis as a diagnostic activity of students' prior knowledge is often carried out in the early stages of developing teaching materials (Wicaksana et al., 2021). As part of the early stages of developing teaching materials, misconception analysis aims to confirm students' prior knowledge of concepts in pre-made propositional sentences (Wicaksana et al., 2021). A propositional sentence is a sentence consisting of a subject, predicate, object, attribute, and adverb that contains a certain thought (Bellin, 2009). These propositions later became the main foothold in the teaching materials provided to students. By analyzing misconceptions, teaching material developers will know which sub-concepts students have misconceptions.

One of the diagnostic tests used to analyze student misconceptions is the three-tier diagnostic test. The three-tier diagnostic test is a three-level diagnostic test (Arslan et al., 2012; Fikri et al., 2022; Kirbulut & Geban, 2014). The first level is a multiple-choice question that asks for concept knowledge, the second level is a question that asks students to answer why they chose the answer they did in the first level question, and the third level is a question that asks for confidence in the answer that has been chosen (Kirbulut & Geban, 2014; Suwono et al., 2021; Wahyono & Susetyorini, 2021). The three-tier diagnostic test has several advantages: it can be used on a wide sample, is easy to analyze, and allows for broad generalization of the findings obtained (Arslan et al., 2012).

Previous research on misconception analysis using three-tier diagnostic test has been conducted. Conducting diagnostic tests is an effective way to identify students' misunderstandings. Misconception analysis by Arslan et al. (2012) shown that a three-tier diagnostic test can be a capable tool for measured misunderstandings that occur in global warming. Research by Aksoy and Erten (2022) shows that diagnostic tests have concluded that misconceptions are common in the consequences of global warming. In addition, the results of other studies on misconceptions about global warming material show that many students still think that global warming is

caused by ozone depletion, reducing chemical waste discharged into rivers can reduce global warming, and global warming can be prevented by not building nuclear power plants (da Rosa, 2022).

Based on the background and previous research, analyzing students' prior knowledge is urgent as the initial stage of developing teaching materials. Analyzing prior knowledge will reveal students' misconceptions of a concept from a previously made proposition, which will be good input for the teaching materials produced. The novelty of this research is the use of test instruments developed based on local Cianjur issues related to global warming and environmental pollution. The purpose of this research is to get a picture of students' understanding of global warming and environmental pollution as preliminary analysis stage of e-module development.

B. Material and method

This research used the quantitative descriptive method. Quantitative descriptive research aims to interpret and describe an observed phenomenon presented in the form of percentages (Creswell & Guetterman, 2019). In this study, the phenomenon described and interpreted is high school students' misconceptions about the material of global warming and environmental pollution as the initial stage in the development of e-modules. This research was conducted on Friday, January 24, 2025, at a high school in Cianjur Regency. The sample selected was

10th grades students, as many as 96 students were selected. The sample selection was carried out using a purposive sampling technique, considering that the 10th grades students who became the sample had never received the global warming and environmental pollution material while studying biology in high school. Students' answers to global warming and environmental pollution were analyzed.

The instrument used to obtain this data was a three-level misconception test instrument. The misconception test comprised 16 multiple-choice questions. Each question consisted of three sub-questions: a) questions about the concept of proposition matter, b) questions about the reasons for choosing the answer in part a, and c) confidence in answering the question. The material in the questions covers the concepts of global warming and environmental pollution at the high school level following the Learning Outcomes of Phase E of the Merdeka Curriculum. The indicators of each question are presented in Table 1.

The questions were made and develop independently with concerning teaching materials in the form of student books published by the Ministry of Education and Culture and Campbell Biology book 12th edition. The results of this misconception analysis will be considered when listing the material propositions for the e-module to be developed. The questions had made were tested for validity and reliability. The results of the validity and reliability of the questions were presented in Table 2 dan Table 3.

