Identification of Students' Misconception on Newton's Law of Gravitation Concept Using The Four-Tier Diagnostic Test

Instrument

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Abstract

This study aims to develop 18 items four-tier diagnostic test (4TDT) instrument for Newton's Law of Gravitation concept including sub material Mass and Weight, Gravitational Force, etc., and identify the misconceptions profile of 32 students in 11th grade at SMAN 1 Gresik using the developed instruments. The type of this research is the development research using ADDIE model (Analyze, Design, Development, Implementation, Evaluation). The analyze phase was carried out to determine the importance of developing instruments from various sides. In the design phase, the initial instrument is made according to the results of the analysis in the previous stage. At the development stage, the 4TDT instrument was compiled and tested for its feasibility. In the implementation phase, 32 students were tested to identify their misconceptions profile. The evaluation phase is formative so that it is carried out during the development process. Based on the calculation, the instrument is declared valid by two lecturers validator in the aspects of content, constructs, and language. External validity was carried out by testing the instrument to 20 other students and obtained 15 items valid and reliable. From the misconceptions analysis results obtained, it is known that 87.5% of students experiencing misconceptions on the matter Newton's Law of Gravitation. The percentage of misconceptions experienced by the students in each sub-material ranged from (0 - 44) %. The highest percentage of misconception occurred in sub-material Gravitational Field. The reason is the student associate Gravitational Field concept with Vertical Upward Motion and Fluid Statics. Students understanding sub-material Kepler's first law well and no students found to experience misconceptions. It can be concluded that the developed instruments are appropriate to be used to identify students' and their causes.

Keywords: four-tier diagnostic test, misconceptions, and Newton's Law of Gravitation

Introduction

Newton's Law of Gravitation is an abstract Physics concept because the main discussion includes enormous objects ($\geq 10^{23}$ kg) (Giancoli, 2014) and only a small portion can be seen clearly, like the Earth, the Sun and other planets. As a result, students only imagine Newton's Law of Gravitation learning presented by the Teacher according to each student's reasoning ability. Given the differences in socioeconomic background, family and student environment, it is very possible that the reasoning ability of each student is different. The differences in reasoning ability have the potential to cause the difference in each student's understanding of Newton's Law of Gravitation concept. Concept is the definition or characteristic of something that is universally agreed, while the results of student interpretation of the concept presented

by the Teacher are called conception (Wiyono, et al., 2016), The difference between the conception and universally agreed upon the concepts cause someone experiences misconceptions.

One misconception on Newton's Law of Gravitation concept is the students assume that the shape of the planet's orbit is circular and the Sun in the center of the circle. While other students consider the planet's orbit to be an ellipse that has two focal points namely F1 and F2 and has an elliptical center point located between the two focal points. Students thought that the Sun is located at the center point of the ellipse. According to the correct concept, all planets move in an elliptical orbit, but the Sun is at one focal point (F1 or F2).

If a misconception is maintained, it will potentially prevent students from understanding the next material related to the concepts above, so that students' misconceptions need to be detected early. There are several methods that can be used to detect misconceptions. There are several methods that can be used to detect misconceptions. According to Kirbulut & Geban (2014), one of the methods that can be used to determine the students' misconceptions is to use diagnostic tests. The diagnostic test is a test used to determine the student's way of thinking in answering the questions and the reasons stated.

One form of diagnostic tests that can be used to identify students' misconceptions effectively is a multiple-choice test. Judging from the data completeness misconceptions captured, then the multiple-choice diagnostic test consists of four types, namely: (1) One-Tier Diagnostic Test (1TDT), (2) Two-Tier Diagnostic Test (2TDT), (3) Three-tier diagnostic Test (3TDT), and (4) Four tier diagnostic Test (4TDT). The misconceptions data that can be captured with 1TDT is only one answers. While the data provided to 2TDT are answer choice and choice of reasons. Data misconceptions 3TDT consists of answer choice, choice of reasons, and answers and reason confidence. While the data can be filtered to 4TDT are answer choices, answer confidence, choice of reasons, and reason confidence, that that can be filtered, it is easy to understand that 4TDT can be used to detect students' misconceptions.

