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Research Artikel

IDENTIFICATION OF STUDENTS' MISCONCEPTIONS USING ISOMORPHIC TEST: THE CASE OF NEWTON'S LAW OF MOTION

IDENTIFIKASI MISKONSEPSI SISWA MENGGUNAKAN UJI ISOMORFIK: KASUS HUKUM NEWTON TENTANG GERAK

Fathiah Alatas[1*], Siti Ilhamiah[2], Ahmad Suryadi[3]
[1,2,3] Universitas Islam Negeri Syarif Hidayatullah Jakarta, Indonesia
fathiah.alatas@uinjkt.ac.id

Abstract

Students' misconceptions can lead to learning failure if they are not addressed. In this study, using Google Form, we identify students' misconceptions using the isomorphic test method on Newton's Law of Motion, especially the principles of dynamics. This study is quantitative research conducted in three junior high schools in South Tangerang. There are 90 participants involved that was selected by purposive sampling method. The research instrument was an isomorphic test in form of multiple choice with nine questions with three indicators namely: analyzing the application of Newton's I law in daily life; analyzing the correlation between force and mass and the acceleration of a moving object; and analyzing the application of Newton's III Law in daily life. The results showed that the students were identified as having misconceptions in Newton's Law concept using isomorphic tests, including misconceptions of inertia and misconceptions of Newton's Third Law of Motion. One of the misconceptions is that students assume an object will maintain its initial position in motion by applying a new force in the opposite direction. The students' misconceptions found in this study can be used as a reference so that they can be overcome in the learning process.

***Keywords**: dynamics, misconceptions, motion, Newton's law, tes isomorphic.*

Abstrak

Miskonsepsi dapat menyebabkan siswa sulit belajar jika tidak segera diatasi. Dalam penelitian ini, dengan menggunakan Google Form, kami mengidentifikasi miskonsepsi siswa menggunakan instrumen tes isomorfik pada materi Hukum Newton tentang gerak, khususnya pada prinsip-prinsip dinamika. Studi ini merupakan penelitian kuantitatif yang dilaksanakan di tiga SMP di Tangerang Selatan. Terdapat 90 partisipan yang dilibatkan yang dipilih dengan metode purposive sampling. Instrumen penelitian berupa tes isomorfik berupa pilihan ganda dengan sembilan soal dengan tiga indicator yaitu menganalisis penerapan hukum I Newton dalam kehidupan sehari-hari; menganalisis hubungan antara gaya dan massa dengan percepatan suatu benda yang bergerak; dan menganalisis penerapan Hukum 3 Newton dalam kehidupan sehari-hari. Hasil penelitian menunjukkan bahwa siswa teridentifikasi mengalami miskonsepsi pada konsep Hukum Newton. Diantara miskonsepsinya adalah siswa berasumsi bahwa benda akan mempertahankan posisi awalnya dalam gerak dengan memberikan gaya baru dalam arah yang berlawanan. Miskonsepsi siswa yang ditemukan dalam studi ini dapat menjadi referensi sehingga dapat diatasi dalam proses pembelajaran.

Kata Kunci: Dinamika, miskonsepsi, gerak, hukum Newton, tes isomorfik.

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*Corresponding author

INTRODUCTION

Learning physics is basically not only related to the implementation of learning which contains a collection of facts and principles but also emphasizes students to seek, find, and analyze the facts and principles obtained (Harijadi & Sulisworo, 2015; Redish, 2003). The failure of students to master and understand the concepts of physics properly and completely will result in the misunderstanding of concepts and not in accordance with concepts that have been accepted by experts or known as misconceptions (Alwan, 2011; Eshach et al., 2018, 2018; Suparno, 2013). Misconceptions have the disadvantage of preventing students from developing ideas that are in accordance with the correct concepts as initial insights for further learning (Soeharto et al., 2019). If corrections of the understanding are not given, misconceptions will have a greater impact. It might cause difficulty and even failure in learning (Ainiyah et al., 2018; Suryadi & Kusairi, 2021).