Table 1 Indicator of each questions

No	Indicator	Question number
1	Understand the facts and phenomena of global warming	1, 2, 3, 4
2	Understand the activities that cause global warming	5, 6, 7, 8
3	Understand the phenomenon of ozone depletion and environmental pollution	9, 10, 11
4	Understand the impacts of global warming, ozone depletion, and environmental pollution	12, 13, 14
5	Understand efforts to stabilize global warming, ozone depletion, and environmental pollution	15, 16

Table 2 Validity of the questions

Question	R value	Category
1	0,380*	Valid
2	0,663**	Valid
3	0,627**	Valid
4	0,376*	Valid
5	0,747**	Valid
6	0,550**	Valid
7	0,590**	Valid
8	0,695**	Valid
9	0,494**	Valid
10	0,772**	Valid
11	0,384*	Valid
12	0,443*	Valid
13	0,371*	Valid
14	0,836**	Valid
15	0,656**	Valid
16	0,691**	Valid

Table 3 Reliability of the questions

Cronbach's alpha	N of item	Category
0,869	16	High reliable

Table 4 Three-tier possibilities knowledge categories

Level 1	Level 2	Level 3	Categories
Correct	Correct	Certain	Scientific knowledge
Correct	Incorrect	Certain	Misconception (false-positive)
Incorrect	Correct	Certain	Misconception (false-negative)
Incorrect	Incorrect	Certain	Misconception
Correct	Correct	Uncertain	Lucky guess, lack of confidence
Correct	Incorrect	Uncertain	Lack of knowledge
Incorrect	Correct	Uncertain	Lack of knowledge
Incorrect	Incorrect	Uncertain	Lack of knowledge

(Source: Arslan, 2012)

The misconception test was conducted over one day. The test was conducted during biology class time. Data collection was preceded by an explanation of the instructions for completing the test. Students used Google Form to take the test. Students were then given 60 minutes to complete the test. Supervision is conducted during the test to discourage students from cheating. Students were also prohibited from looking for answers on the Internet or other sources, aiming that the results were purely the students' initial understanding. The test results were then collected and analyzed to describe the students' initial abilities regarding these questions. The data were analyzed using a three-tier possibilities knowledge categories (Table 4). There are five categories of assessment decisions based on the results of students' answers: scientific conception, misconception, guessing, lucky guess, and lack of knowledge. The number of each category for each question was calculated and presented as a diagram. Furthermore, the interpretation is performed to explain the situation that appears in the decision category that appears in each question.

Scientific knowledge is knowledge that's believed to be true and is the result of scientific work accompanied by supporting evidence and reasons (de Ridder, 2019). In this context, scientific knowledge about global warming and environmental pollution is knowledge that's believed to be true and has been proven by expert research. Misconceptions in this study refer to students' knowledge about global warming and environmental pollution that's believed to be true, but different from the concepts agreed by experts. (Dellantonio & Pastore, 2021; Malaterre et al., 2023). If the student's belief turns out to be true in understanding the concept and wrong in understanding the reason, then the students is included in the false-positive misconception, while if the opposite is true, then the student is included in the false-negative misconception (Arslan et al., 2012).

Lucky guess is the probability of someone answering a question correctly even though they do

not actually master the material (de Chiusole et al., 2013). In this study, lucky guess refers to students who answered the concept and reasoning correctly, but were unsure of the answer chosen. Lack of knowledge or often describe Ignorance is commonly defined as the absence of knowledge understanding, or clarity about a topic (Carter, 2019). In this study, lack of knowledge refers to the student's ignorance and uncertainty in the answer he/she chooses.

Data were analyzed using descriptive statistics. The categorized data then calculated and presented in the form of a graph that contains a comparison of the categories obtained by students after complete the test. The presented data will provide an overview of the misconceptions of students' understanding of global warming and environmental pollution.

C. Results and discussion

The data processed came from the results of the recapitulation of students' answers to knowledge questions, which were then categorized according to the three-tier possibilities knowledge categories (Table 4). After all the results of student answers are categorized, grouping is carried out based on the number of aspects of the decision for each question. For each question, an analysis was conducted to explain the phenomenon that occurred which represented the proposition. Answers to questions that fall into the high misconception category or categories other than scientific knowledge indicate an urgency to include the proposition of the question in the teaching materials to be developed.

