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PORTRAIT OF STUDENTS' MISCONCEPTIONS USING FOUR-TIER MULTIPLE CHOICE DIAGNOSTIC TEST ON ROTATIONAL DYNAMICS MATERIAL IN CLASS XI SENIOR HIGH SCHOOL

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ABSTRACT

Misconception is a mismatch between the understanding of the concept known by students and the actual concept. Physics is a science that has several concepts. The profile of misconceptions on physics concepts must be identified so that students have an appropriate understanding of the concepts. The purpose of this research is to analyze students' concept understanding and misconceptions of Rotational Dynamics material using a four-tier multiple choice diagnostic test. The type of research used is descriptive with qualitative and quantitative approaches. This research was conducted in one of the high schools in Medan in Grade XI IPA. The population in this research was grade XI students majoring in IPA. The research sample was obtained by using purposive sampling technique as many as 64 students of grade XI IPA 2 and XI IPA 3. Sampling based on certain criteria from population participants. The criteria are classes whose students have finished learning Rotational Dynamics material and have not been tested on Rotational Dynamics material. Data collection techniques in the form of diagnostic tests response questionnaires and interviews. The test used is a four-tier multiple choice diagnostic test that has been validated by experts. The diagnostic test consists of 18 valid items with a reliability of 0.912 including a very high category, good differentiating power, and moderate difficulty level. The results showed that students' concept understanding of Rotational Dynamics material was categorized as moderate with 44.88% of students understood the concept, 50.17% of students had misconceptions, and 4.95% of students did not understand the concept, and students' responses to the use of four-tier multiple choice diagnostic tests obtained 80% with good criteria.

Keywords: *Misconception, Understanding of Concepts, Four-Tier Diagnostic Test*

INTRODUCTION

Physics is a science based on natural phenomena that occur in everyday life, so there are many principles, theories, and concepts. Physics is also the most fundamental science because it deals with the behavior and structure of objects (Giancoli, 2001). In learning physics, students must be able to understand concepts. Understanding physics concepts is needed to solve physics problems either in everyday life or in the form of questions. The ability to understand concepts is a requirement to achieve learning success, especially in physics. Concept understanding is a person's ability to construct an existing concept based on the basic knowledge possessed. Kilpatrick and Findel in Ilyas (2022) state that indicators of concept understanding include: (1) the ability to restate concepts that have been learned, (2) the ability to classify objects according to certain properties, (3) apply the concept of problem solving algorithms, (4) the ability to provide examples of concepts, (5) the ability to present concepts in the form of mathematical representations, (6) the ability to develop the necessary conditions of a concept.

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Depdiknas states that concept understanding is one of the mathematical skills expected to be achieved in physics learning (Asri, 2019). In fact, during the learning process teachers rarely consider the concepts that exist in the minds of students and prioritize teaching mathematical formulas and solving calculation problems to students rather than physics concepts. So that the concepts that students understand are often not in accordance with the concepts adopted by the physical experts (Suparno, 2013). The discrepancy of understanding the concept in the minds of students is called misconception.

Misconceptions generally occur in physics learning because there are physics concepts that are abstract and difficult to explain. Misconception or concept error is an incorrect interpretation of a concept that is not in accordance with the theory (Zulvita& Halim, 2017). Misconception is also defined as a difference in understanding by students of the actual concept so that the concept that is finally owned by students has an error which, if not resolved, will affect the student learning process and learning outcomes. Misconceptions that occur in students are inseparable from the causes that come from students themselves (internal factors) and causes that are outside of students (external factors) such as teachers, textbooks, context, and the way teachers teach (Suparno, 2013).

The results of observations made at SMA Negeri 11 Medan stated that students consider physics as a subject that is difficult to understand compared to other subjects, therefore students are not interested in learning physics. The results of interviews with physics teachers at SMA Negeri 11 Medan also revealed that students experience physics misconceptions in a material taught, one of which is Rotational Dynamics. Misconceptions that occur in students affect the effectiveness of the teaching and learning process, especially if students have incorrect concepts that will affect student learning outcomes. Misconceptions can be reduced by diagnosing misconceptions that occur in students using instruments, one of which is a diagnostic test (Widayani, 2023).

