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Analysis of Physics Misconceptions of Students in Mechanic Materials Using the Tier Multiple Choice Diagnostic Test

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ABSTRACT

Misconception is a problem in physics education that affects both teachers and students and stops them from fully accomplishing their learning goals. It is a problem that haunts both teachers and students. The four-tiered test is a useful tool for determining the misconceptions that students have based on the reading of the literature. In spite of this, there are not a lot of diagnostic tests in the form of a four-tier test, one of which is on the topic of business and energy. The aim of this study is to examine the misconceptions held by students in class XI of the Senior High School in Medan regarding mechanics-related material. The study under consideration employs a descriptive qualitative research approach. The study involved a total of 377 student volunteers who were selected from six distinct educational institutions situated within the urban area of Medan. The present study employed a diagnostic test instrument comprising of 25 items and questionnaire sheets, utilising a multiple-choice format with four tiers. According to the findings, 9.1% of the students are able to comprehend the idea, 19.2% do not comprehend the idea, 26.2% are only partially comprehending, 41.4% were able to overcome their misconceptions, and 4.1% of the students could not be coded. Consequently, the level of students' misunderstandings of physics material related to mechanics at Senior High School in Medan falls into the medium category. After the conclusion of this study, a diagnostic test was created internally, employing a four-tier structure, specifically designed for assessing mechanical materials. As a result of this technological progress, instructors are now able to more easily identify and address students' misconceptions pertaining to the subject matter. This study can provide a basis for future research by serving as an initial stage of development.

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1. INTRODUCTION

Article 4 of Law no. 2 of 1989 explains that the purpose of national education is to educate the life of the nation and develop a complete Indonesian human being. Human beings who believe in and fear God Almighty and have a noble character, as well as human beings who have knowledge and skills, physical and spiritual health, a personality that is stable and independent, as well as a sense of social and national responsibility, are the types of people that the Indonesian government wants to see educated(Oktavia & Admoko, 2019). The teaching and learning process, also known simply as the teaching process, refers to the activity of carrying out the curriculum of an educational institution in such a way that it can influence students to attain certain educational goals that have been specified (Soeharto & Csapó, 2021). A teacher as an educator has a very important role and influence on students in building the character of students at school, and must be able to create an atmosphere study teach that is active, pleasant, and makes students impressed in learning activities in order for students to be able to absorb and receive the knowledge they get as a provision for their future life. In order to achieve these educational goals, a teacher has a very important role and influence on students in building the character of students at school (Samsudin et al., 2021). One of the learning goals, particularly in disciplines dealing with physics, is to guide students to a point where they are able to master physics concepts and apply these physics concepts to everyday life (Aprita et al., 2018).

The reality in the field generally still focuses on teachers as learning resources or teacher-centred. This can cause students to not always be able to fully absorb the knowledge that is being transmitted by educators, particularly in physics courses which contain many scientific concepts, so that sometimes the concepts that students grasp are not acceptable or different from the notions that are adopted by professionals. This is especially true in physics disciplines which contain many scientific concepts (Capriconia & Mufit, 2022);(Budi Bhakti et al., 2022). Students frequently encounter misconceptions or alternative notions, which refer to incompatibilities in their conceptual understanding. These incompatibilities are called alternative concepts. Because misunderstandings are, in a sense, mistakes, they provide a significant barrier for students in their efforts to comprehend and become proficient with the subject matter (Entino et al., 2021);(Kaltakci Gurel et al., 2015).

Misconceptions or wrong concepts, as defined by Nainggolan (2016), are ideas that conflict with the scientific consensus or the general acceptance of experts. For example, some students could think that if an automobile is being pushed by another person but hasn't moved, then there is no force acting on it. This idea is flawed due to the fact that even if the car is not moving, there is still a force acting on it as a result of the push; nevertheless, the resultant of this force is zero because of the frictional force (Juliper, 2016). Conducting a diagnostic test is one strategy for determining whether or not students hold misunderstandings. Diagnostic tests are standardized examinations that can be administered to pupils to precisely determine areas in which they struggle academically and those in which they excel (Maison et al., 2020);(Fariyani et al., 2017). This false belief is a severe issue for pupils since it can obstruct their ability to acquire new knowledge. S. Sadhu asserts that if misconceptions are recognized as soon as feasible, they can be reduced. If adequate identification is done, the instructor can also decide the best course of action to turn these myths into scientific notions. In addition to addressing the issue of this misconception's existence, there is something even more crucial to address: the issue of the misconception's root causes. According to some researchers, this misconception can be caused by several sources including the students themselves, the teacher's way of teaching, the textbooks used, and students' prior knowledge. Research conducted by Maharani et al. (2019) Misconceptions in learning physics is not a strange thing considering that physics is an abstract science so it is very prone to misconceptions. Mechanical waves are one of the topics that is important to recognize the presence of misconceptions at the improper high school level. Because waves are an abstract concept and often occurring phenomena involving waves exhibit qualities that are inconsistent with what they are studying, many students are puzzled (Soeharto & Csapó, 2021);(Budi Bhakti et al., 2022). Of course, the proper techniques or devices are required in order