Analysis of three-tier knowledge category on each question

The 16 questions created and used in this test represented one or more propositions for each question. Thus, the decision analysis for each question will determine which propositions are selected to be included in the teaching materials for the course. Students' answers to the 16 questions reflected their prior knowledge of global warming and

environmental pollution. The propositions used as questions are presented in Table 5.

Based on the three-tier possibilities knowledge categories in Table 4, the results of student answers can be categorized into four decisions: scientific knowledge, misconception, lucky guess or lack of confidence, and lack of Knowledge. Scientific knowledge describes students' understanding and confidence in the correct answer to the concept asked of the three levels of questions (Potvin & Cyr, 2017). Misconceptions describe student understanding that

is less precise but believed to be true by students (Duda et al., 2020; Kumandaş et al., 2019). Lucky guess describes an understanding that is "coincidental" or, in other words, students answer correctly but are unsure what they answered (Natalia & Sudrajat, 2023). Simultaneously, a lack of knowledge describes the student's incorrect understanding, accompanied by uncertainty about the answer (Turmuzi et al., 2024). The percentages of knowledge categories of 96 student participants are shown in Table 6.

Table 5 Propositions for each question

Question	Proposition
1	• Earth changes cause environmental anomalies; • Rising average temperature in Cianjur Regency
2	• El-nino and la-nina affect seasonal changes up to the Cianjur Subdistrict
3	• Sea level rise caused by melting polar ice caps
4	• Global warming has caused directional climate change over the past three decades. • Increased CO2 causes the earth's average temperature to rise; • CO2, methane, and other greenhouse gases absorb infrared radiation and reflect it back to Earth, which is called the greenhouse effect.
5	• Global warming is caused by an increase in CO2 in the atmosphere as a result of human activities
6	• The use of fossil fuels for electricity, heat, and transportation is a human activity that causes CO2 and other greenhouse gases to be in the atmosphere
7	• Deforestation and marine debris affect atmospheric CO2 reduction
8	• The food industry and livestock are other activities that contribute to greenhouse gas emissions
9	• Just like global warming, ozone in the atmosphere also changes in concentration due to human activity; • Ozone destruction is caused by the accumulation of CFCs (Chlorofluorocarbons).
10	• Ozone depletion affects plants, animals, and microorganisms
11	• Environmental pollution is also caused by irresponsible human activities.
12	• The Earth's warming temperatures are causing the climate to change rapidly and affecting life; • Global warming affects all levels of living things • Global warming affects the ecosystem of a region
13	• Global warming and ozone depletion can exacerbate human-caused environmental pollution • Biological magnification occurs due to the accumulation of toxins from the environment in higher-trophic living things
14	• Global warming and environmental pollution affect human health and life
15	• Stabilizing CO2 requires international efforts and changes in personal lives and industrial processes
16	• Sustainable development is a human endeavor to improve human life while maintaining biodiversity. • Sustainable lifestyles are how we reduce global warming

Table 6 Percentage of student knowledge categories

Question	Scientific knowledge (%)	Misconception (%)	Lucky guess (%)	Lack of knowledge (%)
1	41,7	51	2,1	5,2
2	16,7	66,7	2,1	14,5
3	31,3	62,5	0	6,2
4	38,5	51	1,1	9,4
5	43,7	41,7	4,2	10,4
6	30,2	57,3	3,1	9,4
7	35,4	51,1	3,1	10,4
8	31,3	50	5,2	13,5
9	52,1	30,2	14,5	4,2
10	34,4	50	2,1	13,5
11	7,3	81,2	0	11,5
12	26	61,5	0	12,5
13	14,6	76	1,1	8,3
14	25	66,7	1,1	7,2
15	27,1	64,6	3,1	5,2
16	30,2	64,6	0	5,2
Average	30,1	57,9	2,7	9,3

The results of the percentage of student knowledge categories in Table 6 show that, students' initial knowledge of global warming and environmental pollution materials tested using the initial knowledge test shows that the average scientific knowledge of students is only 30.1%. In other words, only 1/3 of the students had the correct initial knowledge of the concepts of global warming and environmental pollution in question. In addition, the percentage results were dominated by misconceptions, with an average of 57.9%, and the remaining 12% fell into the lucky guess (2.7%) and lack of knowledge (9.3%) categories.