One of the topics where students often experience misconceptions is the concept of dynamic force and motion. In this kinematic dynamic concept, there are several topics, those are, force, motion, Newton's laws of motion. In line with Rusli et al. (2016) research, the results of the study, the percentage of misconceptions in the material of force was 73.2% and motion was 26.5%. According to Anggraeni et al. (2018), there are misconceptions in the concept of Newton's law, there are 32.85% of students identified as having misconceptions. Ergin (2016) found many misconceptions in the concept of Newton's law of motion, students assume that if an object has no force then the object has no motion, constant velocity requires constant force, reaction force and action will cancel each other out. Students' misconceptions will persist if no rebuttal is provided to correct them (Taylor, 2017). Qualitative analysis or multiple choice exams are used in these research. Unfortunately, qualitative analysis is time consuming. Additionally, multiple choice questions frequently fail to differentiate between students who answer questions inconsistently (Kusairi et al., 2017). Therefore, a more accurate method of identifying misconceptions is needed.

One method of analyzing student misconceptions that has been widely used is the isomorphic test. The isomorphic test is a model assessment tool that consists of questions arranged in pairs with different contents but requires the same concept or principle to solve isomorphic questions are questions that are in one indicator (Kusairi, 2020). The items consisted of 3 items that looked different, but were solved with the same principle (Kusairi, 2020; S. Y. Lin & Singh, 2011). Previous research showed that this isomorphic test its able to detect students who actually have the correct conception, who are weak in mastery of concepts and misconceptions isomorphic test requires students to think harder when answering and develop the analogy skills in choosing the right answer (Diyanahesa et al., 2017). Thus, a diagnostic test in the form of isomorphic questions is needed to identify students' understanding of concepts in the form of solving different problems but using the same physics principles in solving them (Cahyani et al., 2012; Kusairi, 2020; Kusairi et al., 2020).

The isomorphic test in this study used information technology (IT) assistance in the form of Google Form. It is one of the features from Google in an educational context, Google Form is one of Student Response System which is used in learning process Google Form makes the students' understanding assessment is easier easy to be made by everyone and takes just a little time This application is suitable for making quiz, form, and online survey which easily to be used by using Application Programming Interface (API) weband it can be used to identify misconception. The use of Google Form as an assessment tool is to support paper saving program, easy distribution and also processing the data becomes more efficient and easier Respondents' data who done the isomorphic test using Google Form automatically would be saved and can be downloaded in Google Drive in the form of Excel document. Certainly, this will accelerate the obtaining of occurred misconception information. In this study, we present the use of IT could be an evaluation tool for assessing concept

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understanding in students and being an information source to the teachers to find out the misconception that experienced by the students in the principles of dynamic, especially in Newton's laws.

METHOD

This research is a quantitative study to analyze students misconception in Newton's law of motion concept. This study conducted in three junior high school in Tangerang Selatan that involved 90 students of grade VIII selected by purposive sampling. The size of sample is determined by Slovin formula (Yuniastuti et al., 2015):

$$n = \frac{N}{1+N(d)^2} \qquad (1)$$

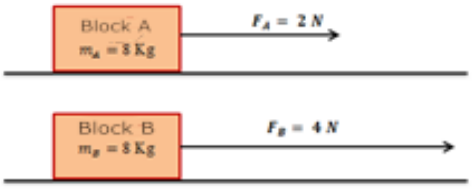
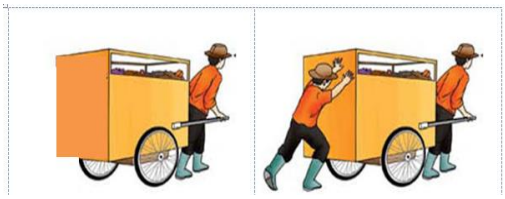
Equation 1 is an equation to measure sample size which is collected for data. Where n is sample size, N is population size, and d is degree of chosen error (10%).

