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Four-Tier Test Based On Local Wisdom to Analyze Misconceptions in Rotational Dynamics

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A B S T R A C T

This R&D research resulted in a four-tier diagnostic test instrument based on local wisdom. The purpose of the study was to describe the instrument's characteristics, test the validity, reliability, and characteristics of the items developed, and describe the misconception profile of the students of MA Islamiyyah Attanwir Talun. The development method uses the Borg & Gall model with sample selection through purposive sampling. Data collection techniques include tests, interviews, questionnaires, and documentation. The test instrument was made by correlating physics material and the local wisdom of the community. The validity test results by the expert stated that the instrument developed was valid. The reliability of the developed instrument is 0.978. The test instrument consisted of 15 moderate and 13 difficult questions; with differentiating power, 12 items were corrected, seven were accepted but had to be corrected, and nine were accepted without improvement. There were 50% misconceptions about the answer, 57.14% about the reason, and 50% about the answer and reason. The highest misconception occurs in the concept of applying the moment of inertia, with a percentage of 67.23%. The lowest misconception is found in the concept of rigid body equilibrium, with a percentage of 38.98%.

Introduction

The purpose of learning physics in the 2013 curriculum is that students are expected to master the principles and concepts and expand their knowledge and self-confidence for further educational capital (Kemendikbud, 2014). The principles and concepts of physics are closely related to facts. Kaur (2013) states that facts or experiences can lead to the emergence of a concept based on students' thinking ability, which is not necessarily true. Different thoughts between the concepts that exist in students and the

concepts of the scientific theory set by experts are called misconceptions. The wrong concept will be used by students as a guide so that it will be challenging to repair and hinder the process of receiving new knowledge (Gurel et al., 2015; Köse, 2008; Tayubi, 2005). Misconceptions need to be identified so that parts that need improvement can be identified and remediation can be carried out immediately before the wrong concept increases its roots in students (Haris, 2013; Styer, 2005).

One of the efforts to uncover misconceptions is with a diagnostic test. Rusilowati (2006) states that diagnostic tests can inform students' lack of understanding of the material. There are several types of diagnostic test questions, including one-tier diagnostic test, two-tier diagnostic test, three-tier diagnostic test, and four-tier diagnostic test. The four-tier diagnostic test is the suitable type of diagnostic test to identify students who understand and do not understand concepts, as well as misconceptions (Fariyani et al., 2017).

Until now, it is still rare for teachers to use tests to identify students' misconceptions due to various factors, one of which is the limited availability of diagnostic test (Maharani et al., 2019; Pujayanto et al., 2018; Wahidah S. et al., 2018; Yuberti et al., 2020). Based on interviews with physics teacher MA Islamiyyah Attanwir Talun, information was obtained that it is still rare for teachers to develop unique instruments for misconceptions. Teachers only develop one-level multiple-choice test questions that are not optimally used to reveal misconceptions. As a result, teachers do not know whether there is a misconception in students or not. Teachers must distinguish students who understand the concept well, do not understand the concept, or have misconceptions. In addition, teachers must also detect the location of students' conceptual errors to improve the quality of education received by students (Hafizah & Haris, 2014; Mutlu & Sesen, 2015). Misconceptions that have been embedded in students will be difficult to fix if they are not identified early (Tayubi, 2005). Therefore, a four-tier diagnostic test instrument is needed to reveal the misconceptions of MA Islamiyyah Attanwir Talun students.

Misconceptions do not occur in all materials in physics (Arslan et al., 2012; Bunawan et al., 2015). Many sub-materials and abstract concepts make students have misconceptions (Faraoni, 2007). One of the misconceptions in physics learning is found in Rotational Dynamics and Equilibrium of Rigid Body material. The results of research by Alfiani (2015) showed that students identified misconceptions in the subject of Rotational Dynamics and Equilibrium of Rigid Objects for the Moment of Force sub material by 51.4%; in the Moment of Inertia sub-material of 37.6%; and the sub-material of Kinetic Energy of Rigid Objects is 50.5%. The research results by (Fitrianingrum et al., 2017) show that there are misconceptions about the material for the equilibrium of rigid bodies, namely the Moment of Force, the Moment of Inertia, and the Center of Gravity. Misconceptions are found in the concept of the moment of inertia in the cognitive domain of remembering. However, the diagnostic test instrument used by Alfiani (2015) and Fitrianingrum et al. (2017) is a three-tier diagnostic test that still has shortcomings

in uncovering misconceptions, especially at the level of students' confidence in giving answers and reasons that cannot be distinguished so that the details of students' misconceptions are not known.

