Phys. Comm. 3 (1) (2019) 53 - 59

Physics Communication

http://journal.unnes.ac.id/nju/index.php/pc

Misconception Remediation through Analogy to Increase the Understanding of Learners Concepts in Rotational Dynamics Subject

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Article Info

Article History :
Received February 2019
Accepted April 2019
Published June 2019

Keywords:
Analogy, misconception, remediation

Abstract

This research aims to a11alyze the basic concepts that form a pattern of misconceptions on the rotational dyna111ics. The misconceptions formed by several incorrect patterns of concepts are remediated using a11alogy leaming method. This research is applied using the mix method (qualitative and quantitative). Quantitative data is taken using two tier diagnostic tests for pretest and posttest which consists of 10 questions. Qualitative data is taken by applying direct observations and interviews with the students. The result of the pretest showed a misconception average of 83.8%. Analogy learning process with posttest. After leaming analogy done, the result of posttest showed that misconceptions average decreased to 41.9%. With the decreasing in the posttest, the understanding of concepts average has increased from 16,2 % to 53,6 %. However, the results of this study cannot be said to be effective because there is still incorrect concept pattern from the posttest results. This is due to interest of student in physics, the student ability and the cognitive development.

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p-ISSN 2528-5971
e-ISSN 2528-598X

INTRODUCTION

As science and technology progress, many countries have begun to put more emphasis on science education. For ensuring meaningful learning, exploration of students' conceptions on certain topics has great importance. These investigations constitute the foundation or give direction to other studies that are intended to design appropriate learning or to determine appropriate teaching methods. There has been an acceleration in science education on investigating students ways of conceptualization and reasoning about the physical phenomena that they encounter. Physics learning aims to help students understand concepts, compile, and perfect the concept pieces that students have so that the knowledge can be integrated as a whole concept. In general, the knowledge in the memory of students is described in the form of small pieces of information. Such knowledge will become a concept when interconnected (Ibrahim, 2012). The importance of understanding and mastering concepts is also the goal of implementing the curriculum at various levels of education. To realize this, the correct understanding and mastery of concepts is needed to avoid misunderstandings. Misconceptions have been one of the most prominent and widely studied research areas in physics education since they are thought to be an important factor that prevents students learning and understanding the concepts.

Many studies prove that the reason of error that occurs in students is because they lack the mastery of physics concepts. Elwan (2010) has conducted a case study relating to misunderstandings in physics and the factors associated with it. Understanding occurs because understanding is based on personal experience and scientific concepts. Elwan has examined several misconceptions in the physics subject about Newton's Law and the concept of Kinematics. Errors mostly occur in the concept of position and distance, also in speed and acceleration in straight motion and energy. Duman (2015) writes that in the concept of rotational dynamic, students are less able to analyze and describe some free diagrams of the cause forces of rotation so students are unable to understand the concept. Rotational dynamic is a complex subject. This is because this subject study about translation and rotation motion. One of rotation motion is torque. Tthe torque of an exerted force on a pulley has the same direction as the exerted force (Barniol, 2013). Several studies have been conducted related to rotational dynamics learning strategies as an effort to improve understanding of concepts (Ambrosis et al., 2015; Close et al., 2013; Pranata, 2017; Mulyastuti, 2016; Sarkity, 2017).

Misconceptions in rotational dynamic occur for several reasons. The causes are various so that they impact on the difficulty of the teaching and learning process. One of the causes of this is because students do not understand the previous concepts related to the concepts that will be delivered. Generally, misconceptions occur as the result of understanding the initial concepts that are wrong because they are only obtained from experience by making their own concepts. If the initial concept is wrong, it will be very difficult to fix because this misconception has unconsciously settled and become a handle in their lives (Wahyudi, 2013). What students understand about a scientific concept is often different from the concept adopted by physicists in general (Suparno, 2013). Disagreements about understanding concepts are referred to as alternative misconceptions or concepts.

To overcome these obstacles, efforts must be made to remedy the misconception by using a more meaningful presentation and making learners more effective in facing it. A strategy that can help in the formation of concepts of learning can be more easily done by using one or several analogies or logic. Analogious learning is one of the strategies to form a mindset to find a solution to the problem at hand. By analogy, a problem is easily recognized so that complex problems can be simplified. Thinking by analogy is one example of constructivism learning. Analogical thinking is a transformation of the habit of thinking from a simple and spontaneous way to being more structured and systematic as the way scientists think (Pujayanto, 2013). According to Harisson (2013) the appeal of the analogy in learning science, especially physics lies in the ability to explain abstract ideas in familiar terms.

This study aims to analyze the pattern of concepts that cause misconceptions of rotational

dynamics, then overcome these misconceptions by learning analogy. The initial step is done by identifying misconceptions using diagnostic tests. A good diagnostic test can provide an accurate picture of the misconceptions experienced by students based on their mistakes. (Rusilowati, 2015). The purpose of diagnostic tests is to identify learning difficulties of students in terms of understanding key concepts on a particular topic (Suwarto, 2013: 113-114). The test used is a two-tier diagnostic test. The first level consists of questions with five choices of answer, while the second level consists of the reasons described and refers to the answers at the first level. The reason consists of one correct answer and a distractor. Distractor answers are students' explanations obtained from the literature, interviews or from open responses (Tuysuz, 2009).

