

**REASONING-BASED DIAGNOSTIC TEST TO IDENTIFY LEARNING
DIFFICULTIES AND MISCONCEPTIONS OF WORK AND ENERGY AMONG
SENIOR HIGH SCHOOL STUDENTS**

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ABSTRACT

This study was designed to identify physics learning difficulties and misconceptions of work and energy among senior high school students. It was conducted by administering a set of reasoning-based diagnostic test to a group of senior high school students. The test consists of 35 multiple choice problems with space to write down the reasons and confidence level (%) of student in resolving the problem. The results were analyzed by the lost of the learning continuum and hierarchy of matter prerequisite, as well as reasoning used and confidence level (%) of student in resolving the problem to identify learning difficulties and misconceptions. The findings revealed that most of the students who were the subject of this study are: (1) experiencing learning difficulties, either in understanding of certain physics concepts as well as the application of mathematics concepts to resolving physics problems. (2) having misconceptions about some concepts of physics, especially those that have a relationship very closely, both functionally and the similarity of the term.

Key words: reasoning-based diagnostic test, learning difficulties, misconceptions, work and energy

INTRODUCTION

The students' ability in using physics knowledge depends on how effectively the knowledge is organized. Furthermore, the solution of a physics problem is becoming increasingly easier if widely available information required. Therefore, it is important to note that physics knowledge organized effectively will facilitate the solution of physics problems. The fact we found in the field is often precisely indicate that students in general tend to classify physics knowledge that they earn into sections which seems not inter-related.

Physics is the study of the fundamental properties of the universe; but in general person understands just little physics, at least not in the way a physicist does. Thus, most people have little understanding of the world they live in, except for things limited to humankind, which tends to have a small influence on the universe as a whole. Of course, if people understood themselves better, the world would be a nicer place to live.

There are some cognitive ability which, according to Reif (1994: 17) is acting to improve the success of solving a physics problem, namely the ability to identify and accurately interpret the physics concepts and principles and the ability to make a description as well as a knowledge of physics organized effectively. Many of learning difficulties encountered by most students are in interpreting various concepts and principles of physics, because they claimed to be able to interpret precisely of physics knowledge and not vague or double meaning. The ability of the students in identifying and interpreting the physics concepts is obviously an important prerequisite for the use of the concepts to make a more complex inference or to solving physics problems related to these concepts.

Solving problem is one of the important part of learning physics. Basically, solving problems is an aspect of the application of physics concepts that is obtained through the learning process. According to Reif (1994: 17), the cognitive skills required by students to apply physics knowledge, as it has been expressed before, among other things: the ability to interpret correctly the physics concepts and principles, as well as the ability to describe and organize the knowledge effectively. These skills are required as a prerequisite to solving problem skills which in general includes the ability to analyze the matter, devise solutions, and re-examine the solutions.

Energy in physics is defined as a work of certain force (and is usually named after that force: gravitational energy, electric energy, etc). Energy is a property of a system. The energy could be increased or decreased by work, heat flow, or advection. Work is not associated with energy, but with changes in energy; $W = \Delta E$. In teaching energy some of the most powerful misconceptions or alternative understandings of energy are: energy and force are interchangeable terms, things use up energy, energy is not conserved because we are running out of it, an object at rest has no energy, energy is a thing, energy is only associated with movement, energy is a fuel, energy is recycled (Clement, J. 1987). Meanwhile, Idol Jones have found that students routinely think that energy, force, momentum, and power, all have the same meaning.

The many difficulties faced by students in solving of physics problem depends not only on the level of difficulty of the question itself, as well as the acquisition of physics knowledge, but also in its ability in decision-making to select a series of actions that can lead to acquire of a solution. Learning difficulties include some things that can affect the success of student learning. Experts have found three categories of learning difficulties, namely: on the aspect of language, academic skills, and other aspects that have not been included in these two aspects. Learning difficulties can be a lifelong condition that can affect some aspects of life such as education, employment, family life, and routines of life. However, a person with learning difficulties can learn. Support and academic aspects of accommodation can help the learning process. Not very clear exactly what causes learning difficulties. However, the ability to think is very useful in a variety of application situations (Matteo Baldoni, Cristina Baroglio, Alberto Martelli, and Viviana Patti) retrieved on March 30, 2013

The diagnostic test designed to detect the learning difficulties of among senior high school students, so format and it response collected must have diagnostic functions developed based on the analysis of sources of error or difficulty. The function of the diagnostic test or formative test is to monitor the learning progress. Whether the students are able to achieve the expected learning outcomes? Achievement of the certain basic competencies used as requirements to achieve the next basic competencies.