The physics teacher of Madrasah Aliyah Islamiyah Attanwir Bojonegoro stated that students could experience misconceptions in some physics materials, one of which was Rotational Dynamics and Rigid Body Balance. According to the MA physics teacher, misconceptions about the Equilibrium Rigid Body material can occur due to the many materials covered. Students find it challenging to understand the material well and create opportunities for misconceptions.

The four-tier diagnostic test in this study was developed based on local wisdom. The concept of physics is closely related to facts encountered in everyday life, one of which is in the form of local wisdom (Hartini et al., 2018; Nimah et al., 2021; Ramadhan et al., 2019). This underlies the four-tier diagnostic test mode based on local wisdom to determine the extent of the truth between the concepts of students' thoughts on the facts they encounter and the concepts received during class learning. In addition, the amalgamation of the four-tier diagnostic test with local wisdom aims to preserve the identity of an area that is starting to be replaced with various modern things nowadays. Anggraeni & Mundilarto (2020) argues that local wisdom is a critical identity to be presented to youth through education.

The four-tier diagnostic test questions are developed in multiple-choice at each level. There is one answer key and four distractors in the answer choices; one answer key, three distractors, one genuine reason for selecting reasons, and six options of answer and reason confidence levels. In addition to identifying misconceptions more deeply than the existing diagnostic test forms, the test questions developed in this study have specificity based on local wisdom that other researchers have not developed.

Literature Review

Diagnostic Test

A diagnostic test is a test that can be used to find out the weaknesses of understanding and learning difficulties of students (Depdiknas, 2007). A good diagnostic test can provide a clear and precise picture in reviewing student learning difficulties and the patterns formed from these difficulties. Through diagnostic tests, teachers can map students' abilities and plan appropriate remediation as needed (Kruit et al., 2020; McClary & Bretz, 2012).

Diagnostic tests can be in the form of descriptions or multiple choice. There are four types of diagnostic tests, namely: one-tier diagnostic test, two-tier diagnostic test, three-tier diagnostic test, and four-tier diagnostic test. The one-tier diagnostic test contains questions that students must answer. A one-tier diagnostic test is considered less able to identify student learning difficulties in detail, so it is enhanced by a two-tier diagnostic test consisting of questions and reasons for answering questions. However, the two-tier diagnostic test cannot determine students' confidence in answering questions (Pesman, 2005). The three-tier diagnostic test consists of questions, reasons for answering questions, and the level of confidence in answering questions

and reasons. The three-tier diagnostic test was able to map students' learning difficulties, including students' misconceptions (Kaltakci & Eryilmaz, 2010). However, the three-tier diagnostic test also has a weakness, namely, it cannot distinguish the level of students' confidence in giving answers and reasons. This underlies the emergence of a four-tier diagnostic test consisting of questions, the level of confidence in the answers, the reasons for answering the questions, and the level of confidence in the reasons. The four-tier diagnostic test can distinguish the level of confidence in the answers and reasons given by students so that they can map students' abilities more deeply (Caleon & Subramaniam, 2010; Fariyani et al., 2015). The advantages of the four-tier diagnostic test include: being able to map students' abilities accurately, not only can be used to test understanding of cognitive concepts but can also be used to test misconceptions and various students' thinking skills, such as critical thinking skills, creative thinking, and scientific communication.

Misconception

Misconceptions are intellectual aspects inherent in students' minds that are different from the concepts agreed upon by scientists (Morales López & Tuzón Marco, 2021). Misconceptions can prevent students from accepting new knowledge because they previously believed in the wrong concept. Misconceptions cause students' inconsistency of a concept. Misconceptions are difficult to correct because they are already attached to the minds of students. Students who experience misconceptions can solve simple problems, but when given a complex problem, misconceptions will reappear (Uwamahoro et al., 2021; Winrich & Garik, 2021). Misconceptions can be experienced by everyone, both teachers and students, at the elementary and college levels. A person tends not to realize that he is experiencing misconceptions, therefore evaluation is needed to identify misconceptions.

Students already have an initial concept (preconception) that students bring to formal classes (Jafer, 2020; Suparno, 2013). Students have constructed their knowledge since childhood through their life experiences. Students with different educational backgrounds and ages have different initial concepts (Demirci, 2005). This will affect the next student learning process. The initial concepts brought by students are usually misconceptions, although not all of the initial knowledge brought by students are misconceptions. Students do not explain in accordance with the laws of physics that have been agreed upon by scientists. Several characteristics of misconceptions, including 1) the concept is not in accordance with the conception found by experts in the field, 2) one or a small number of misconceptions tend to be widespread (from one person to another), 3) many misconceptions are resistant to change, 4) misconceptions sometimes include alternative beliefs that students use systematically, 5) some misconceptions are one of the concepts that students have from the teacher (Kaur, 2013).

