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ANALYSIS OF STUDENT'S MISCONCEPTIONS USING FOUR-TIER DIAGNOSTIC TEST IN BUSINESS AND ENERGY MATERIALS OF STUDENTS

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Abstract :
Misconception is one of the causes of a student's learning difficulties. This study aimed to obtain information about whether there were students' misconceptions about work and energy and the factors that caused these misconceptions. The population of this research is class X Negeri 1 Kupang students. The data collection technique used in this study was a written test instrument with multiple choices, totaling 10 questions and documentation. This research method uses quantitative research with research data consisting of quantitative data and qualitative data. The subjects of this study were class X SMA Negeri 1 Kupang students. Data collection methods include tests and documentation of student work. The four-tier diagnostic test consists of 4 levels: questions with answer choices, choice of answer confidence level, choice of reasons, and choice of confidence level of reason. The results of the study show that the category of misconceptions about work and energy by students of SMA Negeri 1 Kupang is in the moderate category.

Keywords: Misconception; Physics Education; Students

INTRODUCTION

Education is an aspect of national life in educating the life of the nation, the success of the implementation of education is inseparable from the success of the education staff in implementing the educational activities of one of the educational staff, namely the teacher. Teachers are professional educators with the main task of educating, teaching, guiding, directing, and training to assess and evaluate students in early childhood, formal, basic, and secondary education (Depdiknas 2006). Education is one form of effort toward maturity in life.

Through a good education, a person can change towards a better one in terms of knowledge, attitudes, and skills so that it is expected to be a good provision for living together in society. This is obtained through a good learning process as well.

Physics is part of the Natural Sciences consisting of several aspects, namely the purpose of Natural Science as a tool to control nature and contribute to the welfare of mankind. Physics subjects demand several advantages, including experimentation and reasoning. In addition, there are abstract physics concepts, so many physics think that physics lessons are difficult (Puji, 2016: 3). This also

affects the results of learning Physics students. Two factors influence student physics learning outcomes, namely internal factors (from within the student), including physiological factors and psychological factors (interest, talent, intelligence, motivation, and cognitive abilities such as perception, memory, thinking, and basic knowledge abilities owned). External factors, such as family, school, and community, come from outside the students. One of the internal factors that support the success of learning physics is the causality ability of students.

In physics education, educators often find that students have an initial concept at first glance before entering the learning space where these concepts are not the same or different from scientific concepts; that conception is called preconception. One of the low student learning achievements is due to a preconception different from the scientific concept that students bring before entering the learning space using a different concept by using the wrong concept and clarifying wrong examples. Confusion of different concepts and a concept that is not appropriate with a concept that is recognized by experts, then it is called a misconception. Therefore, this study aims to obtain information about whether there are students' misconceptions about work and energy and the factors that cause them.

RESEARCH METHOD

This type of research uses quantitative research. The research data is quantitative data and qualitative data. Quantitative data is students' understanding when working on the fourth-level multiple-choice questions given. Meanwhile, qualitative data are misconceptions or wrong understanding and the causes of the concept of Work and Energy found in students through a diagnostic test (four-tier diagnostic test). This misconception research focuses on the phenomenon of Business and Energy misconceptions only, ignoring other phenomena, such as the learning methods and books used in learning. This research will describe the phenomenon of Business and Energy misconceptions that occur.

This research was started by making a research instrument in the form of a level four diagnostic test and documentation. after that, it is given to students as face-to-face or offline research samples. Based on the written test, participants must answer questions according to their understanding. The next step is the researcher processes the participants' answers to obtain the expected data. The data will be analyzed later so that information can be obtained about the level of misconceptions held by students based on interpretation guidelines. Then, the results of the analysis of the questions are associated with a combination of four-tier multiple-choice answers used to classify the answers given by students. the combination of answers from the four-level multiple-choice diagnostic test results was divided into four criteria: understanding the concept, not understanding the concept, misconception, and error. The classification of students who understand, do not understand, misconceptions, and errors (Ismiara Ismail 2015).