The source of misconception can be caused by student, teacher, textbook, context and learning situation. This study researching causes misconception that source from student. Misconception can be identified with several causes. They are presented in Table 1

Table 1. Cause of misconceptions that comes from students

Particular Cause	Info	Code
Pre Conception	Researched	P
Associative Thought	Researched	AT
Humanistic Thought	Researched	HT
Reasoning is incomplete or wrong	Researched	R
Intuition	Researched	I
Stage of cognitive Development	Researched	CD
Student Ability	Researched	SA
Interest to Learn	Researched	IL

(Source : Suparno, 2013)

The subject of rotational dynamics selected for this study are:

1. Moment of force
2. Moment of inertia
3. Relationship between moment of force and moment of inertia
4. The law of conservation of angular momentum
5. Energy conservation law
6. The relationship between translational and rotational motion

METHOD

The research design of this study is using the mixed-method (qualitative-quantitative). Qualitative data uses concurrent triangulation strategy developed by Creswell (2009). The quantitative data was observed using the design of one group pre-test post-test. The data analysis technique used by descriptive analysis obtained from the results of the pretest and posttest. This strategy is useful for collecting two types of data at a time, then combining them into one information in the form of an overall result interpretation. The steps taken are as follows:

1). The research begins with formulating similar problems (qualitative and quantitative problems).
2). The qualitative research, researcher becomes a human instrument for collecting and analyzing qualitative data. Quantitative research uses theoretical studies and quantative analysis.
3). Qualitative data collection uses triangulation. Quantitative data collection is done using a test sheet.
4). Both data groups are combined with a meta-analysis to look for relationships.
5). The researcher concludes the effectiveness of the results of the meta-analysis

The sample used was 32 grade XI students of MAN 2 Brebes who had received rotational dynamics subject. Test scoring is done based on scoring criteria in Table 2.

Table 2. Pattern of Misconceptual Answers

Criteria of Reason	Answer		Category	Score
- No response -Null (no reason)	Right	Wrong	NR	0
- Answering with illogical explanations - Answer indicates the existence of a mastered concept but there are statements in the answers that indicate misconceptions			A1	1
- Answers show that only part of the concept is mastered without any misconception - Answers show concepts understood with all correct explanations			A2	R-2 W-1

Information:
NR: Do not understand
A1: Misconception
A2: Understan

Scoring result was taken to collect samples of students who experienced misconceptions. Then remediation is done using an analogy. Changes in concept patterns are analyzed to test the effectiveness through gain tests.

The determination of item indicators is adjusted to 10 indicators of rotational dynamics subject, there are :

1. Analyze the amount of force moment on a massless rod
2. Compare the level of ease of opening the bolt using an English wrench with different moment arm factors
3. Compares the effect of the force position on the magnitude of the force moment on the box that is rotated on the axis at the center
4. Comparing the moment of inertia of identical solid balls rotated with different rotational axis locations
5. Compare the angle acceleration of two objects made of wood and iron, when the same mass is rotated on the shaft without slip
6. Comparing the highest position achieved by solid balls, solid cylinders, hollowed balls and solid cylinders which are rolled from the flat plane to the inclined plane
7. Compare angular velocity and moment of inertia to ballerina
8. Comparing kinetic energy in the inclined plane towards rigid objects
9. Compare balls that roll and slide
10. Compare the speed of the motor gears

RESULT AND DISCUSSION

Based on the results of quantitative data analysis, the pretest and posttest presentation of misconceptions and understanding of concepts can be seen through Table 3.

Table 3. Results of Misconceptions and understanding of the Pretest and posttest concepts

Question No	Misconception		Concept Understanding	
	Pretest (%)	Posttest (%)	Pretest (%)	Posttest (%)
1	90	30	10	70
2	96	45	4	55
3	92	60	8	40
4	80	40	20	60
5	86	50	14	50
6	92	60	8	40
7	70	30	30	70
8	80	30	20	70
9	72	32	28	68
10	80	42	20	58
Average	83,8	41,9	16,2	53,6

An increase in understanding of concepts from the results of the pretest and posttest is presented by the diagram in Figure 1.

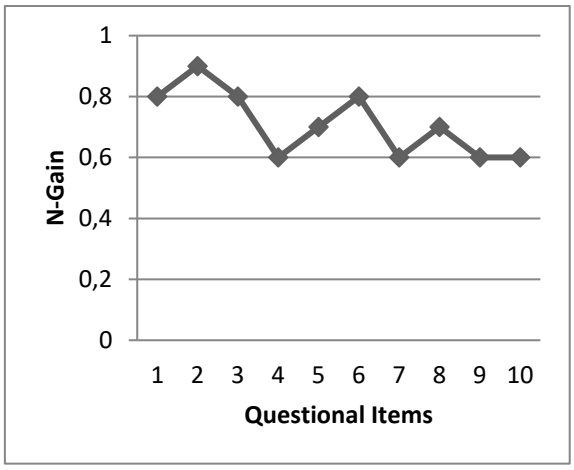

Figure 1. Pretest-posttest Gain Test

Based on Table 3, the average pretest results indicate that the percentage of misconceptions is 83.8%. Understanding the correct concept is obtained with a percentage of 16.2%. The post-test results, misception decreased to 41.9% and understanding of concepts increased to 53.6%. This data shows that there are still misconceptions in the subject of rotation dynamics. The average gain test for each question indicator has increased by 0.7 so that it is included in the high category.