to detect the presence of this misunderstanding. Up until quite recently, the type of diagnostic instrument that was employed was multilevel multiple-choice examinations.

Multiple-choice questions have been devised from a one-tier to a two-tier, three-tier, and even a four-tier system to identify students' misunderstandings (Banawi et al., 2022). The three-tier diagnostic test was developed into the four-tier diagnostic test, which consists of multiple choice questions with three distractors and one answer key that students must choose, the level of confidence that students have in choosing answers, and students' reasons for answering questions, with three reasons students answer questions and one open reason. The three-tier diagnostic test consists of multiple-choice questions with three distractors and one answer key that students must choose. As well as the degree to which the student is self-assured while selecting justifications (Entino et al., 2021);(Tumanggor et al., 2020). An incorrect understanding of ideas expressed in a statement. In the meantime, Feldsine argues in Suparno that a mistake is an inaccuracy and a misplaced link between ideas. Misconceptions can manifest themselves in many different ways, including incorrect assumptions, false associations, illogical reasoning, and naive perspectives.

According to the explanation provided, a misunderstanding is defined as an original concept owned by students and not appropriate with explanations commonly accepted as a consequence of experiences made by students. This definition comes as a result of the explanation that has been supplied (Dirman et al., 2022); (Siswaningsih et al., 2014). Because the use of the word alternative idea is founded on experiences generated by students, and because often contextually alternative notions make sense and are appropriate for some of the challenges experienced by students, misconceptions can also be referred to as alternative concepts (Mustari et al., 2020);(Negoro & Karina, 2019).

In this study, only student factors, which were specifically divided into several specific sections such as student preconceptions, associative thinking, humanistic thinking, incomplete/incorrect reasons, wrong intuition, stages of student cognitive development, student abilities, and student learning interest, were considered as potential contributors to misconceptions (Susanti, 2021). Of the eight special reasons above, this research is limited to only reviewing the factors that contribute to misunderstandings, based on the learning interests of the pupils (Jannah & Rahmi, 2020);(Roza, 2022). Interest is a condition that is experienced by someone when observing a situation or activity that is in accordance with the wishes or needs (Domyancich, 2014). The test is an objective test that consists of a description of an incomplete understanding, and in order to complete it, you must choose one of the potential solutions. The test is also known as multiple-choice test. Only one solution may be selected from the possibilities (possible answers), and the others are distractions (Arikunto, 2010). The most commonly used multiple choice is one-tier multiple choice, for each item of questions consists of one part, namely the choice of answers to questions. The three-level multiple-choice diagnostic test was the precursor of the current four-tier diagnostic test that has been developed (Ammase et al., 2019). This improvement can be seen in students' increased level of self-assurance while selecting responses and reasoning. At the beginning, pupils will be presented with a multiple-choice question with four possible incorrect answers and one correct one. The students' levels of self-assurance in selecting appropriate responses constitute the second level. The third level consists of the students' justifications for their responses to the questions, which can be presented as one of four predetermined justifications or as an open justification. The student's level of confidence in selecting appropriate justifications is the topic of the fourth level (Sukarelawan et al., 2019).

Before learning, Misconceptions and the factors that contribute to them can be uncovered with the help of the Four Tier Multiple Choice Diagnostic Test. The results of the pre-learning diagnostic test can be used to figure out the students' preconceptions about the topic, allowing the teacher to modify the learning design to fit those preconceptions and transform the students' preconceptions into scientific ones in order to decrease the number of misconceptions. This test can be administered both before and after instruction to obtain student performance during instruction. Due to the previous discovery of misconceptions, it is anticipated that the use of the Four-Tier Multiple-Choice Diagnostic Test on these students will be the first step in reducing the amount of misconceptions detected in students will be able to give an overview of instructional strategies that meet the needs of the pupils.