Research Method

Research Design

This research includes R&D, with the

resulting product being a four-tier diagnostic test instrument based on local wisdom on Rotational Dynamics and Equilibrium of Rigid Objects. The research procedure followed the Gall et al. (2003) development procedure. The research was conducted at MA Islamiyyah Attanwir Talun. The sampling technique was performed using purposive sampling with 25 students in class XI IPA 2 in the preliminary field testing and 59 students in class XI IPA 1 and XI IPA 3 in the main field testing.

Data Collection and Analysis

Data collection techniques consisted of tests, interviews, questionnaires, and documentation. The test was carried out twice, on a preliminary and main field testing. Interviews were conducted with teachers and students. Interviews with teachers were performed twice, namely at the beginning of the study to obtain information about students and at the end of the study to know the opinion of teachers regarding the developed local wisdom-based four-tier diagnostic test instrument. Interviews with students were conducted to explore the findings of misconceptions. Two types of questionnaires are used for data collection: assessment and response. The assessment questionnaire was used to determine the test script's readability, the material's scope, the time needed to work on the questions, and the benefits of the local wisdom values in the test. The response questionnaire was used to determine the overall response of students to the four-tier diagnostic test based on the developed local wisdom.

The data analysis techniques included validity, reliability, level of difficulty, discriminating power, distractor function, questionnaire analysis, misconception analysis, and interpretation of misconceptions. Material expert lecturers and evaluation experts carried out the validity test. The reliability test was carried out using the Cronbach Alpha equation. The analysis of students' misconceptions was carried out by following the research of Caleon & Subramaniam (2010) using CDQ = (CFC-CFW)/S. The interpretation of the results of misconceptions is carried out by dividing students into three categories: understanding, not understanding, and misconceptions. The level of confidence is low when it is in the range of 1 (just guessing), 2 (very unsure), and 3 (not sure). The level of confidence is high when it is in the range of 4 (sure), 5 (very confident), and 6 (very, very sure).

Result and Discussion

The final product developed was 28 four-tier diagnostic test instruments based on local wisdom with nine indicators and seven sub-topics, namely moment of force, a moment of inertia, angular momentum, the law of conservation of angular momentum, Newton's second law of rotational motion, object equilibrium, and center of gravity. Local wisdom included in the developed test instrument includes traditional games, local community traditions, and local community activities.

Each item of the questions made consists of four levels. The first level contains multiple-choice questions with five answer choices. The second level is confidence in the answer choices in the range of 1 to 6. The third level contains the reasons for the answers chosen at the first level. At this third level, four choices of reasons have

been provided, and one reason is open. The fourth level contains the level of confidence in choosing a reason.

The four-tier diagnostic test instrument based on local wisdom is also equipped with a grid of questions, question cards, working instructions, answer keys, scoring guidelines, and results in interpretation guidelines. The four-tier diagnostic test grid components based on local wisdom include six components: indicators of competency achievement, sub-materials, question indicators, question-level categories, types of questions, and several questions. The question card component explains in more detail, such as a description of the question, answer key, and an explanation of the answer key. Instructions for working on questions contain 17 crucial points that students must pay attention to. A score of 1 is obtained when students answer correctly for answers and reasons, while a 0 is obtained if students answer wrongly for answers and reasons.

Validity of Four-Tier Diagnostic Test Based on Local Wisdom

Validation is carried out to determine the feasibility of a test instrument developed in measuring something to be measured, in this study, namely the misconceptions of students. There are 23 assessment indicators with three aspects: language, construct, and material.

A validation test is carried out on each item. The validation test on each item is carried out to ensure that the test instrument used is feasible and can measure what will be measured, namely the student's misconceptions (Fadllan et al., 2019). Assessment of each item in detail can make it easier to identify parts that need improvement (Anggraeni & Mundilarto, 2020; Arini et al., 2017). The four-tier diagnostic test instrument based on local wisdom has been declared valid by the validator. This shows that each test item contains the value of wisdom and can reveal students' misconceptions.

Reliability of Four-Tier Diagnostic Test Based on Local Wisdom

Reliability testing is used to determine the stability of the developed test instrument. The results of data analysis show a reliability coefficient of 0.978, which is greater than rtable, so it can be said that the test instrument developed is reliable.

The results of data analysis show that the test instrument developed is reliable. Shidiq et al. (2014) state that a reliable instrument will provide consistent results in measuring something to be measured. The test instrument developed consistently reveals students' misconceptions on Rotational Dynamics and Equilibrium of Rigid Objects.