Diagnostic tests are tests used to determine students' strengths and weaknesses in the learning process. Diagnostic tests are also used to see students' initial abilities and misconceptions (Suwarto, 2017). The four-tier diagnostic test is a development of the three-tier according to what has been done by Caleon&Subramaniam (2010). The difference between the three-tier and four-tier choice tests is the addition of a level of confidence in the reason for the answer to the question. In the first level, questions are given in the form of multiple choice answers. At the second level, students are given a choice of confidence levels. At the third level, the reasons are given in the form of multiple choices. At the fourth level, a choice of confidence is given from the reasons that have been chosen. Diagnostic tests have advantages including: 1) it can distinguish the level of confidence of the answers and the level of confidence of the reasons chosen by students so that it can dig deeper into the strength of students' concept understanding, 2) it can diagnose misconceptions experienced by students, 3) it can determine the part of the material that requires more discussion, 4) it can plan better learning to help overcome student misconceptions (Fariyani et al., 2015).

The problem of misconceptions is still a topic of concern in the scope of education, several studies have revealed that students still experience misconceptions in Rotational Dynamics material. Research (Jannah &Ermawati, 2020; Oktavia et al, 2019; Syahrul&Setyarsih, 2015) identified student misconceptions with several indicators of causes in students according to Suparno, namely preconceptions, associative thinking, humanistic thinking, incomplete or incorrect reasoning, and intuition. Jannah &Ermawati (2020) stated that the test results given to 30 students had the highest misconception in rotational dynamics in the rotational motion sub-material of 55% due to students memorizing formulas without understanding the concept and the lowest misconception in the moment of inertia sub-material of 15%. Oktavia et al (2019) revealed that the test results given to 89 students were the lowest misconception on the concept of the moment of

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force of 19.84% and the highest misconception experienced by students on the concept of kinetic energy of 46.31%. Both studies identified students' misconceptions using a four-tier diagnostic test instrument. The research (Furoidah et al, 2017) also identified students' misconceptions using a four-tier diagnostic test to 157 students with the highest misconception on the concept of linear velocity of the center of mass at 80.25% and the lowest on the concept of the moment of force at 45.86%, but did not reveal the causes of misconceptions experienced by students.

METHODS

The method used in this research is descriptive research using quantitative and qualitative approaches in explaining the research results obtained. This research was conducted at SMA Negeri 11 Medan which is located at Jalan Pertiwi No. 93, Medan Bantan, Medan Tembung District, Medan City, North Sumatra. The population in this study were grade XI students majoring in science. The research sample was taken using purposive sampling technique as many as 64 students of class XI IPA 2 and XI IPA 3. Sampling is based on certain considerations from the population, with the consideration that the class taken whose students have finished learning Rotational Dynamics and have never done a diagnostic test on Rotational Dynamics material. Data collection techniques in the form of diagnostic tests, response questionnaires, and interviews. Diagnostic tests used with a total of 18 items.

The data analysis technique in this study first grouped the test results into several categories of understanding the concept, misconceptions, and not understanding the concept. The grouping of student answers based on the combination of diagnostic test answers is in Table 1.

Table 1. Answer Combinations of Concept Understanding Categories of the Four-Tier Multiple Choice Diagnostic Test

Category	Answer Combinations			
	Answer	**Confidence Level Answer**	**Reason**	**Confidence Level Reason**
Concept Understanding	Correct	Sure	Correct	Sure
Not Understaning the Concept	Correct	Not Sure	Correct	Not Sure
	Correct	Sure	Correct	Not Sure
	Correct	Not Sure	Correct	Sure
	Correct	Not Sure	Incorrect	Not Sure
	Incorrect	Not Sure	Correct	Not Sure
	Incorrect	Not Sure	Incorrect	Not Sure
	Correct	Sure	Incorrect	Not Sure
	Incorrect	Not Sure	Correct	Sure
Misconception	Correct	Not Sure	Incorrect	Sure
	Correct	Sure	Incorrect	Sure
	Incorrect	Sure	Correct	Not Sure

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	Incorrect	Sure	Correct	Sure
	Incorrect	Sure	Incorrect	Not Sure
	Incorrect	Not Sure	Incorrect	Sure
	Incorrect	Sure	Incorrect	Sure

(Adaptation ofFariyanidkk., 2015)

In addition, the second is to calculate the percentage of students who understand the concept, misconceptions, and do not understand the concept with the calculation of misconceptions as follows (Wahyudi, 2021):

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

P is the percentage of students, F is the score obtained by students, and N is the overall score. The three results obtained were grouped according to the percentage of misconceptions as shown in Table 2.

Table 2. Misconception Percentage Criteria

Percentage (%)	Criteria
$0\% \leq N < 30\%$	Low
$30\% \leq N < 60\%$	Moderate
$60\% \leq N < 100\%$	High

(Wahyudi, 2021)

After the diagnostic test was given to students, interviews were conducted. Interviews were conducted to teachers and students, to teachers to find out information about misconceptions that occur in students. Interviews to students were conducted to find out students' conceptual errors after doing the diagnostic test, as well as to find out the causes of misconceptions in these students.