Learning difficulties is a generic term relating to a child or student who is having difficulty with his or her learning. Learning difficulties are a problem that concerns the understanding or emotion that affects a person's ability to learn, communicate with others, and follow the rules. Currently most of students at some schools are still experiencing learning difficulties. Learning difficulties typically associated with one's internal condition when receiving, absorbing, and communicate information. This difficulty is not easily seen due to presence other conditions. Students with this problem will grow up to adult still with the learning difficulties. Learning difficulties experienced by someone are highly of various kinds, such as inability in mathematics, reading, writing, speaking, listening, and logical thinking. Research results (Louden, et al: 2000) mentions that almost 15% of children demonstrating difficulties in academics and skills.

Taale, K. D. (2013), presents that academic performance and achievement of students is highly dependent on the approach of presenting information and how it is received. This study was an action research using the problem-solving strategy to find out the effect of multiple representations-based instruction on students' performance in some physics concepts. The results obtained showed an improvement in students' achievement on basic concepts in optics, heat, and mechanics. Students performed relatively better in optics (80% of the students) scoring 45% and above of the marks; followed by thermal physics (heat) (70%) and mechanics (50%). This study suggests that it is possible to use multiple representations in physics instruction to motivate and sustain students' interest in the subject, especially those with limited physics knowledge to apply the laws and formulae learnt to calculate and solve problems correctly.

The reasoning based diagnostic tests needs to be developed because it has not been much done by the physics teacher in order to improve understanding, creativity, and results of student learning. According to the researches that have been done, almost in every level of school and area is still going on a wide range of learning difficulties and misconceptions that are experienced by students. Therefore, it is very urgent to do the identification of learning difficulties and its causes as well as misconceptions going to be overcome and made improvements soon. The findings of this research are very beneficial to students who concerned as the basis for settling the issue. Therefore, reasoning based diagnostic tests developed in this study can be used as a model for the development of diagnostic tests for high school physics teachers.

RESEARCH METHOD

The test developed by the following steps:

- Identify of the competencies and indicators of the subject matter Work and Energy.
- Develop the learning continuum of the competencies and the hierarchy of the material prerequisites.
- Develop the blue print of the test.

Example:

No.	Code LC	The Hierarchy of the Material Prerequisites	Details of The Problem
1.	U ₃	<pre> graph TD U1((U1)) --> U3((U3)) U2((U2)) --> U3 </pre>	<p>In physics, work is defined as... ..</p> <p>A. the scalar multiplication between force and displacement.</p> <p>B. the vector multiplication between force and displacement.</p> <p>C. the scalar multiplication between force and distance.</p> <p>D. the vector multiplication between force and distance.</p> <p>E. the multiplication between power and displacement.</p> <p>Reasoning:</p> <p>.....</p> <p>.....</p> <p>Conviction: (.... ..%)</p>

Code of learning continuum and indicators:

U_1 : Distinguish between dot product and cross product between two vectors.

U_2 : Explain the difference between distance and displacement.

U_3 : Define the meaning of work.

This study was designed and carried out to identify physics learning difficulties and misconceptions of Work and Energy among senior high school students. It was conducted by administering a set of reasoning-based diagnostic test to a group of senior high school students. The test consists of 35 multiple choice problems with space to write down the reasons and confidence level of student in resolving the problem. The responses were analyzed by the lost of the learning continuum and hierarchy of matter prerequisite, as well as the reasoning used and the confidence level of the student in resolving the problem to identify learning difficulties and misconceptions.

Analysis of the reasoning on each multiple choice questions are done to find out whether there are learning difficulties and or misconceptions experienced by students. Some categories may be mentioned as follows:

Table 1. The categorization of learning difficulties and or misconceptions.

