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Identification of Students' Misconceptions to the Kinetic Gas Theory in Physics

Nurulwati[1], A Halim[2], Mailizar[3], Muhammad Syukri[2], Mawarni Saputri[2*]

[1] Doctoral Students of Educational Sciences, Syiah Kuala University, Aceh, Indonesia.
[2] Department of Physics Education, Syiah Kuala University, Aceh, Indonesia.
[3] Department of Mathematics Education, Syiah Kuala University, Aceh, Indonesia.

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Corresponding Author:
Mawarni Saputri
mawarni_saputri@usk.ac.id

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Abstract: This study aims to identify students' misconceptions on the material of Kinetic Gas Theory in physics learning. This study uses a qualitative approach and the type of research used is descriptive research. The subjects of this research were 20 students of class XI. The data was collected by means of a diagnostic test technique equipped with CRI (Certainty of Response Index) and free-guided interviews. The results of data analysis show that the average Lucky Guess level is 13%, concept understanding is 39%, not understanding concept is 20%, and average percentage of misconceptions are 28%. Based on the identification results, the highest misconceptions in students appear in the indicator of the question of calculating the ideal gas equation by 55%. The results of the analysis and interviews that have been carried out, misconceptions occur due to the students themselves because they do not understand the concept as a whole and the lack of interest of students to repeat the lesson.

Keywords: Certainty of response index (CRI); Kinetic gas theory; Misconceptions

Introduction

In physics, there are formulas, concepts, laws, principles and events of everyday life where students are required to understand concepts, not just knowing formulas (Halliday et al., 2023; Kim et al., 2018; Syuhendri et al., 2019). According to Anggraeni (2018) states that a concept is an abstract idea where the explanation is in the form of a term or a series of words. Misconception frequently referred to as 'misunderstanding' have been a central focus of scientific education research over the last thirty years (Kumandaş et al., 2019; Prinz et al., 2018; Theobald et al., 2021). This alternative framework is commonly characterized as a 'theory-like' approach to understanding the world or an alternative mode of cognitive thinking (Bahtaji, 2023; Castro et al., 2020; Mirski et al., 2020). Understanding concepts is very important in the early stages of thinking, especially in the field of physics, which is one of the fields of science that focuses on understanding concepts rather than memory (Ates et al., 2020; Bigozzi et al., 2018; Mason et al., 2021).

Physics learning so far in schools tends to be directed at the ability to memorize concepts consisting of understanding, memorizing the sounds of the law and remembering formulas only (Arokoyu et al., 2018). While the learning process through direct experience and discovery is often ignored, so that students do not understand the concepts of physics and are unable to apply them in real life (Etwiory et al., 2022). Physics trains people to be able to find scientific principles through correlations between physical natural phenomena so that to understand them it is not enough just to read, but must be understood, memorized and

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practiced in everyday life (Anjani et al., 2020; Barra, 2018; Hartini et al., 2018; Sulistiyono, 2022).

Most students said that what made physics difficult to understand was because the concepts were abstract, giving rise to misconceptions. One of the abstract physics material is the kinetic theory of gases. As research conducted by Barra (2018) was obtained that it was difficult for them to master the concept of Kinetic Gas Theory because gas is abstract so it becomes a barrier for students to deepen other physical concepts. Another cause is the preconceptions of students who are not intact and the many uses of mathematical equations.

The results showed that the most misconceptions experienced by 28.57% of students with a form of misconception, namely ideal gas particles always move regularly at a constant speed at all times. Then followed by misconceptions such as the pressure of gas particles only depends on gas temperature (14.29%), the characteristics of non-ideal gas particles are difficult to move freely (14.29%). Based on the results of the study, it can be concluded that there is a misconception in the material of the kinetic theory of gases. In addition, previous research that has been conducted by Harizah (2016) obtained the percentage of misconceptions category dominates in each item given. The largest percentage of misconceptions is found in the items that contain sub-materials of ideal gas laws. From a total of 34 students, 62.5% of students experienced misconceptions on the question.