2. METHODS

This study was carried out in one of Medan's senior high schools as part of a larger study. This study was carried out during the even semester of the academic year. The steps that were taken from the beginning to the very finish of the research project. A technique known as proportional stratified random sampling was utilized throughout the course of this investigation to identify the schools that would serve as research samples. Using the technique of proportionate stratified random sampling, samples were obtained consisting of higher, medium, and lower stratas, each of which acquired two schools for each stratum, namely SMAN 3 Medan, SMAN 5 Medan, SMAN 6 Medan, SMAN 8 Medan, SMAN 12 Medan, and SMAN 16 Medan. Additionally, samples were obtained consisting of upper, middle, and lower stratas, each of which obtained two schools for each stratum. The stages of this research involved making observations, preparing research instruments, testing those instruments, carrying out the Four Level Multiple Choice Diagnostic Test, collecting data, and analyzing that data. The technique of purposive sampling was utilized to choose the sample for this investigation. 63 individuals were chosen at random to participate in this study. All of these individuals were seniors at one of Medan City's senior high schools.

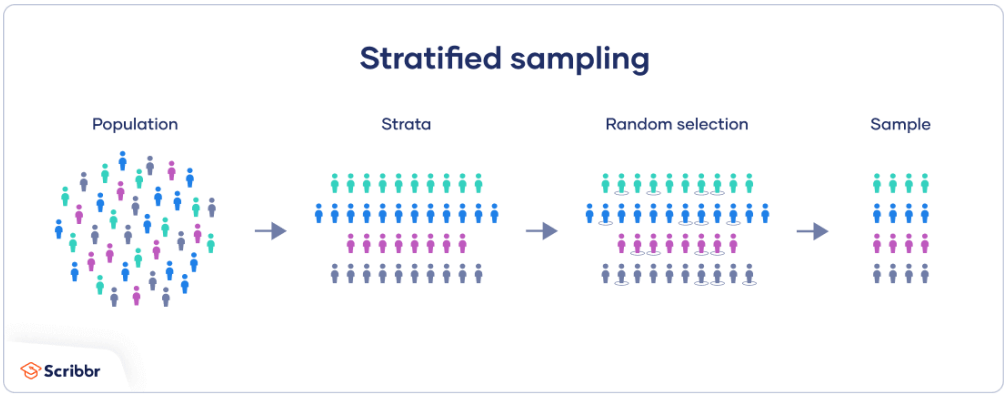

Figure 1. Proportional stratified random sampling technique design, sample

3. FINDINGS AND DISCUSSION

3.1 Findings

The level of misunderstanding that each of the 377 senior high school students in Medan had regarding mechanics is summarized in Table 4.1, which can be found below.

Table 1. The Level of Misconceptions that All Senior High School Students in the City of Medan Have Regarding the Material of Mechanics

Conclusion									
PK		TPK		PS		M		TKD	
Σ	%	Σ	%	Σ	%	Σ	%	Σ	%
855	9.1%	1807	19.2%	2472	26.2%	3903	41.4%	388	4.1%

If the percentage of data in Table 3 above is displayed in the form of a round graph, it will look like in Figure 1 below.