The population is a subject generalization area with certain characteristics to study and draw conclusions (Sugiyono, 2016). The population was students of class X IPA, SMA Negeri 1 Kupang. For sampling, the researcher uses a quota sampling technique which is a technique for determining the sample the researcher is free to determine the sample up to the desired amount (quota) from a population that has certain characteristics (Sugiyono, 2008: 85). Therefore, sampling in this study was carried out by selecting students as samples until the minimum sample was met.

In this research, steps are needed, namely collecting technical data and supporting data. The data required are diagnostic test Data and data documentation. Furthermore, the data collected is used to calculate and perform data that can be presented under the problems encountered in this research. The data analysis technique carried out in this study first grouped the student test results into several categories, namely Understanding Concepts, Not Understanding Concepts, and Misconceptions, according to the criteria contained in Table 1

Table 1. Interpretation of Four-Tier Diagnostic Test Results

Answer	Answer Confidence	Reason	Faith of Reason	Criteria
True	Sure	True	Sure	Understand
True	Sure	True	No	Do not understand
True	Sure	False	No	
True	No	True	Sure	
True	No	True	No	
True	No	False	No	
False	Sure	True	No	
False	Sure	False	No	
False	No	True	No	
False	No	False	No	
True	Sure	False	Sure	Misconceptions
True	No	False	Sure	
False	Sure	False	Sure	
False	No	False	Sure	
False	Sure	True	Sure	Error

Second, calculating the percentage value of students who understand concepts, do not understand concepts, and have misconceptions using the equation proposed by Sudijono (2015) as follows:

$$P = \frac{f}{N} \text{ x } 100\% \quad (1)$$

P is the percentage value of student answers, f is the frequency of student answers, and n is the number of students. Third, the results of calculating the percentage value are then described in tables and diagrams. Fourth, categorizing student diagnostic test results and calculating the percentage of student misconceptions then categorizing student misconceptions based on (Kurniawan & Muliyani, 2018).

0%< Misconception <30% : Low

30%< Misconceptions <70% : moderate

70% Misconception ≤100% : high

RESULTS AND DISCUSSION

RESULTS

The data obtained from the results of the four-teir diagnostic test were implemented and grouped into understanding the concept, not understanding the concept, misconceptions and errors in the question indicator table for each item.

Table 2. Percentage of students who understand the concept of Class X SMA Negeri 1 Kupang

No	Inditacor Test	No Item	Students	%
1	Business concept	1	42	67
		2	29	46
		4	54	87
2	Problem solving with the scientific method on the concept of mechanical effort	3	52	83
		5	42	67
		6	32	51
3	Solving problems with the scientific method on the relationship between work and energy.	7	32	51
		8	20	32
		9	33	53
		10	16	52

Table 2 shows the grouping of students who understand the concept of each item. Overall students who understand the concept of each item, namely the business concept of question numbers 1, 2 and 4 are 67%, 46% and 87% respectively. In the problem solving indicators with the scientific method on the concept of mechanical effort in question numbers 3, 5, and 6, respectively 83%, 67%, and 51%. In the problem solving indicator with the scientific method on the relationship between effort and energy in question numbers 7, 8, 9, and 10 respectively 51%, 32%, 53% and 52%. From the grouping data of students who understand the concept above it is found in question number 10 with a low level of student understanding where in question number 10 there are only 16 students who understand the concept out of 62 students who take the test.

Table 3. Percentage of students who do not understand the concept of Class X SMA Negeri 1 Kupang

No	Inditacor Test	No Item	Students	%
1	Business concept	1	2	3
		2	6	9
		4	1	1
2	Problem solving with the scientific method on the concept of mechanical effort	3	3	4
		5	11	17
		6	8	13
3	Solving problems with the scientific method on the relationship between work and energy.	7	12	19
		8	16	25
		9	7	11
		10	12	19

Tabel 3 shows students who do not understand the concept of each item. Overall students who did not extinguish the concept in the indicator of business concept questions with question numbers 1, 2, and 4 respectively 3%, 9% and 1%. In the problem solving indicators with the scientific method on the concept of mechanical effort in question numbers 3, 5, and 6 respectively 4%, 17% and 13%. In the problem solving indicators with the scientific method between effort and energy in question numbers 7, 8, 9, and 10 respectively 19%, 25%, 11%, and 19%.