Data can be filtered from 4TDT diagnostic tests can be used to detect students' conceptions which includes Understanding Concepts (UC), Partial understanding (PU), Misconceptions (M), No Understanding (NU) and Cannot be Encoded (CE). Table 1 below shows the combination of the answer and the level of students' conceptions.

N	Category	Combination of Answers			
0.		Answer	Answers Confidence	Reason	Reason Confidence
1	Understanding Concepts (UC)	Right	Sure	Right	Sure
2	Partial understanding	Right	Sure	Right	Not sure
3	(PU)	Right	Not sure	Right	Sure

Table 1. The Combination of Answers and Categories of Students' Conception in The

 4TDT Instrument (Zulfikar, et al., 2017 with modification)

4		Right	Not sure	Right	Not sure
5		Right	Sure	False	Sure
6		Right	Sure	False	Not sure
7		Right	Not sure	False	Sure
8		Right	Not sure	False	Not sure
9		False	Sure	Right	Sure
1		False	Sure	Right	Not sure
0					
1		False	Not sure	Right	Sure
I					
1		False	Not sure	Right	Not sure
1 3	Misconceptions (M)	False	Sure	False	Sure
1		False	Sure	False	Not sure
4					
1 5	No Understanding (NU)	False	Not sure	False	Sure
1		False	Not sure	False	Not sure
6					
1 7	Cannot be Encoded (CE)	If there are part available.	ts that are not answered	l or answered more	than one option

The focus of discussion in this research is the conception of number 13, namely misconceptions. Deep misconceptions by students can be caused by several factors, such as the students itself, book, Teacher, etc. The causes of the misconception that comes from students include preconception, associative thinking, humanistic thinking, wrong intuition, and incomplete reasoning (Suparno, 2013), These five causal factors can be identified through the answer options chosen by students in the 3rd and 4th tier.

Some research on the development of 4TDT that have been published such as Kaltakçi, et al., (2017) has developed instruments 4TDT for Optical Geometry concept. Based on this research it is known that more than 10 % of pre-service teacher experienced a misconception on the concept. Fratiwi, et al., (2017) has made a comparison of 2TDT and 4TDT instruments for Newton's Laws of Motion concept. The results showed that misconceptions found in sub-materials Newton's law, Friction, and Rope Tension. Utari & Ermawati (2018) developed a 4TDT instrument for Temperature, Heat, and Displacement concept. Based on these studies it is known that misconception occurs in sub-material Heat,

Conduction, and Thermal Equilibrium. Anggrayni & Ermawati (2019) has developed 4TDT instruments for Work and Energy concept. The results obtained from the study stated that it fulfills the validity and reliability so that the 4TDT instrument is suitable for use.

For the development of instruments misconceptions on Newton's Law of Gravitation concept has been carried out by Kaltakçi & Didiç (2007) using 3TDT instruments. In this study, the students' conceptions distinguished by understanding concept, partial understanding, and error. As far as the author knows, the development of 4TDT instruments on Newton's Law of Gravitation concept has never been reported.

Methodology of Research General Background of Research

This research is development research using the ADDIE model (Analyze, Design, Development, Implementation, Evaluation) (Anglada, 2007). In the analysis phase, there are three activities, namely an analysis of need, material analysis and analysis of potential misconceptions. In the design phase conducted by making the open-ended two-tier type of instrument and give the instrument to 30 pre-service teachers to find answers and reasons that may be owned by the students. The development phase is carried out in the preparation of a four-tier diagnostic test and tested its feasibility. The developed instrument is declared feasible if they fulfill the validity and reliability. In the implementation phase, 32 students of 11 MIPA 2 class at SMAN 1 Gresik were tested to identify the profile of the student's misconception. The evaluation phase is carried out during the development process.

Instruments and Procedures

The four-tier instrument is made after obtaining the answers and reasons data for the result of the initial trial in the design phase. The developed instrument was amount 18 questions (draft 1) which includes the sub-material Mass and Weight, Law of Gravitation, Gravitational Field, Gravitational Potential Energy, and Kepler's laws. Instrument draft 1 further reviewed and validated by two Unesa Physics lecturers using the validation sheet instruments. From the reviewed results obtained suggestions to make the instrument better (draft 2). Then draft 2 tested on 20 students of 11th grade at SMAN 1 Gresik to determine the feasibility of the instrument externally. An instrument that was declared feasible then tested to 32 other students to find out the students' misconceptions profile and its cause.