The data collection technique used in this study was a multiple choice test in the form of isomorphic which was conducted online with the assistance of Google Form. The isomorphic test question grid used to identify students' understanding of concepts, namely 1) analyzing the application of Newton's I law in daily life; 2) analyzing the correlation between force and mass and the acceleration of a moving object; 3) analyzing the application of Newton's 3 Law in daily life.

The isomorphic multiple choice diagnostic test instrument has the following specifications: (1) The isomorphic diagnostic instrument consists of three items that are equivalent in one material indicator, (2) multiple-choice questions with four answer options, (3) answer options are made based on categories namely category 1 to 4. Category 4 is the correct answer and according to the concept, while categories 3, 2, and 1 are distractors in the answer choices, (4) the isomorphic diagnostic instrument states that students have a correct conception, a wrong conception (misconceptions) and inconsistent based on at least two answers from three multiple choice question consistently.

A grid of questions with indicators of the relationship between force and mass with the acceleration of a moving object. In this indicator, there are 3 questions that present the events of two objects moving simultaneously with known mass sizes and forces exerted on these objects. So, students must be able to analyze the value of the acceleration produced by these two objects by applying Newton's Second Law. Isomorphic test questions are as shown in Table 1 below.

Table 1. Examples of isomorphic problems

No	Question Isomorphic
Indicator: analyzing the correlation between force and mass and the velocity of a moving object	
1	Look at the following picture!  Block A and block B have the same mass and will be shifted to the right with a force applied to block A by 2 N and to block B by 4 N. After both blocks are shifted at the same time, then the acceleration caused by the force acting on object A and object B is… a. Block B shifts with a greater acceleration than block A, because the acceleration is directly proportional to the force acting on the block. **(Category 4)*** b. Block A shifts with a greater acceleration than block B, because the acceleration is inversely proportional to the force acting on the block. **(Category 3)** c. Block A and block B slide with the same acceleration, because the acceleration is directly proportional to the mass of the block. **(Category 2)** d. There will be no difference in the acceleration of Block B and block A, because changes in force and mass do not affect the acceleration of an object. **(Category 1)**
2	Look at the following picture!  Budi and Beni are cleaners. When Budi pulled a cart filled with garbage, he asked Beni to help him push the cart. If Budi feels a difference in the speed of movement after Beni works together, then the

acceleration caused by the force of the two officers is ....

a. The force of two officers working together has the same acceleration, because the acceleration is directly proportional to the mass of the cart. **(Category 1)**

b. The force of two officers working together has a greater acceleration than that of an officer, because the acceleration is inversely proportional to the force acting on the block. **(Category 3)**

c. The force of two officers working together has no effect on the difference in the acceleration of an officer's force, because acceleration does not affect the acceleration of an object. **(Category 2)**

d. The force of two officers working together has an acceleration greater than that of an officer, because the acceleration is directly proportional to the applied force. **(Category 4)***

3 Look at the following picture!

Bayu walked quickly around a shop while pushing an empty trolley. Then Bayu put some of the things he bought into the trolley. Bayu felt a difference in the speed of movement when Bayu pushed the trolly that was already full of goods with the trolly that was originally empty. If Bayu uses the same force to push the trolley, then there is a difference in acceleration when the trolley is empty and full because....

a. The force given to the trolley is the same and has a large value, so that the acceleration of the trolly is reduced or decelerated. **(Category 3)**

b. The greater the change in the mass of the trolly causes the acceleration of the trolly to decrease or slow down. **(Category 4)***

c. The greater the change in the mass of the trolly, the greater the acceleration of the trolly's thrust. **(Category 2)**

d. There is no difference in acceleration when the trolly's mass is getting smaller with the trolly's acceleration with increasing or greater mass. **(Category 1)**

Data analysis techniques from the isomorphic test are divided into 3 categories, namely understanding concepts, misconceptions and not understanding concepts, based on a minimum of two answers from three multiple choice questions consistently at a certain level. Students will be declared to understand the concept (PK), when students answer category 4 two times. Students are said to have misconceptions, when students answer two times in categories 1, 2, and 3. But if students fill in different categories, then are students are considered not to understand the concept (or it can be said to guess when filling out questions).

