Identify misconception with multiple choice three tier diagnostik test on newton law material

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Abstract. Knowing the location of students 'misconceptions is one of the conditions for success to remediate students' misconceptions. An appropriate and effective way to identify the students' misconceptions is using a three-tier diagnostic test. After the students' misconceptions are identified, misconceptions are remediated using the conceptual change learning model. The purpose of this research is to identify misconceptions that are often experienced by students and their causes related to the concept of Newton's Law, describe how to remedy misconceptions of Newton's laws, and test the effectiveness of conceptual change learning models in remediating Newton's misconceptions experienced by students. This type of research is a mixed methods of concurrent embedded models with qualitative methods as primary methods, and qualitative methods as secondary methods. The pre-test results showed that the percentage of students' misconceptions on Newton's first, second, and third law concepts, solving, and applying were less than 60%. These misconceptions can be remediated by applying the Conceptual Change Learning Model. There was a decrease in the average percentage of the misconception of Newton's law from 50.9% to 25.9%. Therefore, the conceptual change learning model is considered effective in remediating the misconceptions of Newton's law experienced by students.

1. Introduction
Physics is the most fundamental of all natural science [1]. The Newtonian mechanics is a core topic in introducing physics, where Newtonian mechanics is based on the concept of Newton's laws [2]. Therefore, ideally students should be able to master the concept of Newton's law correctly, because Newton's law is the basis for them in studying physics. Therefore, misconceptions about Newton's law need to be minimized.

Misconception is one of the causes of students failing to understand physics concepts correctly [3]. The concept is a representation or description that is used by the mind to understand things that exist outside of language. A concept can be explained by educators verbally, namely with text or sentences so that the concept can be understood by students [4]. Understanding the concepts that students have is the result of student learning that they get from a learning process [5], understanding the concept that someone has is called conception [6].
Misconceptions as initial concepts that come from students' experiences and knowledge that are not in line with theories made by experts [7]. According to [8], misconceptions refer to conceptions that are contradictory or inconsistent with the concepts agreed upon by experts. So, it can be concluded that misconceptions are conceptions that are scientifically inaccurate and not in accordance with the concepts agreed upon by experts.

The right and effective way to identify student misconceptions is to use a multilevel diagnostic test. The diagnostic test is a test that prepared based on a detailed analysis that is able to assess students' conceptual understanding of key concepts on certain topics [9], and can diagnose learning problems faced by students [10]. The results of research by [11] show that the three-tier test predicts student misconceptions more accurately than two-tier test and the conventional multiple-choice test (one-tier test) because the three-tier test includes a two-tier test and the level of confidence of students in their answers.

Student misconceptions are difficult to remove completely, but can be remediated. In accordance with [12] statement, when there are indications of misconceptions, it is necessary to do remediation as soon as possible because resistant misconceptions will be difficult to remove. Therefore, after the students' misconceptions were identified using the three-tier diagnostic test multiple choice instrument, an effort was needed to remediate these misconceptions by turning them into scientific concepts. One of the ways to remediate misconceptions is by implementing a conceptual change learning model. This model is an appropriate learning model as an effort to remediate alternative conceptions or student misconceptions [13]. In this research, will be identifying of misconception related to the concept of Newton's Law, describe how to remedy misconceptions of Newton's laws, and tested the effectiveness of the conceptual change learning model in remediating student misconceptions.

2. Methods
The research design used was mixed methods of concurrent embedded research with quantitative methods as the primary method, and qualitative methods as secondary methods. The steps of quantitative research methods as primary methods and qualitative research methods as secondary methods are shown in Figure 1.

![Figure 1. Mixed methods research of concurrent embedded, with quantitative methods models as the primary method.](image)

This research was conducted at one of Senior High School at Central Java. The variables analyzed were the percentage levels of students' misconceptions and after the conceptual change learning model was carried out. This research is generally conducted in 3 stages, namely: pre-test to identify students 'wrong initial conceptions, the learning process of conceptual change, and post-test to identify students' final conceptions.

The research instrument used was a three-tier diagnostic test multiple choice, totaling 22 questions, a Likert scale sheet with 5 assessment aspects as many as 10 statement items, interview guidelines, and
the researcher as the main instrument in this study. The categories of student answers can be seen in Table 1.

| Answer Pattern                  | Categories       | Code |
|---------------------------------|------------------|------|
| Correct + Wrong + Sure          | Misconception    | M    |
| Wrong + Wrong + Sure            |                  |      |
| Wrong + Correct + Sure          |                  |      |
| Correct + Correct + Sure        | Understand       | U    |
| Correct + Wrong + Not Sure      |                  |      |
| Wrong + Wrong + Not Sure        |                  |      |
| Wrong + Correct + Not Sure      |                  |      |
| Correct + Correct + Not Sure    |                  |      |

The percentage of students who experience misconceptions, understand, or not understand is calculated using the formula:

\[ P = \frac{n}{N} \times 100\% \]  \hspace{1cm} (1)

\( P \) : percentage, \( n \): the number of students who experienced M/U/NU; \( N \): the total number of students.