Data analysis

The developed instrument can be declared feasible if they fulfill the validity and reliability. The validity process carried out twice, namely the validity to the expert lecturers (internal validity) and validity to students (external validity). Internal validity fulfilled if the average percentage on every aspect of the instrument is ≥ 61 % (Riduwan & Akdon, 2013). External validity includes content validity and constructs empirical validity. The instrument will fulfill the content validity if the value of the percentage of false positive and false negative is < 10% (Hestenes & Halloun, 1995). The false positive is a term that refers to a combination of right-sure-false-sure answers in all four tier (conception of number 5 in Table 1), while false negative is the term for the combination of the answer false-sure-right-sure answer (conception of number 9 in Table 1). The construct empirical

validity will be fulfilled if the value of the product moment correlation coefficient (r count) is greater than the reference coefficient (r reference) (Arikunto, 2016). The instruments stated reliable if the Alpha Cronbach coefficient value is greater than the value of the reference coefficient value (Arikunto, 2016). The reference coefficient in this study was 0.444 because the sample used in the test is 20 people with a significance level of 5 %.

Result and discussion

The purpose of this study is to determine the feasibility of the instrument that has been developed. The feasibility of the instrument can be known through validity and reliability. Internal validity is carried out to two Unesa Physics lectures that include the content, constructs, and language. The results of the internal validity of each aspect can be seen in Table 2.

Sphere	Rated aspect	validator	Average	percentage
		1	_	validity
Contents	Correspondence between the	3	3.5	84%
	items with the Newton's Law of			
	Gravitation concept			
	Conformity items with the	3	3	
	indicator about			
	Conformity items with the	4	4	_
	order of the material			_
	Clarity limitation questions,	3	3	
	answers, and explanations of			
	reasons to expect			
Construct	Clarity diagnostic test	4	4	95%
	instructions			_
	Correspondence between items	4	3.5	
	with the criteria of Bloom's			
	Taxonomy and Basic Competence			_
	Item diagnostic tests can	3	3.5	
	identify students' misconceptions			_
	Impostors on the choice of	4	4	
	reason are rational and			
	homogeneous with the first level			
	answers			_
	Tables, graphs, images, and the	4	4	
	like are in line with the problems			
	presented			
Language	The sentence using Indonesian	3	3.5	83%
	is good and right			_
	Variety sentence or question do	3	3	
	not cause multiple interpretations			

Table 2. Results of Internal Validity Instruments

Sphere	Rated aspect	validator	Average	percentage
		1		validity
	Question every item test	3	3.5	
	articulated and communicative			

Based on Table 2, it is known that the instrument which has been developed fulfill the internal validity by Riduwan & Akdon (2013) because the percentage value of validity is obtained between 83-95%. After the internal validity carried out, the instrument further tested on limited students to determine the feasibility externally. The results of the external validity of the test are shown in Table 3 and Table 4 below.

No.	false	false
Question	Positive	Negative
	(FP)	(FN)
1	7	1
2	4	0
3	1	3
4	3	1
5	0	1
6	0	0
7	0	0
8	2	0
9	0	0
10	0	0
11	0	0
12	5	0
13	1	0
14	4	0
15	3	2
16	0	1
17	1	0
18	0	0
Total	31	9
Percentage	8.61 %	2.50 %

Table 3. Results of External Validity of Contents (Izzah & Madlazim, 2019)

Based on Table 3, it is that the developed 4TDT instrument fulfills the content empirical validity because of the percentage of false positive and false negative instruments are less than 10 %. The data is in accordance with the content validity proposed by Hestenes & Halloun (1995). These results are according to research conducted by Kaltakçi, Eryilmaz, and McDermott (2017) entitled "Development and Application of A Four-Tier Test to Assess Pre-Service Physics Teachers' Misconceptions about Geometrical Optics" in ERIC, the results of these studies indicate the percentage of FP and FN respectively 3.5 % and 3.3 %. In

addition, the results of the study are also similar to studies conducted by Kirbulut & Geban (2014) entitled "Using Three-Tier Diagnostic Test to Assess Students' Misconceptions of States of Matter" and published in Eurasia Journal of Mathematics, Science & Technology Education. In that study obtained FP values is 8.9% and FN amounted to 3.8%.