The reliability value of isomorphic test instrument for force and motion concept is 0.79 which indicates that the test instrument has high reliability criteria (Budiastuti & Bandur, 2018).

RESULTS AND DISCUSSION

This study reports the results of the analysis of students' misconceptions on Newton's law of motion. By using nine isomorphic items. In general, this study shows that the percentage of students who experience misconceptions is still relatively high. The percentage of students' misconceptions in each indicator is presented in Figure 1.

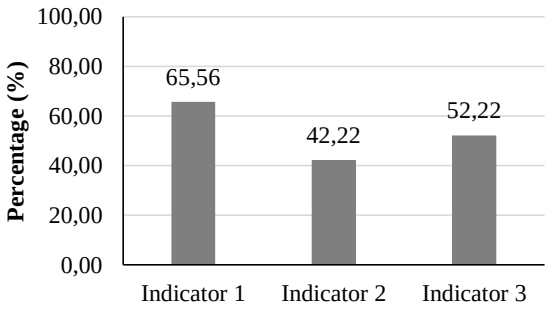


Figure 1. The percentage of students misconception in each indicator

The results of the study in Figure 1 show that students' misconceptions about Newton's law of motion are still relatively high. These results confirm several studies which show that students' misconceptions about Newton's law are relatively high (Rahmawati et al., 2020; Rusilowati et al., 2021; Sulistri & Lisdawati, 2017; Sundaygara et al., 2021). Most students experience misconceptions on indicator 1, which is related to the application of

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Newton's First Law. Furthermore, although it is still relatively high (42.22%), indicator 2 is the indicator with the lowest level of misconception among the three indicators. This indicator is related to analyzing the correlation between force and mass and the velocity of a moving object. In particular, a description of the misconceptions experienced by students is presented in Table 2.

Table 2. The percentage of students' misconceptions using the isomorphic test on the concept of Newton's Law

No	Indicator	Case	Kind of misconceptions	Percentage	Explanation
1	Analyse the application of Newton's First Law in daily	An object that is initially stationary or moving at a constant speed, then it gets an external force that affects its initial state. Students must analyse the events that occur in connection with Newton's First Law	Category 3 The object will maintain it's an initial position in motion by applying a new force in the opposite direction	38 students (42.22%)	Students assume that the object will maintain it's an initial position in motion by giving a new force in the opposite direction. The real concept is that an object has an initial state of motion, so it will continue its state of motion to maintain its velocity. So that the opposing force produced when the object stops suddenly is not an attempt to retain its initial state, but only an impact was resulting from the effort made.
2			Category 2 The object will maintain it's an intial stationary position by applying a new force in the opposite direction.	16 stuents (17.78%)	Students assume that the object will maintain it's an initial position at rest by giving a new force in the opposite direction. The correct concept is that an object at rest will continue to remain at rest, or continue to move straight at a uniform velocity, as long as there is no external force acting on it.
3			Category 1 The object cannot maintain a state of rest or motion when there is, or it is not a net force that affects it.	5 students (5.56%)	Students assume that objects cannot maintain a state of rest or motion when there is or is not a net force that affects them. The correct concept is that an object at rest will continue to remain at rest, or continue to move straight at a uniform velocity, as long as there is no external force acting on it.
4	Analyse the relationship between force and mass and the acceleration of a moving object	Presented events related to daily activities and involve several quantities, including mass and force. Students must analyse the relationship of these quantities with Newton's Second Law.	Category 3 Acceleration is inversely proportional to the amount of force acting on the object.	21 students (23.33%)	Students assume that acceleration is inversely proportional to the magnitude of the force acting on the object. It means that objects that are still or moving slow tend to experience a large force. The correct concept is that the acceleration of an object is directly proportional to the force acting on it, and is inversely proportional to its mass.
5			Category 2 The acceleration is directly proportional to the mass of the block.	8 students (8.89%)	Students assume that the acceleration is directly proportional to the mass of the block. It means that the higher the mass of an object, the greater its acceleration. The correct concept is that the acceleration of an object is inversely proportional to its mass. That is, the higher the mass of an object, the smaller its acceleration.
6			Category 1 Force and mass do not affect the acceleration of an	9 students (1.11%)	Students assume that the value of the acceleration of an object's motion is not influenced by the amount of the force and mass of the object. The correct concept is that the value of the