RESULT & DISCUSSION

The analysis of misconceptions experienced by students was assessed using a combination of answers to a four-tier multiple choice diagnostic test with the categories of conceptual understanding, misconception, and not conceptual understanding found in Table 1. The questions before being implemented have been validated by experts. The misconception diagnostic test questions consisted of 18 valid items with a reliability of 0.912 with a very high reliability category, and the student response to the use of the four-tier multiple choice diagnostic test was 80% with good criteria. Analysis of students' misconceptions using diagnostic tests based on indicators of concept understanding and based on the Rotational Dynamics concept category. The concept of Rotational Dynamics taught by the teacher is in accordance with the basic competencies contained in the 2013 curriculum syllabus. The results of the analysis of the category of misconceptions, understand the concept, and do not understand the concept on the Rotational Dynamics material are shown in Table 3.

Table 3. Results of Category Analysis of Student Misconceptions on Rotational Dynamics Material

No.	Misconception	Total Score (%)	Average Score

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	Category		(%)
1.	Misconception	903,12	50,17
2.	Concept Understanding	84,32	4,95
3.	Not Understanding the Concept	807,80	44,88

The results of the percentage of misconceptions that occur in the question items using the four-tier multiple choice diagnostic test, on the concept understanding indicator, obtained the results of the misconceptions of each class in Table 4 below.

Table 4. Student Misconceptions Based on Indicators of Concept Understanding

No.	Concept Understanding Indicator	Item	Percentage
1.	Restate the concept learned	1, 16	46,88%
2.	Classify objects according to certain properties	2, 5, 6	43,23%
3.	Apply problem-solving concepts	3, 14, 18	62,50%
4.	Provide examples of the concept	11, 17	45,31%
5.	Presenting mathematical representation concepts	4, 7, 8, 10, 13, 15	47,92%
6.	Develop the necessary condition of the concept	9, 12	57,03%

Based on each indicator of concept understanding, the level of students' misconceptions contained in each item was analyzed to determine the level of students' misconceptions. The level of student misconceptions based on the achievement of concept understanding indicators can be seen in Figure 1.

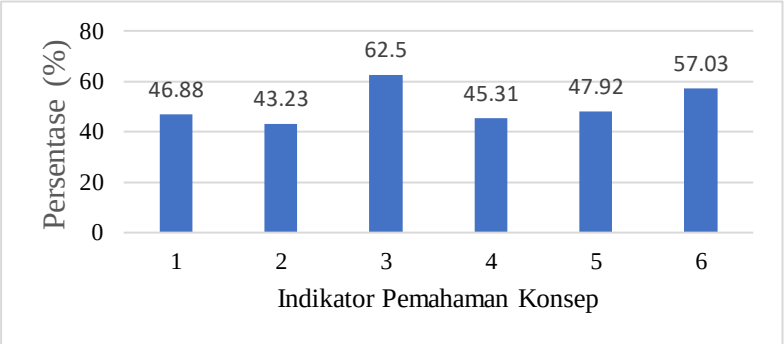

Figure1. Students' Misconception Profile Based on Achievement of Concept Understanding Indicators

The concept understanding indicators listed in Table 3 are used to diagnose misconceptions experienced by students. The results listed in Table 3 show that the lowest misconception is found in indicator 2, namely classifying objects according to certain properties of 43.23% contained in question items 2, 5, and 6. Students have difficulty in classifying objects according to certain properties in accordance with the concept. In item 2 students cannot connect the moment of force and acceleration on the graph. Item 5 students are not able to classify the factors that affect the moment of inertia. Item 6 students do not understand the concept of moment of inertia.

While the highest misconception experienced by students is in indicator 3 of applying the concept of problem solving, which is 62.50% contained in question items 3, 14, and 18. In item 3, students were not able to connect between the force arm and the moment of force on the application in opening the door. Item 14 students cannot analyze the relationship between the velocity of the center of mass and angular momentum. Item 18 students are also less able to solve problems from the problem.

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The results of the calculation of the percentage of misconceptions that occur in Rotational Dynamics material using a four-tier multiple choice diagnostic test analyzed on each item, the results are shown in Table 5 below.