No.		14		
Questio	Questio r count rafarance		Criteria	
n		rejerence		
1	0.711	0.444	Valid	
2	0.860		Valid	
3	0.477		Valid	
4	0.456		Valid	
5	-0.160		Invalid	
6	0.456		Valid	
7	0.711		Valid	
8	0.516		Valid	
9	0.629		Valid	
10	0.472		Valid	
11	0.711		Valid	
12	0.711		Valid	
13	0.537		Valid	
14	0.283		Invalid	
15	0.445		Valid	
16	0.711		Valid	
17	0.224		Invalid	
18	0.623		Valid	

Table 4. The Results of Construct Empirical Validity (Izzah & Madlazim, 2019)

The result of the calculation of the product moment correlation coefficient instrument that has been developed is 0.610 so that the instrument fulfills the construct empirical validity. Furthermore, to determine the construct empirical validity of each item, product moment correlation coefficient (r count) is calculated with the results as in Table 4. In Table 4, it can be seen that the value of r count each item has a range from - 0.160 to 0.860. Of the 18 items were developed, there are three items that do not fulfill the construct empirical validity because of the value of r count smaller than the r reference (Arikunto, 2016). Furthermore, 15 items that fulfill external validity are used in the reliability test. The instrument reliability test results showed that the value of the Alpha Cronbach coefficient is 0.843. The calculation value is greater than the r reference. Therefore, instruments developed can be expressed reliably.

After the instrument is declared feasible, then the instruments used for 32 students to identify the misconceptions profile held by each student. Based on the results of trials that have been performed, the data obtained in the form of a combination of answers from each student. The combination of the answer consists of four components, namely: (1) answer, (2) answers confidence, (3) the reasons, and (4) reasons confidence. Furthermore, any

combination of answers grouped into categories conception according to Table 1 which includes: (1) Understanding Concepts (UC), (2) Partial Understanding (PU), (3) Misconceptions (M), (4) No Understanding (NU), and (5) Cannot be Encoded (CE). According to data the results of the test by 32 students of 11 MIPA 2 class, the conception profile of students is obtained in the materials Newton's Law of Gravitation concept is generally shown in Figure 1.



Picture 1. Conceptions profile of 11 MIPA 2 students in Newton's Law of Gravitation materials.

From Figure 1 above, it can be seen that the largest percentage of the conception possessed by students of 11 MIPA 2 class is PU that is equal to 31 % and the lowest percentage is CE with a value of 2 %. Percentage of M and PU has almost the same distribution, namely 28 % and 31 %. The highest PU conception experienced by students is due to the lack of understanding of the reasons for the questions presented. Students understand well the main problems on the matter, but students are less capable of choosing the right reasons with confidence. The M conception, the students have confidence in the wrong answers and reasons. Therefore, the distribution of misconceptions and partial understanding has a close value. The students' conceptions profile on each sub-material, can be seen in Figure 2.



Figure 2. (a) Distribution conception of 11 MIPA 2 students on sub material Mass and Weight, Gravitational Force and Acceleration of Gravity, Universal Gravitation, and Earth's Gravity.



Figure 2 (b) Distribution conception of 11 MIPA 2 students on sub material Gravitational Field, Gravitational Potential Energy, Kepler's First Law, Kepler's Second Law, and Kepler's Third Law.

Based on Figure 2 above, it can be seen that the conceptions profile of students in 11 MIPA 2 class for each sub-material is quite diverse. The highest conception percentage of sub-material Mass and Weight is partial understanding. The sub-material ask about the

difference between mass and weight and its application. Most students know that mass and weight are two different things, but the students do not understand the differences between the two. Besides that, it was found the students who experienced misconceptions on the material believes that mass and weight are the two things are the same and both have Kilogram (Kg) units. According to the Physics concept, mass is the amount of material contained in an object, while the weight is a measure of the influence of gravity on an object. Students' ignorance about the difference between mass and weight can occur because in everyday life the use of word "weight" is defined as the mass in physics.