Furthermore the other research conducted by Yudhittiara et al. (2017) showed that the highest level of concept knowledge was in the concept of fluid and static fluid by 40.2%, the level of concept knowledge but lacked confidence in the concepts of adhesion and cohesion was 11.8%, the highest level of misconception was in the concept of Archimedes' law of 54.5%, and the highest level of not knowing the concept of the concept of viscosity and its units is 72.5%. Research that has been done by Nurulwati et al. (2020) obtained that four-tier diagnostic test and three-tier diagnostic test is one of the tests that can be used to detect misconceptions. The results showed that the percentage of the three-tier diagnostic test instrument was 45% and the four-tier diagnostic test instrument was 31%, the three-tier diagnostic test was more diagnostic of misconceptions than the four-tier diagnostic test.

So in this study, researchers identified misconceptions by using a three-tier diagnostic test instrument. Based on the background of the problems described above, the misconceptions that occur in students should be identified as early as possible so that they can be corrected. Misconceptions can be detected through concept maps, multiple choice tests with open reasoning, written essay tests, diagnostic interviews, class discussions, and practical questions with questions and answers. Therefore, further identification is needed to find out the facts that actually happened.

Method

The approach used in this study is a qualitative approach. The qualitative approach in this study is to understand the condition of a learning process by directing it to a systematic description of the misconceptions that occur in schools. The type of research used is descriptive research, because this study aims to describe (explain) the misconceptions that occur in students at SMAN 3 Sinabang class XI IPA 1.

The first data analysis technique was validity test. This validity is done by using a validation sheet marked with a check list by the experts. Question validators are carried out by experts by providing an assessment of the items on the validation sheet. Then, Identifying Misconceptions. Based on the data acquisition of each student, then the data is analyzed by referring to the combination of answers given (true or false) with CRI scores (low or high). So that it can be seen the percentage of students who understand the concept, misconception, and do not understand the concept.

Table 1. CRI Provisions for Distinguishing Know the Concept, Misconceptions, and Don't Understand the Concept

Criteria Answer	Low CRI (<2.5)	High CRI (>2.5)
Correct answer	Correct answer but CRI low means don't understand concept (lucky guess) (LG).	Correct answer and CRI high means master concept well (PK).
Incorrect Answer	Incorrect answer (wrong) and CRI low means not understanding the concept (TPK).	Wrong answer but high CRI means a misconception (M).

The equation to find the percentage of students in answering questions and their level of confidence into groups in the category of understanding, misconception, not understanding the concept, and Lucky Guess in determining questions that are categorized as misconceptions and not understanding the concept, are as follows:

$$P = \frac{f}{N} \times 100\% \quad (1)$$

Description:

f = the frequency you are looking for is the percentage

N = number of case (number of frequencies/number of individuals)

P = percentage number

Result and Discussion

Data collection is obtained from research that has been carried out on students of SMAN 3 Sinabang class XI IPA 1 by using a diagnostic test equipped with a reason column and CRI index on the material of Gas Kinetic Theory. The following is a tabulation of student data based on the Lucky Guess (LG) criteria, do not understand the concept (TPK), understand the concept (PK) and have misconceptions (M) can be seen in table 2.

Table 2. Percentage of Misconception Identification

No Question	LG (%)	PK (%)	TPK (%)	M (%)	Quantity (%)
1	15	25	20	40	100
2	20	5	40	35	100
3	15	55	0	30	100
4	20	45	15	20	100
5	5	80	10	5	100
6	25	50	10	15	100
7	20	20	35	25	100
8	15	70	0	15	100
9	10	30	30	30	100
10	5	50	0	45	100
11	5	30	35	30	100
12	10	45	35	10	100
13	25	35	15	25	100
14	5	35	25	35	100
15	5	10	30	55	100
$\bar{x}$	13	39	20	28	100

From the table above, it is found that there are three questions with the highest percentage of misconceptions, namely Problem No. 1 with the sub-concept of understanding the kinetic theory of gases, the percentage of misconceptions is 40%. Question No. 10 with Boyle-Gay Lussac's sub-concept, the percentage of misconceptions is 45%, and question No. 15 with the sub-concept of the ideal gas equation, the percentage of misconceptions is 55%.

