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ANALYSIS OF HIGH SCHOOL STUDENTS' MISCONCEPTIONS ON STATIC ELECTRICITY AT SMA NEGERI 2 MEDAN USING A THREE-TIER MULTIPLE CHOICE DIAGNOSTIC TEST

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Abstrak

Miskonsepsi dalam fisika, terutama dalam listrik statis, dapat menghambat proses belajar siswa. Studi ini bertujuan untuk mengembangkan tes diagnostik pilihan ganda tiga tingkat untuk mengidentifikasi dan mengukur miskonsepsi secara akurat di kalangan siswa kelas XII. Penelitian ini mengikuti model 4D (Define, Design, Develop, Disseminate) dan melibatkan validasi ahli serta uji coba di SMA Negeri 2 Medan. Hasil penelitian menunjukkan bahwa instrumen tes yang dikembangkan valid dan reliabel dalam mendiagnosis miskonsepsi siswa. Temuan ini menunjukkan bahwa banyak siswa memiliki kesalahpahaman yang kuat tentang konsep dasar listrik statis, termasuk distribusi muatan, hukum Coulomb, dan medan listrik. Alat diagnostik ini menyediakan metode penilaian yang efektif bagi pendidik untuk mengatasi dan mengoreksi miskonsepsi ini.

Kata Kunci: Miskonsepsi, Pendidikan Fisika, Listrik Statis, *Three-Tier Diagnostic Test*

Abstract

Misconceptions in physics, especially in static electricity, can hinder students' learning processes. This study aims to develop a three-tier multiple-choice diagnostic test to accurately identify and measure misconceptions among XII-grade students. The research follows the 4D (Define, Design, Develop, Disseminate) model and involves expert validation and trials in SMA Negeri 2 Medan. The results show that the developed test instrument is valid and reliable in diagnosing students' misconceptions. The findings indicate that many students hold strong misconceptions about fundamental concepts of static electricity, including charge distribution, Coulomb's law, and electric fields. This diagnostic tool provides educators with an effective assessment method to address and correct these misconceptions.

Keywords: *Misconceptions, Physics Education, Static Electricity, Three-Tier Diagnostic Test*

1. Introduction

Misconceptions in physics education, particularly in static electricity, pose a significant challenge in learning. These misconceptions arise due to prior prejudices, misunderstandings of concepts, and ineffective teaching approaches (Resbiantoro et al., 2022). Assessing students' conceptual understanding is essential to determine the effectiveness of the learning process. One way to measure students' comprehension of concepts is through assessment.

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According to a study conducted by Hani et al. (2023), teachers commonly assess students based on study results. Interviews from the study revealed that 40% of teachers assess students during the learning process through assignments or quizzes, while 20% provide feedback to students. This type of assessment is commonly referred to as summative assessment (Resbiantoro et al., 2022). However, summative assessment cannot identify students' misconceptions. Misconceptions can manifest as errors in linking concepts, misunderstandings, or intuitive yet incorrect ideas (Saputri et al., 2021; Wells et al., 2020). Therefore, diagnostic assessment can be used to identify students' misconceptions.

Research on diagnostic assessment has been widely conducted in the design and development of test instruments that accurately and efficiently diagnose misconceptions. Among these are the two-tier multiple-choice test (Syaifuddin et al., 2022) and the three-tier multiple-choice test (Putri et al., 2023). The two-tier test offers advantages over conventional multiple-choice tests; however, it has certain limitations in distinguishing between a lack of knowledge, misconceptions, and scientific understanding. To overcome these limitations, the three-tier multiple-choice test was developed.

The three-tier multiple-choice test includes a confidence level assessment, requiring students to indicate their certainty in their selected answers and reasoning. A response is considered correct if both the answer and reasoning are accurate, with a high confidence level. Conversely, a misconception is identified when a student selects an incorrect answer and reasoning but expresses high confidence in their choice. This test format provides a more precise measure of whether errors stem from misconceptions or a lack of knowledge (Fauzi, 2022). The three-tier multiple-choice test can serve as a formative diagnostic tool to identify students' misconception levels in physics, particularly in static electricity (Wahyuni et al., 2021).

Misconception rate in heat and temperature concepts was 60%. Similarly (Wijaya et al., 2016), reported a 64% misconception rate in the same topic using a two-tier diagnostic test. These findings were further supported by observations conducted at SMAN 2 Medan. On October 14, 2024, the researcher observed that the misconception level on the topic of heat and temperature was significantly high. Interviews with two physics teachers at SMAN 2 Medan revealed that the implementation of the three-tier multiple-choice diagnostic test had not been effective, and misconceptions were still prevalent among students. Furthermore, physics instruction for 12th-grade students at SMAN 2 Medan continues to follow the 2013 curriculum, with assessments

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primarily based on traditional physics textbooks that use one-tier multiple-choice test, essays, and open-ended tests (Ni'mah et al., 2019).