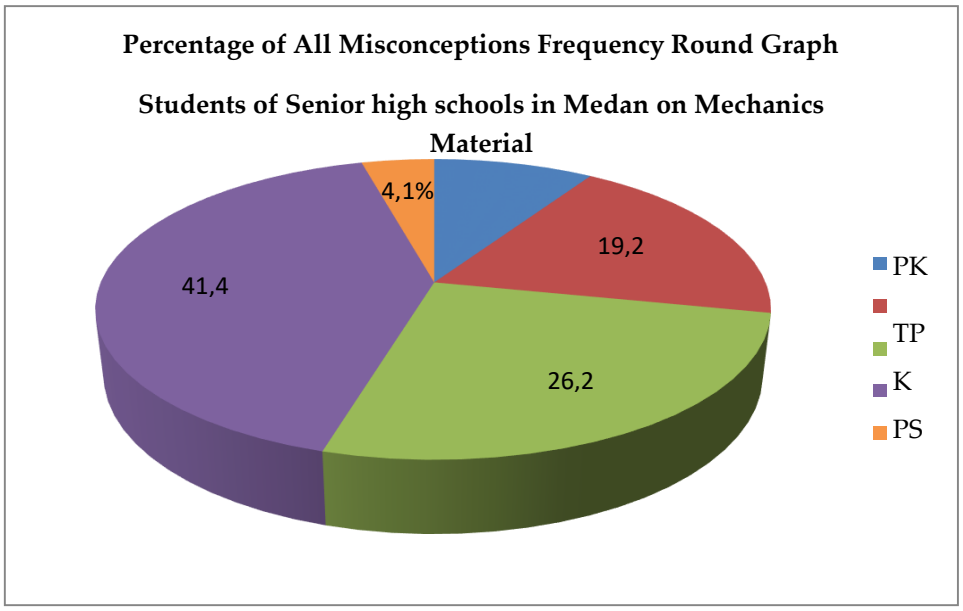

Figure 2: A Round Graph Showing the Percentage of Students at Senior High Schools in Medan Who Have a Frequent Misconception Regarding the Material Studied in Mechanics

According to the findings of the data analysis presented in the table that is located above, it is possible to draw the conclusion that the degree of misconceptions (M) held by all students attending senior high schools in Medan falls into the medium category at a rate of 41.4%. While only 9.1% of all high school pupils in the city of Medan fall into the low group for their level of grasp of the concept (PK), this level of understanding is low overall. In the meantime, the percentage of high school students in Medan who did not comprehend the concept of mechanics (TPK) was 12.2%, the percentage of high school students in Medan who only partially comprehended (PS) the concept of mechanics was 26.2%, and the percentage of high school students in Medan who cannot be coded (TKD), because they do not fill in one, two, three, or all of the answers on the answer sheet, was 4.1%.

According to the results of the questionnaire, it was discovered that various causes produced student misunderstandings, and these elements were investigated for each statement item. These factors are as follows:

1) The lack of interest shown by students in learning about the subject of mechanics (63.7%), particularly in the study of concepts related to physics (53.6%).
2) The content on mechanics that is covered in physics classes is regarded as being overly uninteresting by 58.6% of students.
3) The subject matter of physics is difficult to comprehend (56.5% of people) and to recall (53.3% of people).
4) The lack of interest shown by students in working on physics problems, in particular content pertaining to mechanics (58.9%).
5) Students have less interest in studying physics because there are a lot of formulas to master (53.6% of students).
6) Students' poor engagement in asking questions (56%) and expressing comments (58%) can be attributed to students' laziness (69.8%), as well as students' reluctance (51.7%) to work on physics problems in front of the class.
7) Students' lack of interest in reading physics texts (65.8% of the respondents).

8) Test preparation is when students study physics the most (56.8% of the time), whether for a quiz or an exam.
9) Only 61.3% of students complete physics homework or problems when they are working on them at home.
10) When studying physics, students frequently experience feelings of boredom (61.3%).

The findings research of Mustari et al. (2020), which highlight the sources of misunderstandings, are likewise consistent with this conclusion. In addition to finding that students' carelessness was one of the causes, they also discovered that 54.10% of the misconceptions they gathered from students were primarily brought on by humanistic thinking. According to Saputra et al., (2019);Muhdi et al., (2020), the student's early knowledge can have an impact on the causes of this student's thinking . There are sources of causes from the teacher's explanation or method of instruction in addition to the source of the causes of their own thinking.

3.2 Discussion

Concepts are a means of categorising objects, events, and characteristics by grouping them together based on shared properties. The idea in question has been described as a cognitive factor that aids in the simplification and summarization of information. It serves as a means of mentally categorising and grouping items or occurrences that share certain similarities. According to some individuals, the concept serves as a mechanism for organising diverse knowledge and experiences into distinct categories. It is considered an abstract notion that is derived from specific instances. Alternatively, a more specific viewpoint posits that concepts can be identified as objects, events, situations, or characteristics that possess a defining attribute and are universally represented across cultures through signs and symbols. Therefore, a concept can be regarded as a fundamental element of cognition or an abstract notion that lacks independent existence but is interconnected inside the dynamic framework known as the conceptual system. The idea characteristics can be classified into seven dimensions. Every notion possesses various properties. In terms of the interrelation or conjunction of qualities.