The Likert’s scale sheet is used to determine student responses about the implementation of the conceptual change learning model in remediating student misconceptions on Newton's Law material. The percentage of student responses is calculated by formula (1). Structured interview question sheets were used to collect qualitative data.

3. Result and Discussion

This section will describe the results and discussion of research which includes: misconceptions of Newton's law that are often experienced by students, how to remediate the misconceptions of Newton's law, and the effectiveness of the conceptual change learning model in remediating the misconceptions of Newton's law.

3.1 Misconceptions of Newton's law that are often experienced by students

Based on the results of the pre-test using the three-tier diagnostic test instrument, data on the percentage of students who experienced misconceptions on the concept of Newton's law were shown in Table 2.

| Concept                          | Question Number | Misconception Percentage (%) |
|----------------------------------|-----------------|------------------------------|
| Newton's First Law               | 1, 2, 3, 15     | 60.4                         |
| Newton's Second Law              | 4, 6            | 44.4                         |
| Newton's Third Law               | 7, 8            | 56.9                         |
| Newton's law problem solving     | 9, 10, 11, 12, 13, 16, 22 | 44.8                       |
| Application of Newton's First Law| 5, 20           | 45.8                         |
| Application of Newton's second law| 14, 17, 18, 19 | 45.4                         |
| Application of Newton's third law| 21              | 58.3                         |

The percentage of misconceptions in this study was higher than the results of Tayubi’s study. The Tayubi’s research results show that 42.12% of students experience misconceptions on Newton's First Law; 17.08% of students have misconceptions on Newton's second law; and 50.83% of students have misconceptions on Newton's third law.

Recapitulation of student misconception profiles based on the results of the pre-test and interviews with students can be seen in Table 3.
Table 3. Recapitulation of Student Misconception Profiles

| Indicator | Findings of Misconceptions |
|-----------|-----------------------------|
| Students explain Newton's first law | 1. A moving object always represents Newton's second law  
2. The resultant force is zero, meaning the object is at rest or moving at a constant speed  
3. Newton's First Law causes the acceleration of objects to decrease because Newton's First Law always applies to stationary objects |
| Students explain Newton's Second Law | 1. Force can change the mass of an object  
2. Force cannot change the shape of objects  
3. The magnitude of force that forms an angle in the horizontal plane is proportional to the magnitude of the angle formed by the force  
4. Projections of vectors along coordinate axes  
5. The action-reaction force acts on the same two bodies |
| Students explain Newton's Third Law | 1. The friction force is in the same direction as the causing force  
2. Projections of vectors along coordinate axes  
3. The force that forms an angle to the plane has no effect on the motion of the object  
4. The tension force in the rope depends on the size of the rope  
5. There is a kinetic friction force on objects and floors that are in contact |
| Students solve Newton's law problems | 1. The normal force has a resultant force of zero because the object is at rest  
2. The normal force always equals the object's weight  
3. Trigonometry  
4. The calculation of the component of the force forming the angle involves the mass of the object, not the value of its force |
| Students apply Newton's first law in everyday life | 1. The correct equation for the tension force in the rope contains all the known quantities in the problem  
2. Free body diagram  
3. The direction of the thrust force is in the same direction as the positive object's motion  
4. On an inclined plane, the component of the vertical force uses the cosine of the angle  
5. The magnitude of normal force on the lift moving up is zero  
6. The force that affects the motion of an object on an inclined plane is the downward direction |
| Students apply Newton's second law in everyday life | The velocity of the object is directly proportional to the amount of force it exerts |

3.2 How to remediate misconceptions about Newton's laws
The conceptual change learning model by [14] has the following learning phases: (1) knowing the students' conceptions, (2) creating conceptual conflicts, (3) equilibrating processes, and (4) reconstructing students' conceptions. In practice, the learning phases use the conceptual change learning model such as: creating conceptual conflicts, equilibration processes, and reconstructing learners' conceptions; carried out in line with the arrangement of material delivery by educators to students.

There are two ways in which conception can grow and develop, namely by assimilation and accommodation. Conception assimilation is a combination of new conceptions into old conceptions in one's cognitive process [15]. If a new conception cannot be assimilated with an old one (conceptual conflict occurs), then accommodation is needed.

In order for the accommodation process to take place, students must feel dissatisfied with the conceptions they have, so that students have conflicts with their initial conceptions. After students have dissatisfaction with the conception, educators need to introduce a new concept that is in accordance with the conception of experts. The new concept requirements to be introduced to students are clear, logical, and useful concepts for students [16].