2. Method

This study employs the Research and Development (R&D) method using the 4D model, which consists of four stages: Define, Design, Develop, and Disseminate. The 4D model is well-suited for research aimed at identifying misconceptions, as its stages are not overly complex and do not require an extended period of time to implement.

The data collected in this study consists of students' responses to a three-tier multiple-choice test on static electricity. The formula used to determine the percentage of students' responses, along with their confidence levels, categorizes them into three groups: understanding the concept, having misconceptions, or lacking conceptual understanding. Additionally, the formula is used to identify test items that fall into the misconception and lack of understanding categories (Maydiantoro, 2021).

$$\boldsymbol{P = \frac{f}{N} x 100\%}$$

Informations :

P : Percentage Number (% Group)

f : Number of students in each group

N : Number of individuals (total number of students who are the subjects of the research)

This research was conducted at SMAN 2 Medan School. The subjects of the research were students of SMAN 2 Medan class XII MIA-4 with a research sample of 30 students. The research was conducted from January 2025 to February 2025.

3. Result and Discussion

3.1 Result

The results of the study on reliable test instruments can measure the level of student misconceptions that occur in temperature and heat materials. The results have been analyzed and interpreted into categories of mastering concepts, misconceptions, not knowing the concept and guessing. The results of the analysis can be seen in appendix 17. Miranda & Waindriyani

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(2023) categorizes the level of misconceptions into three categories, including those in (Table 1).

Table 1. Misconception Category Levels

Percentage of Misconceptions	Categories
0%<x<30%	Low
30%<x<60%	Moderate
60%<x<100%	High

Based on the analysis data, there was a low level of misconception in question 2. Students had a moderate level of misconception in questions 1, 3, 6, 7, 8, and 13. Students found a high level of misconception in questions 4, 5, 9, 10, 11, 12, 14 and 15. These results were obtained based on students' answers and the reasons chosen by students. The following graph of the percentage of students' misconception levels in each question item is presented in (Figure 1).

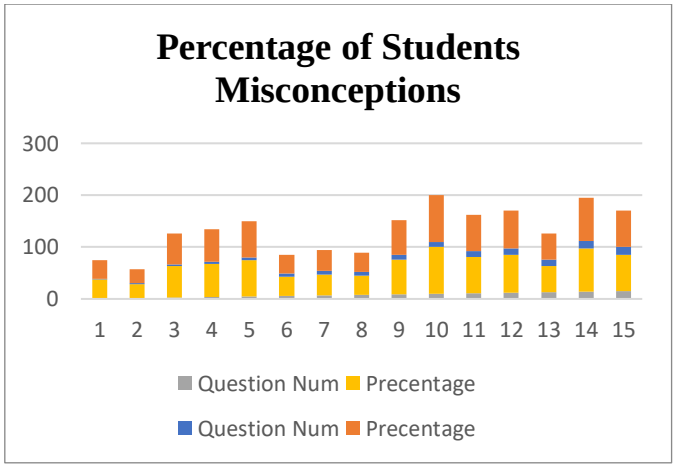

Figure 1 Percentage of Student Misconceptions on Each Question Item

For he 15 questions, students mastered low-level concepts in questions 4, 9, 10, 11, 12, 14 and 15. Students mastered medium-level concepts in questions 3, 6, 7 and 13. Meanwhile, students mastered high-level concepts in questions 1, 2, and 8. The percentage graph of students' mastery of concepts in each question is presented in (Figure 2).

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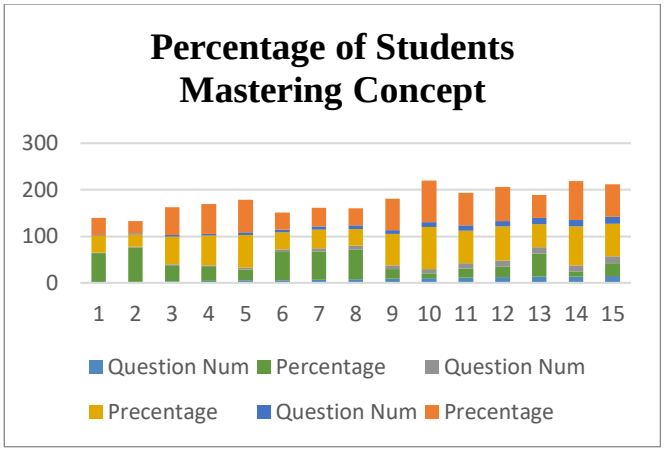