The highest misconception was ideal gas equation because complexity of the concepts and mathematics involved in the equation. Some students may have difficulty understanding the concept of an ideal gas and how variables such as pressure, volume, and temperature interact in equations. In addition, misconceptions can also arise due to a lack of adequate visual representation or lack of student involvement in direct exploration of the concept (Anderson et al., 2018; Gusukuma et al., 2018; Halim et al., 2018; Ilhan et al., 2022; Jauhariyah et al., 2018; Richey et al., 2019).

Based on the results of the research that has been done, the researchers analyzed the test results of students on the material for the Kinetic Theory of Gas. From the results of the data analysis, it was found that the average percentage of misconceptions (M) of students was 28%, the average Lucky Guess (LG) was 13%, did not understand the concept (TPK) was 20%, and understood the concept (PK) by 39%. It can be seen in figure 1.

The concepts tested in this study include the understanding of the kinetic theory of gases, the properties of ideal gases, general equations of ideal gases and solving problems of ideal gases. Each concept is represented from each question with the distribution of questions as in the research instrument.

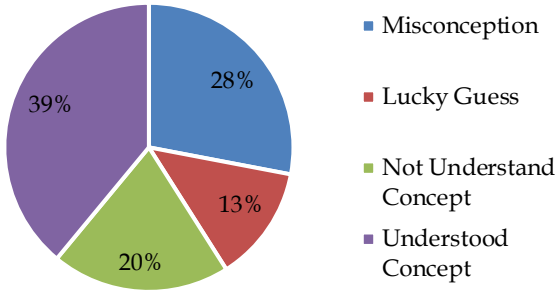

Figure 1. Average percentage of misconception identification

The discussion of each item follows the provisions of the CRI answers in table 2 and the processing of the results of the analysis of student answers is grouped based on the criteria in table 1, namely Lucky Guess (LG) if students answer correctly and the CRI score is low (<2.5) , understand the concept (PK) if students answer correctly and CRI scores are high (> 2.5), do not understand the concept (TPK) if students answer incorrectly and CRI scores are low (< 2.5), and misconceptions (M) if students answered incorrectly and the CRI was high (> 2.5).

Based on the results of research that has been carried out using the CRI method, the researchers found several important notes regarding the advantages and disadvantages of the CRI method in detecting misconceptions experienced by students. The advantages of the CRI method is that this method is able to detect misconceptions experienced by students. Another advantage is that we can know the ability of students, because in this modified CRI method there is a reason column so that we can find out whether students' answers are based on knowledge, or just guesses.

While the shortcomings of CRI include determining misconceptions, not understanding concepts, understanding concepts, and Lucky Guess is only based on CRI scores and student answers. So that the determination of misconceptions, understanding the concept, and not understanding the real concept is largely determined by the honesty of the respondents in filling out the CRI scores (E. Aini et al., 2023; R. Q. Aini et al., 2020). In addition, the number of respondents who

did not give reasons when answering the questions also added to the level of difficulty in categorizing students into misconceptions, not understanding concepts, understanding concepts, and Lucky Guess.

Conclusion

Based on the analysis of research data, it can be concluded that students experience misconceptions in the material of the Kinetic Gas Theory was 28%. The sub-topics that experienced the highest misconceptions were the sub-topics of the ideal gas equation with a percentage of 55%.

Author Contributions

Nurulwati conceptualized the research idea, designed of methodology, management and coordination responsibility; A. Halim and Mailizar are conducted a research and investigation process; Mawarni Saputri conducted literature review and provided critical feedback on the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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