Table 4. Percentage and Criteria for Misconceptions in Students of SMA Negeri 1 Kupang

No	Inditacor Test	No Item	Students	%
1	Business concept	1	18	29
		2	27	43
		4	7	11
2	Problem solving with the scientific method on the concept of mechanical effort	3	11	17
		5	8	13
		6	20	32
3	Solving problems with the scientific method on the relationship between work and energy.	7	20	32
		8	26	41
		9	29	32
		10	34	54

Based on table 4, it is known that all class X students of SMA Negeri 1 Kupang experience the most misconceptions about the business concept question indicator in the second question number by 43% with moderate misconception criteria and on the problem solving indicator with the scientific method on the relationship between business and energy in question number eight is 41% with moderate criteria and in question number ten is 54%. Meanwhile, the problem indicator that experienced the lowest misconceptions was the problem solving indicator with the scientific method on the concept of mechanical effort in question number four of 11% with low misconception criteria.

Table 5. The percentage of students who made errors in Class X SMA Negeri 1 Kupang

No	Inditacor Test	No Item	Students	%
1	Business concept	1	0	0
		2	0	0
		4	1	1
2	Problem solving with the scientific method on the concept of mechanical effort	3	0	0
		5	1	1
		6	2	3
3	Solving problems with the scientific method on the relationship between work and energy.	7	0	0
		8	0	0
		9	2	3
		10	0	0

Based on table 5 there were 6 students who experienced errors, namely in the indicator question on the concept of effort in question number 4 there was 1 student who experienced an error, in the indicator problem solving questions using the scientific method with the concept of mechanical effort in question number 5 there was 1 student and number 6 there were 2 student. In the problem solving indicator problem with the scientific method on the relationship between work and energy in question number 9 found 2 students.

Interpretation of four-teir diagnostic test results

The data obtained from the results of the Fuor-Tier Diagnostic Test were interpreted to group into the criteria of understanding, not understanding, misconceptions and errors on the question indicators as well as on each student.

Table 6. Results of achievement of understanding, not understanding, misconceptions, and errors from each question indicator

No	Inditacor Test	No Item	PK		TPK		M		E	
			N	%	N	%	N	%	N	%
1	Business concept	1	42	67	2	3	18	29	0	0
		2	29	46	6	9	27	43	0	0
		4	54	87	1	1	7	11	1	1
2	Problem solving with the scientific method on the concept of mechanical effort	3	52	83	3	4	7	17	0	0
		5	42	67	11	17	8	13	1	1
		6	32	51	8	13	20	32	2	3
3	Solving problems with the scientific method on the relationship between work and energy.	7	32	51	12	19	20	32	0	0
		8	20	32	16	25	26	41	0	0
		9	33	53	7	11	20	32	2	3
		10	16	52	12	19	34	54	0	0

PK = Understand
TPK= Don't understand the concept
M= Misconceptions
E= Error

DISCUSSION

Misconceptions About Work And Energy Material Experienced By Students

Level four diagnostic tests (four teir diagnostics) are used to analyze student misconceptions from each item that has been validated. The results of the data analysis above show that students of SMA Negeri 1 Kupang experience misconceptions in all the items on the diagnostic test tested. This is evidenced according to the table above, where in each item there are students who experience misconceptions. The following details the misconceptions experienced by SMA N 1 Kupang students.
Misconception analysis on each question indicator

a. Business concept

In this indicator, there are 3 questions which are the first, second and fourth question numbers.