Difficulty Level, Discrimination Power, and Distractor Function

The test instrument developed must not only be valid and reliable, but it must also have a good level of difficulty, discriminatory power, and distractibility. The difficulty level of the 28 items tested was divided into a medium category of 15 questions and a difficult category of 13 questions. The difficulty level ranges from 0.10 to 0.68.

The results of the analysis show that the number of questions in the medium category is more than in the difficult category. This is by Rusilowati's (2006) research, who said that an excellent diagnostic test item is a test item with a medium category. Intelligent students will not feel that the questions are too easy, and not brilliant students will not feel frustrated because they are too difficult to do the questions.

The distinguishing power of 28 items consists of 12 items that must be corrected, seven accepted but need to be fixed, and nine accepted without being corrected. The discriminatory power of the developed instrument is in the range of 0.21 to 0.54.

The analysis of the discriminatory power of items is used to test the items' ability to distinguish smart and less intelligent students (Arikunto, 2006). The questions used in this study are questions that have valid criteria and the power of difference is not discarded. The results of data analysis showed that the 28 questions tested were included in the valid category and there were no questions that had different power with the criteria being discarded so that all items could be used.

A total of 160 distracting items are provided in the answer choice options. The percentage of distractors that can function adequately is 88.75%. The number of distractors in the choice of reasons is 120 items, and 95.8% of the distractors can function correctly.

The function of a distractor can be said to be good if it can attract students' attention. Puthiaparampil & Rahman (2021) states that a distractor can be categorised as good if it has a great appeal to students who do not understand the material. The Ministry of National Education (2008) states that at least 5% of students choose a good distractor function. Almost all distractors on test questions can function properly. Revisions were made to several distractors which were considered to be less than perfect. Improvements were made to the language structure and numbers in the answer choices. The test questions that have been repaired are then validated again so that a distractor that functions properly is obtained.

Students' Misconceptions

The misconception analysis was obtained by calculating the CDQ (Confidence Discrimination Quotient) value. A negative CDQ value can identify students who experience misconceptions. A negative CDQ score indicates that students cannot distinguish from what is not understood (Caleon & Subramaniam, 2010). In other terms, students are told to experience misconceptions without realizing them. The recapitulation of the students' misconception analysis is presented in Figure 1.

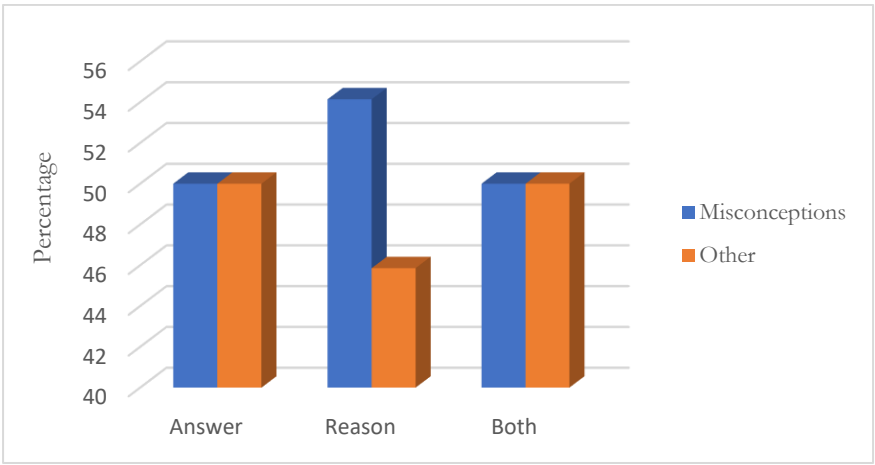

Figure 1. Recapitulation of Students' Misconception Analysis Results

Figure 1 shows that 50% of students have misconceptions in choosing answers, 52.14% in choosing reasons, and 50% in choosing the answers and reasons for the 28 items tested. At least 50% of the questions tested are answered confidently by students, even though the answers given are wrong. Students believe that the answer given is the correct answer. This is reinforced by the results of interviews with students who stated that students did believe the wrong answer was the right answer. This statement clearly shows that students have misconceptions. Students cannot distinguish what is understood and what is not understood correctly, thus indicating a strong misconception in students (Moodley & Gaigher, 2019). The recapitulation of students who understand, do not understand, and experience misconceptions in each item are shown in Table 1.