ANSWER	REASONING	
	Confidence Level ($\geq 50\%$)	Confidence Level ($< 50\%$)
Correct	Right (no learning difficulties and no misconceptions)	Right (lucky guess)
	Not Right (lucky guess and or misconceptions)	Not Right (learning difficulties and or lack of knowledge)
Not Correct	Right (learning difficulties and or misconceptions)	Right (learning difficulties and or misconceptions)
	Not Right (learning difficulties and or misconceptions)	Not Right (learning difficulties and or misconceptions)

FINDINGS AND DISCUSSION

The findings of identification of learning difficulties and misconceptions on Work and Energy experienced by students. Learning difficulties experienced by majority of the students (over 50%) in this subject, namely:

1. Students don't understand the difference of vector and scalar product between two vector quantities.
2. Students don't understand that work is a scalar or vector quantity.
3. Students can't calculate the work done by several forces and the displacement of an object by vector components analysis.
4. Students don't know the unit of work in cgs system.

5. There are students who have not been able to analyze the relationship between mass and displacement of an object with the work done.
6. Students having difficulty in analyzing of work unit, due to lack of understanding of units of speed, acceleration, and force. Students accustomed just to memorizing the unit, so difficulty experienced in analysis.
7. Students having difficulty in formulating and calculating the friction.
8. Students having difficulty in the decomposition of a vector into components.
9. Student difficulty in interpreting graphs about the effort. There's still that does not understand that the graph below the x axis (the axis) is negative and there is still that can't read the numbers in the graph coordinates.
10. There are still Students who did not know about the names of scientific notation.
11. Some students still do not understand the units of force and effort.
12. Students still had difficulty in identifying changes regularity of straight motion and its relation to quantities associated with it.
13. Students still difficulty in applying the law of conservation of mechanical energy in solving problems of physics.

The misconceptions that plagued by most of the students in the Work and Energy, namely:

1. Students could not tell the difference between scalar multiplication (dot product) and the multiplication of vector (cross product)
2. Students do not understand the differences in the way the writing of scalar and vector quantity.
3. Students do not understand the difference between writing a symbol vector and scalar multiplication.
4. Wrong concepts in Students classify the scalar and vector quantity. Because it is seen that students used to memorize examples include scalar quantity and vector, so didn't know that in classifying it requires analysis.
5. Students wrong concepts about the calculation effort according to physics. Students can't analyze vector decomposition since it does not understand the problem.
6. Students wrong concept about the direction of the force because it does not know that the style has a direction.
8. Students don't understand that the distance and displacement are different.
9. Some students are still not appropriate in formulating business and style because it is not familiar with the concept of the force (F) and gravity (W), the acceleration (a) and the acceleration of gravity (g), and transfer (s) and height (h).
10. Students assume that the energy is equal to the effort.
11. There's still that can't distinguish between mass and weight.
12. Students are still not able to understand the law of conservation of mechanical energy; that the eternal is mechanical energy, namely: the amount of kinetic energy and potential energy or kinetic energy, rather than a tremendous potential.

Based on the results of the identification, in general learning difficulties experienced by most of the students are examined on either his inability to understand and use mathematical concepts to solve the answer to question. This kind of learning difficulties, namely the inability of good students in understanding and using mathematical concepts to solve the physics problem answer is usually related to its inability to understand the concepts of physics. Likewise, the opposite can also happen, i.e. that the inability of the students understand the

concepts of physics will cause errors in the application of mathematical concepts for Physics problems solving.

CONCLUSIONS

Through this research has generated a reasoning based diagnostic test that meets the requirements of the assessment tools on subjects of HIGH SCHOOL Physics/MA.

1. Characteristics of a diagnostic test instruments developed in this research are as follows. Each question comes with a description of the competencies to be achieved, the necessary knowledge dimension that is factual, conceptual, procedural, or the level of cognitive ability, learning continuum, and hierarchy matter prerequisite.
2. Each problem is shaped with five multiple choice answers (option) with space to write down the reasons and confidence level students (%) in reply.
3. Identification of the Results showed that:
 - a) Most of the students who were the subject of the research are still experiencing learning difficulties in understanding some physics concepts as well as the application of mathematical concepts for physics problem solving.
 - b) Most of the students who were the subject of the research are still having a misconception about some concepts of physics, especially those that have a relationship very closely, both functionally and similar terms.

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