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Analysis of Student Misconceptions Using Digital Four-Tier Diagnostics Test on Newton's Law

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ABSTRACT

Research has been carried out on the analysis of student misconceptions using a digital four-tier diagnostic test in physics subjects for newton's law class VIII SMP Hasanuddin 05 Semarang. This study aims to determine the students' misconceptions and the factors that cause misconceptions in Newton's law material. The method used in this research is quantitative descriptive, used to describe the level of students' misconceptions by describing the percentage of the number. The sample in this study was 26 students of class VIII C SMP Hasanuddin 05 Semarang. The research instrument uses four-tier multiple-choice tests, at level 1 and 3 objective tests are questions on the questions and reasons for answers, while levels 2 and 4 contain the level of confidence in the answers and the level of confidence in the reasons for the answers. The sampling technique is purposive sampling. Test the validity by using the Karl Pearson Correlation formula. Reliability test using Alpha Cronbach formula. The results of the validity test showed that of the 15 questions developed, there were 11 valid questions. The reliability test results showed that the instrument is reliable. The research data shows that students of class VIII C SMP Hasanuddin 05 Semarang have misconceptions about Newton's law material. The percentage level of students' misconceptions in class VIII C is 53.85% in the medium category. The main factor that influences the students' misconceptions in class VIII C is the lack of interest in students' learning as a result of the teacher teaching only by using the lecture method and working on questions, and there is no concrete example.

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Introduction

Physics is a science that has an important role in the development of science and technology that can facilitate human life. Therefore, every student is expected to be able to understand and master physics with the correct concepts (Mutia et al., 2016). As a science, physics has various concepts (Abbas, 2016). Therefore, in the learning process students are always directed to be able to understand the learning material as well as possible. In fact, during the learning process students do not always fully absorb information, especially in physics subjects that contain many scientific concepts. We know that students and even some students before taking part in the formal physics learning process at school already brought the initial concept of physics. The initial concepts they brought were sometimes not appropriate to concepts accepted by experts (Diani et al., 2018).

Hummer in Gurel et al. (2017) stated that the concept that becomes a misconception can be seen as a concept or cognitive structure that is firmly and stably attached to the minds of students which actually deviates from the concepts put forward by experts, which can mislead the participants. Students understand natural phenomena and carry out scientific explanations, so sometimes what students understand about a concept is often different from the concept adopted by physicists in general. From some of the theories above, it is clearly illustrated that the physics learning process aims to direct students to understand the concept well so that the concepts possessed by students are not different from the actual concepts that cause misconceptions (Khoiri et al., 2020; Huda et al., 2016).

The incompatibility of concepts understood by students can cause the expected physics learning outcomes to be difficult to achieve. The existence of

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misconceptions in students will hinder the process of acquiring new knowledge and will cause students to continue to make mistakes during learning (Nurmala et al., 2018). Concepts that are not in accordance with the concepts recognized by experts are called misconceptions (Khoiri et al., 2021; Susilawati et al., 2021).

Misconceptions are phenomena that have become an important discussion in the teaching of physics and other sciences because their existence is believed to hinder the process of assimilation of new knowledge in the minds of students (Eviyani et al., 2017; Fariyani et al., 2015). Misconceptions can be obtained from different experiences from the previous level. This is a bad basis for students in constructing knowledge. Some means to resolve misconceptions are inappropriate or unsuccessful because educators do not know the exact cause of the misconceptions that occur, therefore looking for the causes of misconceptions is an important element before determining how to overcome them. Actually, there is a more fundamental problem with this misconception, namely the problem of identifying the occurrence of misconceptions.

Identification of misconceptions is an important thing to do in the physics learning process. Identification can be done before, during, and after the learning process and needs to be followed up with efforts so that students are free from their misconceptions (Usu et al., 2019). Misidentification will lead to errors in how to resolve them, and the results will be unsatisfactory. Therefore, before going any further on overcoming them, teachers must first have the knowledge and ability to identify misconceptions appropriately so that they can be used in learning.