In sub material Gravitational Force and Acceleration of Gravity, the biggest conception is partial understanding. The question presented to represent the sub-material is about how the difference between the gravitational force and acceleration of gravity. Students know the differences in the application of the two concepts, but students experience errors in defining the sub-material correctly. Definition of gravitational force by students is the attraction between two objects with mass m_1 and m_2 that are separated by distance r, while the acceleration of gravity is the acceleration that possessed by an object because of interaction with another object. The definition of gravity is the change of speed experienced by objects due to the gravitational attraction. Students' mistakes in defining the concept can occur because students simply memorize the use of both concepts in physics without knowing the definition correctly. Misconception on the sub-material is students believe that the gravitational force is affected by the acceleration of gravity because of the interaction between the object and other objects.

The biggest conception in the sub-material Universal Gravitation is a misconception. Questions about the sub-material contain the reasons why the Moon does not fall to Earth. The most answer is because the Moon is influenced by centrifugal force and centripetal force. The correct concept is that the Moon does not fall to the Earth because the resultant forces experienced by the Moon are zero. The misconception may occur because students assume that the Moon's orbit is a circle so that the Moon only has the centripetal force and the centrifugal force and overrides the existence of a gravitational force that affects it.

In sub-material of Earth's Gravity, the highest percentage of conception is a misconception. The questions are presented is about the motion of objects in space and on the slippery surface. Many students believe that objects in space do not require a force to make it move at a certain speed. According to the physics concept, an object that is placed on a slippery surface and in space require the same force to move at a certain speed. The error of students' beliefs can occur because students have never observed directly or through the media learning about how the motion of an object in space or on the slippery surface. The results of the study were similar to a study conducted by Gonen (2008) which states that many physics student teachers and science student teachers he studied both experienced misconceptions related to the force of gravity on the surface slippery and in space. They consider that in space there is no force that can block the object to move, while on slippery surfaces gravity affects the motion of the object.

The highest percentage of conception in sub-material Gravitational Field is a misconception. The sub-materials asked about the acceleration of gravity value of a satellite when traveling around the Earth. Most students said that the satellite acceleration of gravity

value is less than the acceleration due to gravity at the Earth's surface. The correct concept is the acceleration of gravity value experienced by the satellite is zero because the satellite is in the gravity-free area. The emergence of a less precise thought can occur because students equate the concept of gravity with the concept of vertical upward motion. In addition, errors can also be caused because students just memorize the gravitation field equations without knowing the concepts in depth.

The biggest conception that occurs in the sub-material of Gravity Potential Energy is partial understanding. In this sub-material presented questions about the speed of the meteorite that falls close to the Earth's surface. Students understand well that the meteorite speed will be faster as a reduction in the distance between the meteorite and the Earth's surface, but the students consider that the reasons affecting these problems are the air velocity. When approaching the surface of Earth, meteorite movement is affected by air velocity so that meteorite moves. Actually, the closer to the Earth's surface meteorite will move faster because the potential energy decreases and vice versa the meteorite kinetic energy will increase. The presumption of the students who inaccurate can occur because the Teachers do not associate the concepts learned in everyday life.

In sub-material Kepler's First Law, the highest conception possessed by the students of 11 MIPA 2 is the understanding concept. Questions relating to the sub-material ask about the center of the solar system. As many as 75 % of students understand the concept well and 25 % have a conception of partial understanding. Students who experience the PU stated that every celestial body has its own orbit so that the Sun orbits the Earth and vice versa the Earth around the Sun. Most students answered correctly because the question is categorized as easy and it is generally known that the Sun is the center of the solar system.

The highest number of conception distribution in sub-material Kepler's Second Law is partial understanding. Questions relating to the sub-material ask about the speed of the planet to orbit the center of the solar system. Most students understand that the orbital velocity of the planet depends on the distance of the planet to the sun, but the students did not know that the speed of the planet's orbit affects the length of day and night. In addition, some students who experience misconceptions revealed that the Earth is always moving at the same speed because it has a circular orbit. The lack of students' knowledge of the relationship between the speed of the planetary orbits to the duration of day and night can be caused by learning process only focused on the existing equation without connecting concepts with knowledge in everyday life.