Question number 1 students are confronted with a question of the force acting so that it causes objects to move along a straight line and in the direction of the force then students are asked to understand the statement above defines the concept….. In question number one there are 42 students who understand the concept, with a percentage of 67% 2 students who fall into the category of not understanding the concept, with a percentage of 3%, and 18 students who experience misconceptions from 62 students of SMA Negeri 1 Kupang who take the test, with a percentage of 29% with low misconception criteria. After being analyzed, the answers of students who experienced misconceptions were divided into 2 groups where the first group answered level 1 correctly, level 2 was sure, level 3 was wrong, level 4 was sure. And the second group is level 1 wrong, level 2 is sure, level 3 is the reason for the answer from level 1 is wrong, level 4 is sure. In this study problem number 1 is included in the indicator of the concept of effort where students assume that the magnitude of the force experienced by an object depends on the magnitude of the displacement experienced by the object as the cause.

Question number 2 students are faced with a problem in business physics defined as... in question number 2 there are 29 students who understand the concept with a percentage of 46%, 6 students who do not understand with a percentage of 9%, and 27 students who experience misconceptions out of 62 class students X SMA Negeri 1 Kupang who took the test with a percentage of 43% with moderate criteria. After analyzing the class X students of SMA Negeri 1 Kupang who experienced misconceptions, they were divided into 3 groups, namely the first students who answered level 1 correctly, level 2 were sure, level 3 regarding the reasons for the wrong answers and level 4 were sure. the second group is level 1 wrong, the second level is sure, level 3 is right and level 4 is sure, the third group found 1 student who is at level 1 wrong, level 2 is sure, level 3 is wrong and level 4 is sure. In question number two, students choose the reason for the answer where the force and displacement are included in a vector quantity which, when multiplied by the dots, will get a new quantity, namely a vector.

Students are faced with questions about the efforts made by Michel to push his car, in this question number there are 54 students who understand the concept with a percentage of 87%, there is 1 student who does not understand the concept and 7 students who experience misconceptions out of 62 students who take the test with a percentage of 11 % with low criteria, and 1 student who made an error. After being analyzed, class X students of SMA Negeri 1 Kupang experienced misconceptions which were divided into two groups where students who answered correctly at level 1 were sure of the answers at level 1, at level 3 students were wrong in choosing the reasons for answers at the first level and at level the 4th students are sure of the reasons for the answers at the 3rd level, the second group are students who answer wrongly at the first level but at the 2nd level students are sure of the answers at the 1st level and at the third level the students answer the wrong reasons for the answers at the 1st level. 1st and at the 4th level students are sure of the reasons for the answers at the 3rd level. Where students assume that the effort made by Michael to push his car which broke down is constant even though the car is not moving by choosing at the 3rd level where if the object does not move but there is a force acting then the object still has the possibility to do business both small and large. Big

b. Problem solving with the scientific method on the concept of mechanical effort

In this question indicator there are 3 question numbers, namely question numbers three, five and six. In question number 3 students are faced with a large question of braking effort as done by the driver as in the question, in this question number there are 52 students who understand the concept with a percentage of 83%, students who do not understand the concept as many as 3 students with a percentage of 4% , and found 7 students who had misconceptions with a percentage of 17% with low criteria, in this question number there were no students who were included in the error criteria.

After being analyzed, class X students of SMA Negeri 1 Kupang experienced misconceptions which were divided into 3 groups, namely the first students who at the 1st and 3rd levels answered incorrectly but were sure at the 2nd and 4th levels, the second group, namely students those who answered incorrectly at the 1st level were sure at the second level, correct at the reasons for the answers at the 3rd level and confident at the 4th level, the third group were students who correctly answered at the 1st level sure at the 2nd level and at 3rd level wrong 4th level sure. Where students

answered that the bicycle braking effort made by the cyclist was negative because the braking carried out by the cyclist was in the opposite direction to the direction of movement of the bicycle.

In this question number there were 42 students who understood the concept with a percentage of 67%, students who did not understand the concept were 11 students with a percentage of 17% and students who had misconceptions were 8 students with a percentage of 13% with low misconception criteria and encountered 1 student with error criteria. After being analyzed, the students of SMA Negeri 1 Kupang who experienced misconceptions were grouped into 2 groups, namely the first students who at the 1st and 3rd levels answered incorrectly but were sure at the 2nd and 4th levels the second group, namely students who were correct answered at the 1st level confident at the 2nd level and at the 3rd level wrong in the reasons for the answers at the 1st level and 4th level confident with the reasons for the answers at the 3rd level. Where the student's work done by the car will be greater if the acceleration of the car is getting smaller or less each time.