Students' misconceptions can be identified through various types of instruments including interviews, open-ended questions, concept maps, and multiple-choice tests, all of which have advantages and disadvantages in their use (Gurel et al., 2015). For example, interviews have an important role in exploring students' conceptual mastery because the investigation is more in-depth to get a detailed description of the cognitive structure of students. However, the time required for research is so large that it takes a long time. The open-ended test has the advantage of providing the opportunity for respondents to write their answers in their own words. In addition, it can be given to a large sample compared to interviews, but the open-ended still has limitations, namely, it takes a long time to analyze the results (Kaltakci-Gurel et al., 2017).

Multiple-choice tests solve problems in interviews and open ended, but cannot investigate students' mastery of concepts in depth. The limitations that occur in this multiple choice test encourage researchers to create more effective tests that aim to compensate for the limitations of multiple choice tests, namely two-tier, three-tier, and four-tier tests (Muna, 2015; Setiawan et al., 2017) . Two-tier and three-tier diagnostic tests overcome detection problems than traditional multiple-choice tests. However, in its development, two-tier still has a weakness, namely not being able to distinguish a lack of knowledge and misconceptions. This weakness was later corrected by the presence of a three-tier test. Three-tier comes with adding a confidence level after the first two tiers. Students' answers to each item are considered as misconceptions when students answer the first and second tiers incorrectly with high reasons (Tamungku et al., 2019).

In this study, misconceptions will be identified using a four-tier test diagnostic test. Four-tier has the advantage of checking misconceptions in a shorter time because the teacher does not have much time to check misconceptions. The causes of the problems identified from the documentation study and clinical interviews in the preliminary study, most of the students had misconceptions about physics concepts because most students gave wrong reasons in the third tier. This erroneous reason can be identified by four-tier diagnostic tests. The four-tier misconception diagnostic test instrument is stated to know more about the students' understanding condition (Fariyani et al., 2015). This test consists of four main levels. The first tier is in the form of questions, the second tier is the level of confidence in the answers in the first tier, the third tier is the reasons related to the answers to the first tier, and the fourth tier is the level of confidence in the reasons for the third tier (Zulfikar et al., 2017).

The development of information systems is now running very fast. Along with the development of information technology, the need to obtain information effectively and efficiently is very necessary (Syahrul & Setyarsih, 2015). Following the development of an all-digital era, test instruments were made digitally with the help of google forms. Google form is a system in the form of form templates that can be used for the purpose of obtaining user information. This app works in google drive storage, this template is very easy to understand and use.

Based on the literature study, a lot of students experience misconceptions. Some research on misconceptions such as that has been carried out by Suparno (2013) who says that many students understand force as the properties of an object.

Therefore, students easily believe that heavy objects will fall faster than light objects if a free fall occurs because heavy objects have a greater force than light ones; whereas, in Newton's law concept, the force arises from the interaction between objects (Eviyani et al., 2017). This research is also in line with research conducted by Eviyani et al. (2017), with the acquisition of the percentage of students' misconceptions on Newton's law material, which is 40.88% which is caused by several factors, namely teachers, students, teacher teaching methods, books and contextual (everyday experience) (Annisa et al., 2019; Eviyani; Ariani, Tri; Chali, 2017).

Based on the results of interviews with physics teachers at SMP Hasanuddin 05 Semarang, it was stated that the enthusiasm of students to study physics was very lacking. In addition, students also experience learning difficulties in understanding physics concepts. This causes the physics exam results obtained are often below the minimum completeness criteria. The results of the interview also show that the teacher does not know what are misconceptions and what misconceptions occur to students because they have never done a test to detect misconceptions that students may experience. The evaluation of students' understanding so far has only been in the form of multiple-choice questions. The results of the answers to multiple-choice questions are considered to be able to show that students have understood the material when choosing the most appropriate answer choice among the several answer choices provided. However, the multiple-choice questions have shortcomings in identifying students' misconceptions because they are unable to detect that students answered correctly because they did understand the concept correctly or just happened to choose the correct answer. Thus it shows that the misconceptions in students are because students do not understand the concept as a whole and connect one concept to another with partial understanding, resulting in students making wrong conclusions.

Based on the description of the problem that has been described, it is necessary to conduct research on the analysis of students' misconceptions on Newton's law material. Therefore, this research is entitled "Analysis of Student Misconceptions Using Digital Four-Tier Diagnostics Test on Newton's Law in SMP Hasanuddin 05 Semarang".