Figure 2 Percentage of Students Mastering the Concept of Each Question Item

Table 2. Student Misconception Profile

Question Indicator	Question items	Number of Students					
		MS	MS (%)	MK	MK (%)	TT	TT (%)
Charge interaction	1	11	36,6%	19	63,4%	0	0%
Colomb's Law	2	8	26,6%	20	73,4%	0	0%
Load Sharing	3	18	60%	10	33,4%	2	6,7%
Charge Interaction	4	19	63,4%	9	30%	2	6,7%
EP Energy	6	11	36,6%	18	60%	1	3,4%
Charge Interaction	7	12	40%	18	60%	0	0%
Charges transfer	9	20	66,7%	6	20%	4	13,4%
Colomb's Law	11	21	70%	6	20%	3	10%
Conductor & Isolator	12	22	73,4%	7	23,4%	1	3,4%
Charge interaction	13	15	50%	15	50%	0	0%
Charge induction	15	21	70%	8	26,6%	1	3,3%

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Informations :

MS : Misconception

MK : Mastering Concepts

TT : Lack of Concepts

The results show that students at SMA Negeri 2 Medan often experience misconceptions in understanding static electricity material.

3.2 Discussion

After conducting a large-group trial, the students' misconceptions were analyzed based on data from the three-tier multiple-choice diagnostic test instrument. For question item 1 on the subtopic of interactions between charged objects, 11 students (36.6%) exhibited misconceptions. They believed that electrons in a glass rod move toward a negatively charged object. However, the correct concept is that electrons in the glass rod move away from the negatively charged object, causing the closest part of the rod to become positively charged. For question item 2 on charge distribution, 8 students (26.6%) had misconceptions. Some students assumed that protons within an object could move. In reality, only electrons can move, while protons remain in the nucleus of the atom.

For question item 3 on the interaction between a charged object and a neutral object, 18 students (60%) exhibited misconceptions, believing that a neutral object cannot interact with a charged object. The correct concept is that neutral objects can interact with charged objects through electrostatic induction.

For question item 4 on Coulomb's law, 19 students (63.4%) demonstrated misconceptions. Many students believed that the attractive or repulsive force decreases as the charge increases. However, Coulomb’s law states that the electrostatic force is directly proportional to the magnitude of the charges and inversely proportional to the square of the distance between them. For question item 6 on electric field lines, 11 students (36.6%) exhibited misconceptions, thinking that electric field lines can intersect. In reality, electric field lines never intersect because each point in an electric field has a unique field direction.

For question item 7 on the working principle of an electroscope, 12 students (40%) demonstrated misconceptions. They believed that the leaves of an electroscope always close

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when approached by a charged object. The correct concept is that the leaves can either spread further apart or close depending on the type of charge introduced. For question item 9 on capacitor capacitance, 20 students (66.7%) exhibited misconceptions, assuming that a capacitor retains charge even without a potential difference. The correct concept is that a capacitor can only store charge when there is a potential difference between its plates.

For question item 11 on Gauss's law, 21 students (70%) showed misconceptions, believing that the electric field inside a closed space is always zero. In reality, the electric field inside a closed surface depends on the amount of charge enclosed, as stated by Gauss's law. For question item 12 on work and energy in an electric field, 22 students (73.4%) demonstrated misconceptions, assuming that electric potential energy depends only on charge. The correct concept is that electric potential energy also depends on the position of the charge within the electric field.

For question item 13 on the application of static electricity in everyday life, 15 students (50%) exhibited misconceptions, believing that static electricity only occurs in artificial conditions, such as in a laboratory. However, static electricity naturally occurs in various phenomena, such as lightning and friction between objects. For question item 15 on the industrial applications of static electricity, 21 students (70%) demonstrated misconceptions, thinking that static electricity has no significant role in daily life. The correct concept is that static electricity is widely used in various industries, including electrostatic painting and dust separation in chimneys. These findings indicate that a significant number of students still experience misconceptions in various aspects of static electricity. Therefore, a more effective teaching approach is needed to correct these misunderstandings.

4. Conclusion

The study was conducted at SMA Negeri 2 Medan to determine the level of student misconceptions regarding static electricity using a three-tier multiple-choice diagnostic test instrument in the 12th-grade MIA class. The three-tier multiple-choice diagnostic test instrument was developed with a total of 15 reliable test items. In class XII MIA-4, 33 students participated, with 53.94% exhibiting misconceptions on question item 10. The average percentage of student misconceptions was 58.2%. Based on these findings, the developed three-tier multiple-choice diagnostic test instrument proved to be effective in identifying students' misconceptions about static electricity, making it suitable for wider implementation.

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Furthermore, the three-tier multiple-choice diagnostic test instrument can serve as a practice test or an assessment tool in schools, particularly for topics such as heat and temperature, to evaluate students' conceptual understanding. This instrument effectively identifies whether students understand the concept, hold misconceptions, or lack conceptual knowledge entirely.

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