In this question number students are confronted with the problem of the mass of an object weighing 3 kg that falls freely from the top of a multi-storey building which is 80 m high and if the frictional force in the air is ignored, the work done by the gravity up to a height of 30 m from the ground how many joules. students who understand the concept as many as 32 students with a percentage of 51%, students who do not understand the concept as much as 8 students with a percentage of 13%, and students who experience misconceptions as many as 20 students with a percentage of 32% medium criterion and students who included in the error criteria of 2 students with a percentage of 3%. After being analyzed, students who fall under the misconception criteria are grouped into 2 groups, namely first, students who give correct answers at level 1 believe at level 2 and give reasons for wrong answers at level 3 and are confident at level 4 , the second group is students who give wrong answers at level 1 and level 3 but students are confident at level 2 and 4. In this case students are fooled by reasoning that the answer is where the work done by the gravitational force is equal to minus the change in gravitational potential energy. In this case, the real mistake is that the work done by the gravitational force is equal to the change in gravitational potential energy.

c. Solving problems with the scientific method on the relationship between work and energy.

In this question number students are asked to calculate the amount of kinetic energy and effort made by the athlete when throwing a shot put ball, in this question number there are 32 students who understand the concept with a percentage of 51%, students who do not understand as many as 12 students with a percentage of 19% and students who experience misconceptions are 20 students with a percentage of 32% with moderate misconception criteria, and the number of students who have errors is 0 with a percentage of 0%. In this question number, after being analyzed, students who experienced misconceptions were divided into 2 groups, namely the first group of students who correctly gave answers at the 1st level were sure at the 2nd level and at the 3rd level they were wrong and sure at the 4th level , in the second misconception group, namely students who gave wrong answers at level 1 at level 2 were sure at level 3 they were wrong and at level 4 they were sure. In this case students are fooled by the reason for the answer where the total effort acting on an object is equal to the change in kinetic energy, which is the total force exerted on an object where the direction is opposite to the direction of the object's motion, then the total force increases the speed and the kinetic energy is different. Where the truth is that the total force adds to the speed and kinetic energy of the object.

In this question number students are asked to understand statements about the concept of potential energy in this question number there are 20 students who understand the concept with a percentage of 32% and students who do not understand the concept are 16 students with a percentage of 25%, students who experience misconceptions are 25 students with a percentage of 40% with moderate misconception criteria, and students who are included in the error criteria are 0 with a percentage of 0%. In this study, after being analyzed, students who experienced misconceptions were divided into 3 criteria, namely the first group had 11 students who gave wrong answers at the 1st level and were sure at the 2nd level and the reasons for the answers were wrong at the 3rd level and believed in the level-4, the second group there are 13 students who correctly give answers at the 1st level sure at the 2nd level and the reason for the answer is wrong at the 3rd level and sure at the 4th level, the 3rd group there is 1 student who wrong answer at level 1 but sure at level 2 and on reasons the answer at level 3 is wrong but at level 4 is sure. In this case students experience misconceptions

because students are fooled by the reason for the answer where the change in potential energy that has a certain force is the same as the work done by the force if the object is moved from the first position to the second position which can be stated W = ΔEP which has a positive value, where true is a negative value.

In this question number there are 33 students who understand the concept with a percentage of 53%, and students who do not understand the concept of 7 students with a percentage of 11% and students who experience misconceptions of 20 students with a percentage of 32% with moderate misconception criteria, and there are 2 students who are included in the error criteria with a percentage of 3%. After analyzing students who experience misconceptions are grouped into 2 criteria, the first criterion is that 7 students are correct in giving answers at level 1 are sure at level 2 and wrong in giving reasons for answers at level 3 but are sure at level 3 4, in the second criterion there were 13 students who gave wrong answers at the 1st level and were sure at the 2nd level they were wrong at the 3rd level and believed at the 4th level.