The result of qualitative analysis is conceptual patterns from the second level answer. Concept patterns are grouped according to criteria so that misconceptions emerge. The results of the pretest about items 1, 2 and 3 which discuss about the force moment subject have the highest percentage of misconception and low understanding of concepts. Students are distracted by level one questions and answers so that they provide various reasons with incorrect concepts. The material should have been obtained by students and delivered by the teacher. The moment of inertia subject, and the relationship between moment of force and moment of inertia in items 4 and 5 also experienced high misconception. Item 6, 8 and 9 are concept of rolling and sliding the object (rigid body), student still confuse to distinguish motion. The student doesn't know translation and rotation. They are just memorizing the formula but not find the concept. For example the difference of speed and angular speed, affect of difference object for the moment inertia and also values of kinetic energy. Through the result of interviews and observations, found several causes of the emergence of these misconceptions. The concept patterns and their causes at the beginning of the pretest are presented in Table 4.

Table 4. Pattern of student misconception before learning (pretest)

Misconception Pattern	Cause
The force acting fixed on the axis of shaft has moment of force	P
The force acting in line with the shaft causes the object to rotate and has a moment of force	R
The smaller (nearer) the distance of the force with the axis of shaft, the easier it rotates	I
The force direction on the axis does not affect the magnitude and direction moment of force	AT SA CD IL
A solid ball with a central axis has greater axis moment of inertia than end axis because it will move faster	R
The axis does not affect the magnitude of the moment of inertia because both balls are the same	HT IL
Solid of ball with different material (iron and wood) rotated in center axis. They are have the same mass but radian of wood is larger than iron. students concept are:	R
The acceleration of the ball is large because of the large Radian	I
The value of the acceleration is influenced by different materials	HT
The same mass causes objects to rotate with the same acceleration	
Angular velocity is proportional to the moment of inertia	R
Dancers who fold their hands will have large moment of inertia	IL
The position of the hand does not affect the amount moment of inertia	HT

Four objects of rigid body (solid cylinder, solid ball, cylindrical and Hollow ball) rolling on the plane surface to sloping surface. The solid cylinder have moment of inertia is greater than solid ball so that it moves faster. The solid cylinder will reach the highest position The solid ball that is rolling is easier to move so that it reaches the lowest position The highest position can be reached depends on dimension of subject	P R IL CD SA HT
The amount of kinetic energy is not affected by the moment of inertia Analysis of kinetic energy is seen from the dimension of the object without calculating moment of inertia that affects	R IL
The ball that rolls is faster than the ball that slides Student cannot distinguish the ball rolling and sliding	HT I
The motor gear connected to the chain has the same inertia so that the speed of rotation is the same The gear on the motorbike on the back, which is two times larger than the front gear, has small linear speeds because of their large size, making it harder to move.	AT SA CD

Information :

P	:	Pre-conception	SA	:	Student Ability
R	:	Reasoning	CD	:	Cognitive of Development
I	:	Intuition	IL	:	Interest of Learn
AT	:	Associative Thought	HT	:	Human Thought

The results of the misconception analysis from the pretest are used to establish the right analogy so that no more misconceptions arise. After the posstest, found new concept that lead tto incorrect concept (misconception). New concept patterns that occur during posttest are seen in Table 5

Table 5. Concept patterns after learning (posttest)

Material	Misconception Pattern	Cause
Moment of force	The moment of force is influenced by the moment's arm and force but does not affect the direction	*R* SA CD IL
Moment of Inertia	Students are confused in determining the correct formula	CD SA IL
Relationship between moment of force and moment of inertia	Determination of the wrong formula and its application in the case faced	S SA IL
The law of conservation of angular momentum	Determination of the wrong formula and its application in the case faced	S SA IL
Energy conservation law	Determination of the wrong formula and its application in the case faced Unable to analyze rotating and moving objects	R S SA IL
Relationship between rotation and translation	Cannot distinguish magnitudes on translational and rotational motion	S SA IL

According to Table. 5, there are still misconceptions because of the presence of new concepts that are not right. The misconception after learning is caused by the same cause. Students have no interest, not only for rotational dynamics subject, but also for others. This is supported by the observation data on student learning history. Students' low cognitive abilities also cause students to experience misconceptions. Besides showing misconceptions, some students are said to not understand the concept. The low-thinking ability of students is the main cause of misconceptions and lack of understanding.

CONLUSION

Based on the results, misconception is formed by incorrect concept pattern. The incorrect concept can be caused by many factors from students. The results from pretest and posttest were not experiencing significant increasing on the concept understanding. This study cannot be said to be effective because there is still incorrect concept from the posttest. This shows that further research and special strategies are needed to overcome the causes of misconception.

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