			object.		acceleration of an object is influenced by the amount of force acting on it and the mass of the object.
7	Analyse the application of Newton's Third Law in daily	An interaction event of two objects that exert forces each other in opposite directions is presented. students must analyse the activities that occur in connection with Newton's Third Law.	Category 3 An object that receives a more significant force will get a reaction in the form of another movement after a reaction action occurs, such as an object moving, being pushed, bouncing or falling.	29 students (32.22%)	Students assume that objects that receive a more significant force will get reactions in the form of other movements after a reaction action occurs, such as moving objects, being pushed, bouncing or falling. The correct concept is that if the first object exerts a force on the second object (action force), then the second object exerts the same force on the first object in the opposite direction (reaction force).
8			Category 2 The value of the force applied to an object depends on the mass amount of the object.	11 students (12.22%)	Students assume that the higher the mass of an object, the greater the force exerted by the object when it interacts with other objects in the opposite direction. The correct concept is that if two objects are touching each other, then the two objects exert a force of the same magnitude and in opposite directions.
9			Category 1 An object will move if it receives a force, and an object will be at rest if it does not accept the force.	7 students (7.78%)	Students assume that force exerted by the object causes an object that moves when it interacts with other forces. Meanwhile, if an object is at rest when it interacts with another object, then that object does not receive the force that causes it to move. The correct concept is that when two objects touch each other, they exert a force of the same magnitude and in opposite directions. Moving or staying still when interacting with each other is caused by external factors that influence it.

Based on Table 2, The result of question related to indicators "Analyzing the application of Newton's first law in daily" are presented in questions 1, 2, and 3. These questions are presented through common events that occur in daily for students to analyse the application of Newton's first law. The results showed the percentage of the number of students identified to understand the concept (PK) on the indicator of this question was 3.33% or as many as three students. This data showed the shallow understanding of students' concepts regarding the application of Newton's first law in daily events so that very few students can consistently answer choice of category 4 (PK) answers, in line with Handhika et al. (2016), research that difficulties in learning Newton's first law are not found in life. Newton's first law states that all objects will remain at rest or will continue to move straight and at a constant speed as long as no external force acts on them (Giancoli, 2005). This law requires students to understand the original state of the object, which is used as a frame of reference.

Misconception category 3 (M3) was identified as the highest misconception of this indicator with a presentation of 42.22% or as many as 38 students. In line with Wiyono et al. (2016) research, students have misconceptions, students assume that objects will maintain their initial position that moves by giving new movements in the opposite direction. The identified misconception of category 2 (M2) was 17.78%, or

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as many as 16 people were students who had a misunderstanding of the concept by assuming that the object will maintain its initial position at rest by applying another force in the opposite direction. Furthermore, as many as 5.56% of students consistently chose answers that contained a misconception of category 1 (M1), which is a misconception that assumes that objects cannot maintain a state of rest or motion when there is, or there is no outside force that affects them. The results of this study are in line with the results of Sundaygara et al. (2021) using the four tier instrument that students still have misconceptions about Newton's first law material.

The items are also used to identifying students' understanding of the application of Newton's Second Law which relates to the relationship between the magnitude of force, mass and acceleration of moving objects in questions 4, 5, and 6 (see Table 1). In this indicator, the results of the data analysis showed quite a number of students who understand the concept of applying Newton's Second Law regarding the relationship. Between the magnitude of the force, mass and acceleration of a moving object. This event is related to Newton's Second Law which describes the acceleration of an object which is directly proportional to the force total; acting on him, and is inversely proportional to his mass (Giancoli, 2005).