The number of students who reached the scientific knowledge category was relatively small, considering that the material on global warming and environmental pollution is not new because students have learned the material before. Global warming and environmental pollution are discussed in the context of climate change. The students' Learning Outcomes document states that climate change material has been taught in science subjects from Phase D to Phase E. Phase D is the phase for junior high school student groups, while Phase E is the phase for high school students in 10th grade.

The material taught at the previous level should show better results for students learning at a higher level. Global warming and environmental pollution are related to everyday life because they are related to human health (Ahima, 2020; Kim & Kim, 2018). This should make it easier for student understand the correct concept of the material. However, the reality in the field shows that students do not understand the concepts of global warming and environmental pollution properly.

The analysis also clearly shows that more students do not have a correct understanding of the concept than those who. Table 6 shows that misconceptions still dominate students' understanding of global warming and environmental pollution. As many as 57.9% of students had misconceptions about the material. Misconceptions among students can arise due to the lack of effective learning methods and the use of tools that support learning activities (Hamzah et al., 2019; Hayati & Mufit, 2023). Then, the misinformation students receive when learning can create a misunderstanding of students' concepts (Fajarini et al., 2018). In addition, as in research, Prayitno and Hidayati (2022) explained that learning experiences and teaching materials during previous learning experiences (junior high school) are another cause of misconceptions.

Finally, based on Table 6, the number of students who fall into the lucky guess and lack of knowledge categories is very small, with a total average of only 12%. This result shows that the students were unfamiliar with global warming and environmental pollution. This figure of 12%, (or as

many as 11 students) can appear because students choose the answer "not sure" in level 3 questions.

Figure 1 shows that the average number of students answering "not sure" for each question was 12%. This can occur because these students are not confident in their answers. Therefore, there is a problem with students' confidence in answering questions. Self-confidence influences student understanding because, with confidence, students are more willing to take risks or learn from mistakes (Gita Andriani, 2023). In addition, lack of motivation can also cause students to answer question on Level 3. Many studies have explained that motivation is crucial for students' understanding (Howard et al., 2021; Nauzeer & Jaunky, 2021).

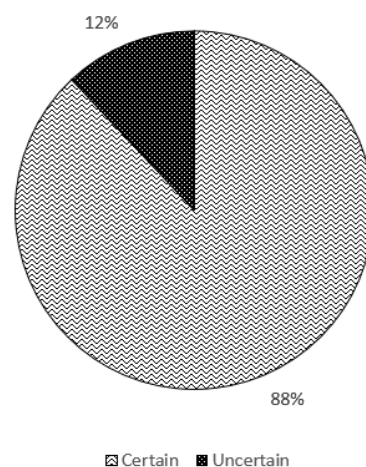


Figure 1 Comparison diagram of tier 3 responses

Based on the percentage of student knowledge categories (Table 6), the description of the condition of students' understanding of global warming and environmental pollution is dominated by misconceptions. Misconceptions that occur in students can be seen in their answers to the questions asked. Almost all the answers to the questions had more than 50% misconceptions. The results show that most students have a wrong understanding of almost all the propositions that have been made. This misunderstanding is also influenced by students' worldview and reflection cognitive skills (da Rosa, 2022). A worldview is the first way to understand the impacts of global climate change. In addition, cognitive reflection helps students understand new knowledge with their prior knowledge.