In sub-material of Kepler's Third Law, the highest conception experienced by students is a misconception. The question that represents the sub-material is about an orbital period of the dust on Saturn's ring. Many students believe that the orbital period of the dust depends on the mass of the dust. The greater the mass of the dust, the longer the movement of the orbital period. The correct concept is the movement of dust in Saturn's rings depends on the location of the dust from the center of Saturn. The difference between the students' understanding and a correct conception can occur because students consider objects that have a larger mass will be more difficult to move than the light-mass objects.

The findings of misconceptions related to the sub-material Kepler's Laws are different from the results obtained by Yu, et al. (2010). From these results, Yu revealed that nonmajor undergraduate students he researched experiencing misconceptions on the shape of the

planetary orbits around the Sun (Kepler's First Law) which is very oval-shaped because of most students' attention from the print and internet. In sub material Kepler's Second Law and Kepler's Third Law, many of these students knew well. That's because the learning process is using an analogy.

The causes of misconceptions experienced by students may come from preconception (P), humanistic thinking (HT), associative thinking (AT), wrong intuition (WI), and incomplete reasoning (IR). Overall, the distribution of causes of misconceptions experienced by students of 11 MIPA 2 class can be seen in Figure 3.



Figure 3. Misconceptions profile of 11 MIPA 2 students in Newton's Law of Gravitation materials.

Based on Figure 3, it is known that most of the misconceptions experienced by students of 11 MIPA 2 class are caused by preconceptions. Preconception is a students' initial idea about a concept before starting learning. The causes of misconceptions due to preconceptions can occur if after Teacher convey correct concepts during learning, students still continue to believe wrong initial thinking.

The next highest percentage of causes students' misconceptions is associative thinking. Associative thinking is the thinking that considers a concept similar to other concepts. This thinking occurred because there are similarities in terms and error in interpreting the relationship between concepts. Both of these causes of misconceptions quite high because they relate to the students' experiences of everyday life, giving rise for each student. In addition, students who already have knowledge of the concepts of physics in the previous material will connect these concepts with a different material. Therefore, associative thinking may also the cause of dominant misconceptions.

The lowest percentage of causes of misconceptions is due to humanistic thinking, which is equal to 4 %, because of the 18 questions that have been developed, there is only one item that has the cause of misconceptions humanistic thinking. That's because Newton's Law of Gravitation material discusses objects in space so that not many concepts are in accordance with human behavior. For example, Kepler's Third Law discusses the planet's orbital period when surrounding the Sun. Problems such as the Kepler's Third Law cannot be equated with human behavior. Furthermore, the distribution of causes of misconceptions experienced by students of 11 MIPA 2 class in each sub-material can be seen in Figure 4.



Figure 4. (a) Distribution of causes of the misconception of 11 MIPA 2 students on sub-material Mass and Weight, Gravitational Force and Acceleration of Gravity, Universal Gravitation, and Earth's Gravity.



Figure 4. (b) Distribution of causes of the misconception of 11 MIPA 2 students on sub-material Gravitational Field, Gravitational Potential Energy, Kepler's First Law, Kepler's Second Law, and Kepler's Third Law.

Based on Figure 4, it can be seen that the highest percentage of misconception on sub-material Mass and Weight due to incomplete reasoning. Students assume that the mass of the object depends on the density and volume of the object. According to the concept of physics, mass and volume of the object affect its density. The existence of these thoughts can occur because most students only memorize the formulas on the material without knowing the meaning physically.

In sub-material Gravitational Force and Acceleration of Gravity, 75 % of students who experienced misconceptions is caused by wrong intuition. Students tend to not understand the meaning of acceleration due to gravity. Students assume that the acceleration of gravity is

defined as the change in velocity per unit time which is owned by stationary objects. The correct concept is the acceleration of gravity is owned by all objects that are in a gravitational field. The students' misunderstanding can occur because students only understand a concept along with the equation without knowing the meaning of the concept.

The highest cause of misconception in sub-material Universal Gravitation is associative thinking. For example in question that asked about the reason why the Moon not falling to Earth, the students associate the concept of Gravitational Force with Circular Motion. According to them, the Moon does not fall to Earth because of the force of centripetal and centrifugal forces without other factors. Based on the physics, the reason the Moon does not fall into the Earth is the resultant forces possessed by the Moon is zero, including gravitational force. The difference between the students' understanding and the physics concepts can occur because students only imagine that the shape of the Moon's orbit resembles a circle.