Table 1. Recapitulation of Students Who Understand, Don't Understand, and Misconceptions on Each Item

Category	Question Number		
	Low	Medium	High
Understand	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28	1	-
Quantity	27	1	0
Don't Understand	1, 3, 5, 9, 10	2, 4, 6, 7, 8, 11, 12, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28	13
Quantity	5	22	1

Misconceptions	-	2, 4, 6, 7, 8, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28	1, 3, 5, 9, 10, 12
Quantity	0	22	6

Table 1 shows that misconceptions were found in all the items tested. Students who experience misconceptions will be disturbed accepting new knowledge (Tayubi, 2005). The wrong concept will be firmly attached to the students' thinking and considered the correct concept. This is by Kiray & Simsesss (2021) opinion, which states that the wrong concept is accidentally used by students as a guide so that it will be challenging to fix.

The four-tier diagnostic test instrument based on local wisdom, apart from being analysed for each item, also analysed each indicator. The percentage of students who understand, do not understand, or experience misconceptions on each indicator are presented in Table 2.

Table 2. Percentage of Students Who understand, do not understand, and experience misconceptions in Each Indicator

Indicator	Understand (%)	Not Understand (%)	Misconceptions (%)
Explaining quantities related to rotational dynamics	11.19	42.37	46.44
Apply the concept of torque to the motion of objects	9.6	29.94	60.45
Apply the concept of moment of inertia to the motion of an object	7.91	24.86	67.23
Analyzing the moment of inertia of a rigid body on the axis of rotation	1.69	53.39	44.92
Apply the concept of angular momentum to the motion of an object	4.24	54.24	41.53
Analyzing the magnitude of the angular momentum of a rotating object	5.93	50	44.07
Apply Newton's second law to translational and rotational motion	5.08	55.93	38.98
Explain the concept of rigid body equilibrium	8.47	52.12	39.41
Applying the concept of center of gravity in daily life	5.08	50.28	44.63

Based on Table 2, the level of understanding of all students is in a low category. This shows that students do not master the material's Rotational Dynamics and Equilibrium of Rigid Objects. The results obtained in this study are in accordance with Aprilianingrum et al.'s (2015) research which states that students' understanding of concepts in the material of rotational dynamics and rigid body equilibrium is still low.

The results of this study indicate that almost all students experience misconceptions spread over the tested items. Four sources of misconceptions were found from student interviews, including teachers, books, the internet, and students' thoughts. This needs to be watched out for because widespread misconceptions can cause students to receive further knowledge (Prinz et al., 2021).

One of the most common misconception cases found is ballet dancers' case. According to students, the ballet dancer's rotation with outstretched hands has a more incredible angular velocity than when the hands are pressed against the dancer's body. Students assume that when the dancer's hands are stretched, the angular velocity of the dancer will increase, and the moment of inertia will decrease, causing the dancer's rotation to be faster.

The students in this study considered the moment of force to be inversely proportional to the moment of inertia. The smaller the object's moment of inertia, the greater the moment of force required to make the object rotate.

Another misconception found is that the moment of the most significant force is owned by objects closer to the center of the object. If the masses of two objects are the same, then the moment of force is most significant for the object closest to the center.

Misconceptions are also found in the concept of angular momentum. Students assume that the moment of inertia is proportional to the angular velocity. If the moment of inertia increases, the angular velocity will also increase. The correct concept is that when the moment of inertia of an object increases, the angular velocity of the object when it rotates will decrease because the moment of inertia is inversely proportional to the angular velocity.

In the center of gravity sub-material, students assume that the center of gravity is the same as the center of mass. The findings of this misconception are the same as the findings of Fitrianingrum et al. (2017), which states that students assume that the center of gravity is the same as the center of mass.

This research can reveal students' misconceptions using special instruments correlated with the value of local wisdom. This study indicates that integrating test questions with local wisdom can make students aware of the local culture of the archipelago. Students also feel interested in learning more about material related to certain local wisdom. The results of this study can be used as a reference by educators in carrying out learning improvements in the material of Rotational Dynamics and Equilibrium of Rigid Objects. Teachers can detect which students do not understand parts of the material, and misconceptions are detected. Thus, teachers can prepare to learn better to correct the misconceptions experienced

by students.

Conclusion

The product developed in this study is a four-tier diagnostic test instrument based on local wisdom to reveal students' misconceptions. The final product results in 28 questions with nine indicators and seven sub-materials. The values of local wisdom listed in the test instrument include traditional games, local community traditions, and local community activities. Each test item is declared valid and reliable with good item characteristics. There are 50% of students experiencing misconceptions in choosing answers, 52.14% of students experiencing misconceptions in choosing reasons, and 50% of students experiencing misconceptions in choosing answers and reasons. The highest misconception is found in the concept of the moment of inertia of the motion of an object by 67.23%, and the lowest misconception is found in the concept of rigid body equilibrium of 38.98%.

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