Only in questions 5 and 9 were students' answers dominated by scientific knowledge or a proper understanding of propositions. Question 5 represents the proposition regarding the cause of the increase in CO₂ due to human activity. Students are better at understanding the causes of CO₂ increase due to human activity because students have already gotten that understanding in previous learning. In

research Zangori et al. (2017) mentioned that the carbon cycle material had explained a little about where CO₂ comes from and contributes to climate change. Question 9 represents the proposition about the cause of the ozone layer depletion due to CFCs. The cause of ozone depletion is also related to human activities, so students indirectly gain knowledge from their daily lives. Thus, students mostly understand the two proposition concepts better.

The other 14 questions that showed student misconceptions above 50% showed a clear urgency regarding learning experiences, teaching materials, and information sources that must be improved in future learning. Through the misconceptions in these 14 questions, most students showed a wrong understanding of the propositional concepts of, both global warming and environmental pollution. Knowing the causes of misconceptions can be the first step in considering the right steps in developing the right learning process and teaching materials (Guerra-Reyes et al., 2024).

Analysis of student misconceptions on each question

The dominance of the category of students who experience misconceptions about a material shows the importance of overcoming the problem. Misconceptions can cause future problems if left unchecked. Prolonged misconceptions will affect students' understanding of phenomena in their lives (Kinchin, 2019). Student understanding based on misconceptions tends to create obstacles in learning

and results in the formation of incorrect concepts (Suprpto, 2020). Errors in understanding a concept will gradually spread to other understandings, resulting in a domino effect that results in thinking defects in all conclusions.

Based on the results of student knowledge categories in Table 6, misconceptions were the dominant category for students on the material of global warming and environmental pollution. Misconceptions experienced by students are specifically divided into three groups: false-positive misconceptions, false-negative misconceptions, and true misconceptions (Arslan et al., 2012). All three fall into the same category, namely misconceptions, but what distinguishes them is the correct answer choices for Level 1 and 2 questions (see Table 4).

The results of student answers in Figure 2 below show that student misconceptions that occur in the material of global warming and environmental pollution are dominated by true misconceptions. In the true misconception category, students choose the wrong answer on Level 1 and Level 2 questions but feel confident in their answers (Arslan et al., 2012). Students believe in inappropriate concepts and reasons for a concepts. The last misconception category in the results of student answers in Figure 2 is the false negative misconception category, namely when students answer correctly on Level 2 questions but are wrong in answering Level 1 questions (Arslan et al., 2012). So, students only understand and believe the reason for the answer to the concept but are incorrect in their understanding of the concept.