The misconceptions that occur in the category 3 (M3) misconception were consistently selected by 23.33% or as many as 21 students with the understanding that acceleration is inversely proportional to the magnitude of the force acting on the object. That is, students' conception of knowledge assumes that objects that are stationary or moving slowly tend to experience a large force. Because the higher the force exerted, the smaller the acceleration of an object, or vice versa Furthermore, the misconception of category 2 (M2) was 8.89% or eight students assumed that if the mass of two objects were the same, then the acceleration would be the same. Students have an understanding that the acceleration of an object is directly proportional to the mass of the object and inversely proportional to the magnitude of the force acting on it (Rusli et al., 2016). Misconception category 1 (M1) as many as 5.56% of students considered that force and mass did not affect the acceleration of an object. Misconceptions that occur in misconceptions of categories 1 to 3 are common because they relate to the application of magnitude values to an equation. So, in addition to understanding events, students must also be able to apply mathematics.

The indicator “analyzing the application of Newton's Third Law in everyday life” which is contained in questions 7, 8, 9 are arranged by presenting an event that is related to the application of Newton's Third Law to everyday life. Students must analyze the events that occurred. However, understanding concepts that are not by the concepts in Newton's Law III, including category 3 (M3) misconceptions with research results of 32.22% or as many as 29 students have a misconception that thinks that objects that receive a more significant force will get reactions in the form of other movements. After a reaction action occurs, such as an object moving, being pushed, bouncing or falling. This is in line with Handhika et al. (2016) research that, which students consider Newton's third law is another form of Newton's first law. The correct concept according to Giancoli is that if the first object exerts a force on the second object (action force), then the second object exerts the same force on the first object in the opposite direction (reaction force) (Giancoli, 2005).

The misconception of category 2 (M2) was 12.22%, or 11 students had a misconception that the value of the force exerted on another object depends on the mass amount of the object. This relates to misconceptions in category three and category 2. Most students assume that if two objects and different masses interact with each other, then the greater force will be given by the object with a more substantial mass (Munfaridah et al., 2018; Wells et al., 2019, 2020). Furthermore, students identified with category 1 (M1) misconceptions were 7.78% or as many as seven students assumed that objects would move when they received a force. Objectives would be stationary when they did not receive a force. If the misconception in category one students give inconsistent answers to each problem, then the student is considered not understanding the

concept. Thus, students need to re-evaluate and repeat lessons to understand.

Based on the results obtained in this study, it shows that the isomorphic test is a test that can be solved using the same physics principles on several similar questions (Barniol & Zavala, 2014; S. Y. Lin & Singh, 2011; S.-Y. Lin & Singh, 2013; Singh, 2008) Isomorphic tests can identify the level of understanding of students 'concepts by exploring students' weaknesses and learning difficulties in the form of misconceptions (Nadhiif et al., 2015). Besides the isomorphic test can describe the dominant and recessive conceptions of students. In line with the theory of epistemolgical belief, knowledge of physics concepts should be comprehensive (Chen et al., 2019; Hammer, 1994). Knowledge transfer can be done easily in various contexts (Hammer et al., 2005; Schunk, 2012). In other words, the instrument must be able to record that students master the concept consistently. On the other hand, misconceptions should also be confirmed by reviewing the consistency of student answers in a category.

The results of this misconception mapping were obtained with the help of an online google form which made this research more accessible. However, one of the weaknesses of isomorphic questions is that it is quite difficult to develop questions with the same context (Kusairi et al., 2020; Suryadi & Kusairi, 2021).

CONCLUSION

The results of this study indicate that the isomorphic test may be administered easily and that accurate data about dominant and recessive student misconceptions can be collected. This study shows that there are still many students who have misconceptions about Newton's laws. Most students experience misconceptions regarding Newton's first law's relevance in everyday life. Many students think that the object will maintain it's an initial position in motion by applying a new force in the opposite direction. This study implies that this list of misconceptions in this study can be used as a reference in compiling physics learning. Furthermore, studies can be carried out in the future to identify misconceptions with isomorphic problems but on different materials.

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