After the students' conceptions were identified based on the results of the pre-test and interviews, the researcher then created a conceptual conflict so that students experienced conflicts with their initial conceptions. The conceptual conflict is in the form of a refutation of the students' initial conceptions. After refuting the students' initial conceptions, the researcher then carried out the equilibration process by proving the concepts and principles through demonstrations, analogies, or examples that could challenge students' misconceptions. The equilibration process is carried out based on the stages of student cognitive development, namely the formal operational stage. At this stage, intelligence is shown through the use of logical symbols related to abstract concepts.

The scale sheet is given after the conceptual change model learning is implemented. Granting a scale aims to determine student opinions regarding the implementation and success of the conceptual change learning model in remediating student misconceptions on Newton's law material. The percentage of students' answers who answered very agree (VA), agree (A), disagree (D), and very disagree (VD) on each aspect of the statement can be seen in Table 4.

| No. | Aspects of The Assessment                                | Percentage of answers (%) |
|-----|----------------------------------------------------------|---------------------------|
|     |                                                          | VA | A  | D  | VD |
| 1.  | The ability of educators to deliver material            | 50.0 | 48.6 | 1.4 | 0.0 |
| 2.  | The ability of educators to relate a material           | 51.4 | 47.1 | 1.4 | 0.0 |
| 3.  | Educator responses to student questions                 | 42.9 | 57.1 | 1.4 | 0.0 |
| 4.  | Students' awareness of their misconceptions              | 41.9 | 49.5 | 8.6 | 0.0 |
| 5.  | Student responses to conceptual change learning models  | 42.9 | 54.3 | 2.9 | 0.0 |
|     | Average                                                 | **45.8** | **51.3** | **3.1** | **0.0** |

| 3.3 The effectiveness of the conceptual change learning model in remediating the misconceptions of Newton's law |

The recapitulation of the percentage of Newtonian law misconceptions experienced by students before and after learning conceptual change can be seen in Table 5. Based on Table 5 in the post-test section, it can be seen that there are still students who experience misconceptions of Newton's law, and there is even an increase in the percentage of misconceptions on the indicators of applying Newton's second law, from 45.4% to 57.1% after learning conceptual change. This can be caused by several factors, such as: school dispensation during learning, lack of students' ability to communicate opinions, lack of research time required, students' lack of understanding of vector material, limited ability of researchers.
The results of this study are in line with [17] research. Other studies supporting the misconception of Newton's laws of this research is [18].

Cognitivism learning theory views learning as a process of organizing cognitive aspects that are strongly influenced by the internal thinking process during the learning process to gain perception and understanding. But if students do not follow the learning process completely it will affect the process of organizing aspects the cognitive aspects of students. Table 5. Recapitulation of Percentage of Misconceptions Based on Pre-Test and Post-test Results

| Indicator                          | Question Number | Pretest (%) | Postest (%) |
|------------------------------------|-----------------|-------------|-------------|
| Newton's First Law                 | 1, 2, 3, 15     | 60.4        | 10.7        |
| Newton's Second Law                | 4, 6            | 44.4        | 21.4        |
| Newton's Third Law                 | 7, 8            | 56.9        | 20.0        |
| Newton's law problem solving       | 9, 10, 11, 12, 13, 16, 22 | 44.8 | 32.2 |
| Application of Newton's First Law  | 5, 20           | 45.8        | 22.9        |
| Application of Newton's Second Law | 14, 17, 18, 19  | 45.4        | 57.1        |
| Application of Newton's Third Law  | 21              | 58.3        | 17.1        |
| Average                            |                 | 50.9        | 25.9        |

Piaget's learning theory states that a person's cognitive development will lead to many viewpoints and alternative actions through social interactions that occur. If students are less able to communicate their opinions, it will affect the student's learning process through social interactions, both with peers and with teachers, so that it will affect the cognitive development of these students. Based on the observations and experiences of researchers in the field, many students felt doubtful and did not dare to ask questions when researchers gave students the opportunity to ask questions, so that it might have an effect on the remediation process of the misconceptions they experienced.

4. Conclusion

Based on the results of research and discussion, it was concluded that the percentage of students' misconceptions on Newton's first, second, and third law concepts were 60.4%, 44.4%, and 56.9%, respectively. The percentage of misconceptions in solving Newton's law problems is 44.8%, and the percentage of misconceptions in applying Newton's laws I, II, and III are 45.8%, 45.4%, and 58.3%, respectively. Remediating the misconceptions of Newton's law can be done by applying conceptual change learning. There was a decrease in the average percentage of Newton's law misconceptions, from 50.9% to 25.9%, so it can be said that the conceptual change learning model is considered effective in remediating the misconceptions experienced by students.

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