The biggest distribution of the cause of misconceptions in sub-material of Earth's Gravity is preconceptions. The question is the force applied to an object in space and on the slippery surfaces, the students believe that the objects in space will float even without being given a force. Therefore, students assume that no force needed to move an object in space at a certain speed. The correct concept is that both objects placed in outer space and on slippery surfaces, both require the same force to make the object move at a certain speed. The students' misunderstandings occur because the students had never been to directly observe how the motion of an object in space. In addition, the Teacher has never demonstrated the problems.

The biggest percentage cause of misconceptions in the sub-material Gravitation Potential Energy is a preconception. Students assume that every object that moves in the air or in the atmosphere of the Earth will have an air force that will accelerate or reduce the velocity of the object, no exception a meteoriteite falls near the earth's surface so that the meteorites' velocity will decrease as it approaches the Earth's surface. According to the physics concept, the velocity of falling meteorites will increase as the reduction in the distance between the meteorite and the Earth's surface because of the gravitational potential energy decreases and its kinetic energy increases. Their students' misunderstanding is due to the daily life of students observed that air friction can affect the movement of the light object when floating in the atmosphere, such as paper, leaves, etc.

In sub-material Kepler's Second Law, the highest cause of the misconceptions is preconceptions. The question presented is about the influence of the speed of the Earth's orbit around the Sun with life on the Earth's surface. Students who experienced misconception believe that the speed of the Earth's orbit does not have any impact on life on Earth. In this sub-material, there is the cause of misconceptions by humanistic thinking. Students assume that when the Earth is closer to the Sun, the day will be slow. It was likened to human behavior that is when you're near a campfire, the body will be hotter than when the body far from the campfire. In fact, the speed of the Earth's orbit has an impact on the duration of day and night. Student's confidence in wrong thinking can occur because the students are not able to realize directly the effects of the Earth around the Sun.

The biggest cause of misconceptions in the sub-material Kepler's Third Law is incomplete reasoning. Students understand that the mass of the dust in the rings of Saturn affects its orbital period. The greater the mass of the dust is, the orbital period will be longer. According to the physics concept, the orbital period of Saturn's dust is affected by the dust distance from the center of Saturn. Students' misconception can occur because students understand some of the physics concepts, that is the movement of the object is influenced by its mass, the students do not understand correctly the context being discussed.

In general, students experiencing misconceptions on Newton's Law of Gravitation material can also be caused due to Teachers errors in presenting the material. Teachers usually teach the material with classical methods, because there are no tools and media that can be used to explain the concept correctly. One way that can be used to facilitate teachers in teaching the material of Newton's Law of Gravitation is by using the application of information and communication technology or interactive learning. The use of information and communication technology can help Teachers to overcome the limitations of observations of natural phenomena that are not easy to reach Wicaksono, et al. (2017). In addition, other causes of misconceptions related to these materials are books or other untrusted sources (Neto & Albrecht, 2018). Most print media contains information that is slightly ambiguous so that is can cause the students to experience thoughts that are not in accordance with the concepts of physics.

Conclusion

Based on the results of this study concluded that the Four-Tier diagnostic test instrument for Newton's Law of Gravitation materials that have been developed is deemed feasible because it fulfills validity and reliability. The instrument is also able to identify students' misconceptions and their causes which include preconception, associative thinking, humanistic thinking, wrong intuition, and incomplete reasoning.

A total of 87.5 % of students did not understand the material of Newton's Law of Gravitation well. The highest misconception is in sub-material Gravitational Field with a percentage of 44 %. While not found students who have misconceptions on the sub-material Kepler's First Law, but on the contrary, 75 % of students understand the concept correctly. Overall, the highest cause of misconceptions is a preconception that is equal to 27 % and the lowest was humanistic thinking with a percentage of 4 %. The highest cause of the misconceptions is caused by the preconception that occurs in the sub-material Gravitational Potential Energy is equal to 71 %. Humanistic thinking is a cause of the misconception that only the material contained in the Kepler's Second Law is equal to 36 %.

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