Based on its organisation, the concept can be categorised into three distinct types: (a) Conjunctive concept, characterised by possessing two or more properties that collectively qualify it as an exemplary concept; (b) Disjunctive concept, requiring the presence of at least one of multiple characteristics; and (c) Relational concepts, which pertain to the interrelationships among attributes of a concept. The level of abstractness pertains to whether a notion is perceptible and tangible, or if it is composed of other interconnected concepts. The principle of inclusiveness is exemplified by the various cases included. The idea of generality may exhibit variations when categorised in either superordinate or subordinate positions. The concept of accuracy pertains to the presence of a defined set of rules that may effectively differentiate between instances that exemplify a certain concept and those that do not. Strength: The degree to which individuals concur on the significance of a concept determines its importance.idea acquisition can be accomplished through two distinct processes, namely idea generation and concept assimilation. Concept formation is a cognitive process characterised by the use of inductive reasoning. When individuals encounter external stimuli, they engage in the abstraction of specific features or attributes that are shared across several inputs. The aforementioned procedure can be classified as a variant of discovery learning. Concept assimilation is the primary method of acquiring concepts both before and after formal education. This approach aligns with the constructivist perspective, which posits that students play an active role in constructing information according to their individual understanding. This process occurs within learning environments that afford opportunities for students to engage in meaningful learning experiences.

A misconception refers to an erroneous comprehension of a particular concept, wherein an individual may employ an incorrect concept, misclassify examples of the concept, or exhibit confusion regarding the hierarchical or relational structure of concepts. The assessment instrument is categorised into three distinct components for evaluating pupils, including diagnostic tests, formative tests, and

summative tests, each serving a specific purpose in measuring their academic progress and performance. The diagnostic test is employed to identify the areas of weakness in students. The formative assessment is employed to ascertain the degree to which pupils have undergone development following their participation in a specific programme, whilst the summative assessment is utilised to examine a broader programme. The diagnostic exam is a tool utilised to identify the areas of weakness experienced by students, enabling the implementation of suitable interventions. A diagnostic assessment is a form of evaluation designed to identify areas of weakness in students and determine the underlying factors contributing to these deficits. The process of diagnosis is multifaceted, involving the analysis of symptoms, the estimation of potential causes, observation, and the accurate categorization of findings.

The findings of a study of research data on pupils of Senior High School in Medan who were taught mechanics revealed a very low level of conceptual understanding on the part of these students. The findings of the analysis of the data revealed that only 9.1% of students had a conceptual comprehension of the mechanics questions that were presented to them; 19.2% of students did not understand the idea; 26.2% of students only had a partial understanding; 41.4% of students had misconceptions; and 4.1% of students were unable to be coded. According to the findings of the investigation into the misunderstandings held by each individual student, 65.3% of the total number of pupils hold a level of misconceptions that is considered to be moderate.

4. CONCLUSION

Based on the findings, several inferences can be inferred. The present study involved an examination of students' misconceptions regarding physics in the field of mechanics. This investigation utilised a four-level multiple choice diagnostic test specifically designed for class XI students. The findings of this analysis are as follows: According to the data, it was found that 9.1% of the student population had a comprehensive understanding of the mechanical principles. Conversely, 19.2% of students exhibited a lack of understanding in this area. Additionally, 26.2% of students only possessed a partial grasp of the idea, while 41.4% of students displayed misconceptions. Lastly, a small proportion of students, namely 4.1%, could not be categorised due to insufficient data. Overall, the schools included in this study exhibited a prevalence of pupils holding erroneous views on the present category. The classification of students' misconceptions pertaining to each sub-concept within the mechanics domain can be delineated as follows: The present study examines the prevalence of students' misconceptions in various sub-concepts of kinematics and work-energy within the domain of physics education. Specifically, the sub-concept of 2-dimensional motion kinematics (bullet motion) exhibits a misconception rate of 59.5% among students. Similarly, the sub-concept of one-dimensional motion kinematics demonstrates a misconception rate of 52.4%. Lastly, the sub-concept of work and energy reveals a misconception rate yet to be specified. Based on the results of a survey study conducted on a subset of students, it has been determined that many elements play a role in the development of students' misconceptions regarding the field of physics. Several factors contribute to the challenges faced by students in studying mechanics, particularly the study of physics concepts. These factors encompass a lack of student interest in the subject matter, a perception among students that the mechanics material covered in physics classes is uninteresting, and a belief that physics subject matter is difficult to comprehend and retain. Additionally, students tend to engage with physics studies primarily in the immediate period preceding a test or exam, rarely dedicating time to completing physics questions or exercises at home. Furthermore, students frequently express feelings of boredom when engaging with physics content.

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