Methods

The subjects in this study were class VIII C determined by the purposive sampling technique. The method used in this research was a quantitative descriptive design equipped with data in the form of the percentage of students who experience misconceptions for each indicator. The data source in this study is the primary data source because the data is obtained directly from the research subject. The research was conducted by providing digital four-tier diagnostic test instruments to students to obtain information about students' misconceptions about Newton's law material. The instrument in this study used a multiple-choice four-tier objective test at levels 1 and 3 which were questions on questions and reasons, while at levels 2 and 4 contained confidence levels and interviews. The test instrument consists of 15 questions.

Result and Discussions

This research was conducted to analyze students' misconceptions on Newton's law material. Analysis was carried out on each material indicator of Newton's law.

Newton's 1st Law Indicator

The indicator of Newton's 1st law questions aims to determine the understanding of students' concepts related to the theories that Newton has put forward and to describe the gravitational force and the normal force of an object. In this concept, 44.23% of students have understood the concept, 49.08% of students have misconceptions and 7.69% of students do not understand the concept. In this indicator it was found that students have not been able to explain the concept of Newton's first law, namely the gravitational force and the normal force.

Newton's 2nd Law Indicator

Each question on Newton's second law indicator aims to determine the understanding of students' concepts related to the theories put forward by Newton and to describe the basic concepts of Newton's second law of an object. In this concept, 36.54% of students have understood the concept, 57.69% of students have misconceptions and 5.77% of students do not understand the concept. Students have not been able to explain the concept of Newton's second law, namely the thrust when an object moves at a constant speed and $\sum F = m\,a$.

Newton's 3rd Law Indicator

The questions on Newton's third law indicators aim to determine students' understanding of concepts related to Newton's theories and describe the basic concepts

of Newton's third law. In this indicator, 38.46% of students already understand the concept, 50.00% have misconceptions, and 11.54% do not understand the concept. Students have not been able to explain Newton's third law design. According to students, the action-reaction force is a force that acts on a pair of two different objects, has the same sign, and the direction of the action force is opposite to the reaction force.

Indicator of Newton's Law Problem Solution

The problem on the indicator of the solution to Newton's law problems aims to determine the understanding of students' concepts related to Newton's law solutions. In this indicator 37.50% of students already understand the concept, 50.96% have misconceptions and 11.54% do not understand the concept. Students have not been able to solve Newton's Law questions about the resultant force on an object which is equal to zero, the shear force, and the magnitude of the influence of the object's motion.

Indicator of The Implementation of Newton's 1st Law in Daily Life

The indicator of the solution to Newton's first law problems in everyday life aims to determine the understanding of students' concepts related to Newton's first law solutions, namely the effect of altitude and the acceleration of gravity on the free-fall motion. In this indicator, 42.31% of students already understand the concept, 50.00% have misconceptions and 7.69% do not understand the concept. Students do not yet have a correct understanding that the motion of free fall is influenced by the height and acceleration of the earth's gravity.

Indicator of The Implementation of Newton's 2nd Law in Daily Life

The indicator of the application of Newton's second law in everyday life aims to determine the understanding of students' concepts regarding solutions to Newton's second law. In this indicator, 34.62% of students understand the concept, 61.54% have misconceptions and 3.85% do not understand the concept. Misconceptions occur in the characteristics of the frictional force of an object and the large workforce on cars and electric poles when they experience an impact.

Indicators of The Implementation of Newton's 3rd Law in Daily Life

The indicator of the application of Newton's third law in everyday life aims to determine the understanding of students' concepts regarding solutions to Newton's third law. In this indicator, 32.69% of students understand the concept, 53.85% have misconceptions, and 13.46% do not understand the concept.

Conclusions

Based on the results of research using a digital four-level diagnostic test instrument, it can be concluded that students have misconceptions about Newton's law material.

Misconceptions occur in all material indicators of Newton's law. The highest misconceptions occur in indicators of the application of Newton's second law in daily life (61.54%), while the lowest misconceptions occur in indicators of Newton's first law (48.08%). The percentage of students who experience misconceptions is 53.85% in the medium category. The main factor that affects students' misconceptions is the lack of interest in student learning due to teachers teaching only using the lecture method and practice questions, and students are not given real examples in delivering learning materials.

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