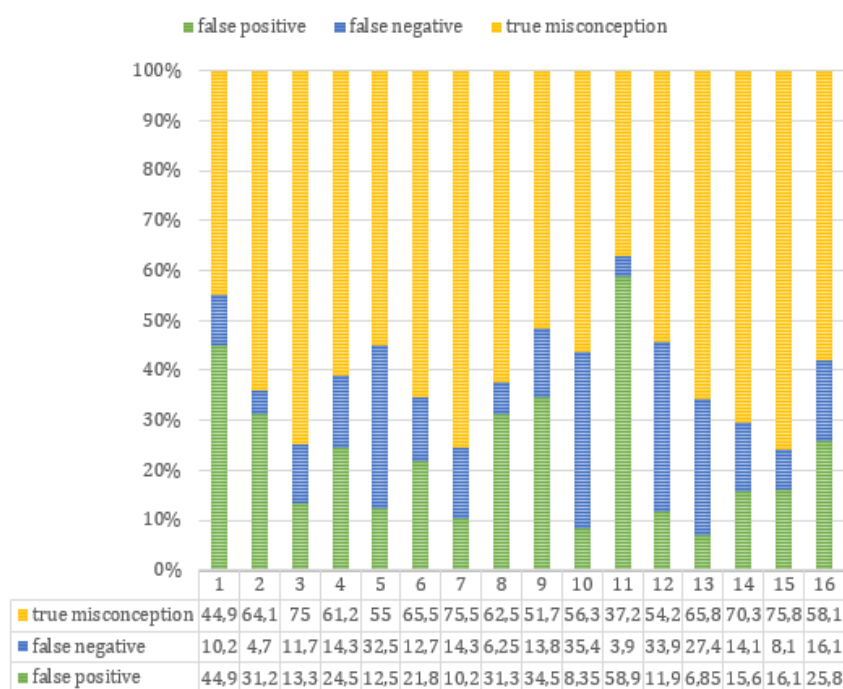


Figure 2 Distribution graph of the number of misconceptions

The number of students who experienced true misconceptions in the test results indicated incorrect information or information received by students. Figure 2 shows that almost all misconceptions in each question have several true misconceptions above 50%, except for questions 1 and 11. True misconceptions can occur because students do not have accurate and complete prior knowledge (Qian & Lehman, 2018; Suprpto, 2020). Students only understand part of the material learned from their previous learning experiences (Chi, 2008). This aligns with other causes of misconceptions originating from teachers, teaching materials, and learning methods. Previous research has shown that teachers who experience misconceptions and unclear teaching materials play a role in the emergence of misconceptions in students (Kinchin, 2019; Kristianti et al., 2022). Other parallel studies have shown that ineffective learning methods, such as lectures without interaction, can reinforce misconceptions (Ningrum et al., 2022; Suprpto, 2020).

The false-positive misconceptions are the second most common misconceptions category after the true misconception. From Figure 2, we can see that 11 out of 16 answers to the misconception questions had a greater number of false-positive misconceptions than false-negative misconceptions. False-positive misconceptions occur when students correctly answer Level 1 questions but incorrectly answer Level 2 questions with confidence in answering Level 3 questions. Finally, the false-negative misconceptions category was the least recognized misconception category by students. In this category, only questions 5, 7, 10, 12, and 13 had more false-negative misconception answers than false-positive misconceptions.

Similar to true misconceptions, the causes of false-positive and false-negative misconceptions can be influenced by an incomplete understanding of the material being studied (Qian & Lehman, 2018; Suprpto, 2020). An incomplete initial understanding of a concept causes students to have only partially correct information about the concept in question. This can be caused by other factors, such as the learning environment and students' daily experiences (Guerra-Reyes et al., 2024).

Misconceptions will be related to students' prior knowledge. Students' prior knowledge might be lost or incomplete. Thus, students' beliefs about their previous understanding may conflict with the actual information, which we refer to as "false beliefs" (Chi, 2008). These misconceptions, which are believed by students, can be changed through conflict with new information. This conflict leads to a change in concept, using e-modules as the medium. The e-modules or teaching materials will serve as "belief revision", capable of improving students' understanding and beliefs about a concept.

Based on the results of the misconception analysis above, incomplete prior knowledge, learning experiences, and misinformation are the main causes of misconceptions among students. One factor that triggers this is the use of unclear teaching materials (Kristianti et al., 2022). To overcome this, ensuring good teaching materials or teaching materials is an urgent need. Previous research has shown that well-designed teaching materials or science textbooks can improve student understanding (Chambliss & Calfee, 1989; Susilaningsih et al., 2019). Using the results of the analysis of student misconceptions, teaching materials such as textbooks can be improved. Concepts that become misconceptions among students can be justified through a deeper emphasis on the teaching materials.

D. Conclusion

Misconceptions about global warming and environmental pollution remain prevalent among high school students. The percentage of misconceptions was quite high, exceeding half of the respondents for almost all question answers, indicating that there are still many students' initial understanding of the concepts in the material. In addition, the misconception most experienced by students is a true misconception that shows students are convinced of the concept that has been considered correct, even though it is completely wrong from the view and reason that is believed. The results of this study are an important asset in the development of e-modules on global warming and environmental pollution that will be carried out. Because of the urgency in the field, confidence in determining the propositions that will be displayed in the e-module, which shows that students still experience many misconceptions. In the future, research on misconception analysis for e-module development can be expanded by using other misconception analysis methods or combined with other initial diagnostic tests besides concept knowledge.

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