Table 5. Student Misconceptions Based on the Concept of Rotational Dynamics

No.	Concept	Item	Students with Misconception	Percentage (%)
1.	Magnitudes of Rotational Dynamics	1,2	25	39,84%
2.	Torque	3,4	28	43,75%
3.	Moment of Inertia	5,6,11,17	27	42,97%
4.	Parallel Axis Theorem	7,8	26	40,62%
5.	Center of Mass Linear Velocity	9,10	34	53,91%
6.	Rolling Motion as a Combination of Translation and Rotation	13	38	59,38%
7.	Rolling Motion as Pure Rotation	15	38	59,38%
8.	Angular Momentum	12,16	38	59,38%
9.	Kinetic Energy	14,18	44	68,75%

The data in Table 5 shows the overall percentage of students answering questions based on the concept of Rotational Dynamics. The concepts listed in Table 5 are concepts in Rotational Dynamics that are used to diagnose conceptual errors experienced by students. Based on the results in the table, it is known that the lowest misconception occurs in the concept of Rotational Dynamics Magnitudes (concept 1), which is 39.84% as many as 25 students. While the highest misconceptions experienced by students on the concept of Kinetic Energy (concept 9) with a percentage of 68.75% as many as 44 students. The misconceptions that occur in the concept of Kinetic Energy are close to the results of Syahrul's research (2015) with a percentage of student misconceptions on the concept of 80.14% including the high category. The high and low misconceptions experienced by students on concept 1 (question items 1 and 2) and concept 9 (question items 14 and 18) are inseparable from misconceptions originating from students and teachers. This needs to be followed up on what causes misconceptions in students can occur. The identification results regarding the misconceptions of the two concepts are as follows.

The results of the diagnosis of item 1 show that when given a problem about comparing the linear rate and angular rate of an object. Students assume that if an object travels the longest distance then the linear rate of the object is fast, but cannot explain the angular rate of the object. Problem item 2 is given a graphic image and students are expected to compare the relationship between angular acceleration and moment of force. Students assume that the graph is the relationship of angular acceleration to the moment of force is constant. The correct concept is that the greater the angular acceleration, the greater the moment of force. The causes of students who experience misconceptions on this concept are that students are less careful in understanding the question, there are students who do not know the concept, students also have difficulty in understanding the concepts related to the problem.

The highest misconceptions that occur in the concept of Kinetic Energy are caused by students who do not know the concept, students who do not learn the concept, and teachers who do not explain the concept to students. In item 14 students could not provide reasons for the answers they gave and also students did not learn the concept. While in item 18 students could not answer the question because the teacher did not explain to students the concept related to the question. The results of the identification of the causes of

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misconceptions of the two concepts are inseparable from the causes of misconceptions originating from students and teachers.

Misconceptions found in the concept of the moment of force with a percentage of 43.75% with a total of 28 students who experience misconceptions. The concept of the moment of force is found in question items 3 and 4. Misconceptions found in the concept of the moment of inertia with a percentage of 42.97% with the number of students who experience misconceptions as many as 27 students. The concept of moment of inertia is found in question items 5, 6, 11, and 17. Misconceptions found in the parallel axis theorem with a percentage of 40.62% with the number of students who experience misconceptions as many as 26 students. The concept of the parallel axis theorem is found in question items 7 and 8. Misconceptions found in the linear velocity of the center of mass with a percentage of 53.91% with a total of 34 students who have misconceptions. Misconceptions found in rolling motion as a combination of translation and rotation with a percentage of 59.38% with a total of 38 students experiencing misconceptions. The concept of rolling motion as a combination of translation and rotation is found in question 13. The misconception found in rolling motion as pure rotation with a percentage of 59.38% with a total of 38 students experiencing misconceptions. The concept of linear velocity of the center of mass is found in question item 15. Misconceptions found in angular momentum with a percentage of 59, 38% with a total of 38 students experiencing misconceptions. Students who suffer from misconceptions on these concepts are due to not being able to answer questions or reasons correctly, not being careful when reading the questions and understanding the meaning of the questions, and even just guessing when answering the diagnostic test questions given.

CONCLUSION

Based on the results of the research and analysis conducted, it can be concluded that the four-tier multiple choice diagnostic test can be used to detect students' concept understanding and misconceptions. Students in grade XI at SMA Negeri 11 Medan experience misconceptions on Rotational Dynamics material. The highest misconception experienced by students on the concept of Kinetic Energy with a percentage of 68.75% with the cause of misconception because students do not know more about the concept and also the teacher does not explain related concepts. While the lowest misconceptions experienced by students on the concept of Rotational Dynamics Magnitudes with a percentage of 39.84%, with the cause of misconceptions because students are less careful in understanding the question, there are students who do not know the concept, students also have difficulty in understanding the concepts related to the problem. The cause of misconceptions that come from teachers such as teachers never teach some of these concepts.

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