In this question number there are 16 students who understand the concept with a percentage of 25%, students who do not understand the concept of 12 students with a percentage of 19% and there are 34 students who experience misconceptions with a percentage of 54% and are included in the medium criteria and for the error criteria there is 0 students with a percentage of 0%. In this study, after analyzing the misconceptions experienced by students, they were grouped into 2 criteria, namely the first student who answered incorrectly at level 1 and was sure at level 2 gave the wrong answer on the reasons for the answer but was sure at level 4, the second criterion are students who are correct in giving answers at the 1st level are sure at the 2nd level and at the 3rd level are wrong but are sure at the 4th level. Where students are fooled by pictures of three different steps and the effort to climb the three different stairs, namely manual stairs that go up straight, two manual stairs that go up curved and the third ladder is an escalator where students answer correctly that the smallest effort is needed to climb the 3rd rung of the ladder but students are fooled by reasoning that the answer is where the work generated by the conservative force depends on the trajectory and does not depend on the starting and ending points of the trajectory. In the problem one of the conservative forces is the weight of the person, which is wrong, actually the conservative force does not depend on the trajectory but only depends on the starting and ending points of the trajectory.

Causal Factors Affecting Students' Misconceptions

From the results of the interviews, information was obtained that the cause of the first misconception came from students, where students had the wrong initial concept or (pre-conception) related to the material work and energy. This was also said by the efficacious teacher of work and energy material that students had the wrong initial concept regarding physics material including work and energy material, because students already had the wrong initial concept caused by environmental factors or basic knowledge when the student was still in junior high school. In addition to the wrong initial concepts or students' preconceptions, one of which is the ability of students to understand physics material, especially work and energy, and difficulties in taking lessons online or face-to-face are limited during the Covid-19 pandemic.

Misconceptions can also occur from the teacher, namely the teacher lacks mastery of the material and there is material or things that are not detailed enough to be conveyed to students. Materials that are less detailed are delivered to students from the teacher. Students read them in books, there is a slight difference from what is conveyed by the teacher and what is printed in the book so that students have difficulty understanding the work and energy material from the source book. regarding high school physics textbooks, found that there were several wrong physics concepts, both pictures and formulas which resulted in misconceptions in the textbook. According to Suparno (2013).

Solutions to Factors Causing Misconceptions

One effort to reduce misconceptions is to choose a suitable learning method. The problem that often arises in the learning process at school is understanding the material conveyed by the teacher or educator, the cause of this is one of the learning methods that is often used with the lecture method where students are only required to listen to the material conveyed by the teacher without inviting students to think actively and develop attitudes. critical, whereas to understand learning material

especially physics learning requires good concentration and students who are actively looking for material and develop a critical attitude to always convey various existing phenomena, with the methods commonly used students tend to get bored and easily assume that physics is a difficult subject to be understood and there is often misunderstanding between learning material and students who respond to it.

CONCLUSION

In general, all students of SMA Negeri 1 Kupang experience misconceptions about all indicators of work and energy questions submitted using the four tier diagnostic test instrument. this is shown through each indicator of the questions worked on by students. Factors that cause misconceptions in SMA Negeri 1 Kupang are caused by several indicators, namely from students in the form of wrong preconceptions related to work and energy material, the causes of misconceptions from teachers or teachers who lack mastery of the material, the causes of misconceptions from textbooks. It is hoped that this four tier diagnostic test instrument can be used to identify students' misconceptions, because it is proven that there are still students who experience misconceptions about the concepts of work and energy. And it is hoped that the teacher as a facilitator when he finds misconceptions in his students to immediately follow up, because if left unchecked it will affect students' understanding of other physics concepts and then can minimize the occurrence of misconceptions, the teacher should do apperception and find appropriate learning methods and explain physics concepts associated with everyday conditions. Even with the limited situation of online learning and face-to-face learning as it is today, students are expected to remain active in participating in learning and students must be more open to teachers to ask questions about concepts they have not understood so that teachers can direct them to the correct concepts.

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