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Analysis of Students' Physics Conceptual Understanding using Five-Tier Multiple Choice Questions: the Newton's Law of Motion Context

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Abstract: Conceptual understanding is one of the physics learning objectives that can support students' thinking skills. Understanding of concepts in physics learning is very important for students, so that learning outcomes can be achieved maximally. This study aims to analyze the level of understanding of students' concepts on the topic of Newton's law of motion. This research is a descriptive research with quantitative approach. The research was at SMAN 4 Padang, SMAN 6 Padang, and SMAN 12 Padang West Sumatera. The total sample was 218 students. The five-tier multiple choice questions was used as a research instruments. Before the questions were used, the questions were tested first in different schools with the aim of knowing the validity, reliability, difficulty level, and distinguishing power of the items. After testing, 14 questions were obtained that could be used in this study. The results showed that 13.37% of students scienctific conception, 9.53% of almost scientific conception, 42.01% of students lack of confidence, 30.14% of students have misconceptions, 0.98% of students have no conception, and 3.96% of students have undefined. Based on these results, it can be concluded that students' conceptual understanding of Newton's law of motion material is still low.

Keywords: Conceptual understanding; Five-tier multiple choice; Newton's laws of motion

Introduction

Physics is one of the studies of science in the branch of Natural Sciences that studies non-living natural phenomena or matter within the scope of space and time (Harefa, 2019). The contribution of physics in the development of science and technology is quite important because it can provide benefits for human life (Amalia, 2018). The learning of physics needs to be enhanced so that the development of physics science can progress even further. Improving physics education can be achieved by emphasizing experiential learning for students to develop their competencies, enabling them to naturally understand their surroundings (Sidik, 2018). One of the competencies that needs to be improved is students' knowledge, which can be supported by a deep understanding of concepts and the ability to integrate their knowledge into life (Guswina & Mufit, 2020; Widayani, 2023).

Students gain absolute understanding of concepts when implementing physics learning (Adnyani et al., 2013). The understanding of concepts is an ability possessed by students to receive and interpret a representation of generalized knowledge from various phenomena (Dewi & Suhandi, 2016). Understanding of concepts is used as the foundation for understanding principles and theories (Fitrianingrum et al., 2017). In order to understand principles and theories, one must first master the concepts that make up the principles and theories.

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Every student has different abilities in understanding concepts. Some students easily understand the concepts, while others may find it difficult. Students who have difficulty understanding concepts and tend to misconceptions will hinder the student learning process, especially their ability to understand physics concepts at the next level (Fakhruddin et al., 2012), and also affect student learning outcomes (Shalihah et al., 2016; Anri et al., 2022). The great learning result does not necessarily indicate that the student understands the concept taught (Tsabit et al., 2020). A lack of conceptual understanding can hinder the acceptance of new knowledge, thus disrupting the learning process (Setianita et al., 2019). Students who do not understand the concept will make them difficult to solve physics problems, because the basis of problem solving ability is a good understanding of the concept (Yana et al., 2020). Understanding the concept does not only mean remembering or repeating the information received but also involves the ability of the student (Utami et al., 2016). Students often memorize physics material so that when solving physics problems they often forget.

Based on the literature study, there are many studies on students' conceptual understanding, especially in the field of physics. Problems in physics learning that are often encountered are low understanding of concepts and misconceptions (Mufit et al., 2018). Misconception research in the field of physics is 300 studies on mechanics, 159 studies on electricity and magnetism, 70 studies on heat, optics, and material properties, and about modern physics there are 10 studies (Sidik, 2018). From this data, it can be seen that mechanics is at the top of the other physics fields that experience misconceptions. The study of mechanics that is difficult for students to understand which results in misconceptions is Newton's Law of motion because it is material that requires students to be able to analyse questions (Shalihah et al., 2016; Hidayati et al., 2023).

Newton's law of motion is essential in explaining physical phenomena in the reality, so this material is taught at various levels of education including elementary school, high school, and college (Sornkhatha & Srisawasdi, 2013). If students understand the concept of Newton's law, it will be easy for them to understand particle dynamics because Newton's law is the basic principle in particle dynamics in various problems of object motion (Hidayati et al., 2023). Newton's law of motion is one of the physics materials that often experience misconceptions because of its high level of difficulty and has quite a lot of forms of questions (Taqwa & Pilendia, 2018). In the material of Newton's law of motion, students must be able to describe the forces acting on an object by analyzing or identifying the interaction of an object to be studied with objects that affect the object.

Based on the results of interviews with physics teachers at SMAN 4 Padang, SMAN 6 Padang, and SMAN 12 Padang, there are still students who find it difficult to understand physics material and some even experience misconceptions. This is known by the teacher from the students' incorrect answers when answering the teacher's questions during the learning process. One of the problems encountered by the teacher when teaching Newton's law about motion. The teacher explained that some of the students' incorrect answers were due to their lack of understanding of the concept as well as from the thoughts they built themselves based on the phenomena they encountered in their lives. Even though the teacher had explained the material and the teaching materials were also owned by each student, there were still conceptual errors when answering the teacher's questions. In all three schools, students experienced difficulties in drawing free-body diagrams and even misconceptions. The difficulties experienced by students when describing free-body diagrams are due to a lack of understanding of the concept of forces acting on objects.

On average, students easily describe the free-body diagram when it is on a flat surface because they memorise from the examples given by the teacher. When the surface of the object is changed to tilt, students have difficulty in describing the free diagram of the object, for example in the direction of normal force and gravity. Students assume that the normal force always points upwards while the gravity always points downwards and ignore the influence of the earth's gravity, this assumption is certainly wrong in physics concepts. The direction of the normal force is perpendicular to the surface of the earth. Problems like this must be addressed immediately by the teacher so that they do not continue to the next level.

Teachers as one of the pillars of education need to evaluate learning in order to determine the understanding of concepts from students and find what difficulties students experience during learning. From the evaluation, the teacher can find out which students need to be given emphasis on concepts. This is done in order to determine the effectiveness and efficiency of the learning process carried out (Mubarak et al., 2016). The way that teachers determine students' conceptual understanding is by using a diagnostic test. Diagnostic test is a type of test that can find out students' weaknesses on a concept so that the results can be given appropriate treatment (Prodjosantoso et al., 2019). Diagnostic test results can be used as a reference for a teacher to carry out learning according to student abilities (Rusilowati, 2015) and can demonstrate one's mastery of concepts (Susanti, 2021). In identifying

students' concept understanding, the most recent and widely used method is to use one type of diagnostic test, namely a five-tier multiple choice test (Hidayatullah & Mufit, 2023).

Five-tier multiple choice is a diagnostic test consisting of five levels. The first level is a question with several options and one correct answer, the second level is the confidence of the answer in the first level, the third level is the reason for choosing the answer, the fourth level is the confidence of the reason chosen, and the fifth level is an additional open-ended question (Putri & Ermawati, 2021). The advantage of this test is that it can reveal students' conceptual understanding more deeply because the fifth level is in the form of an open question that asks students to describe a concept or write a conclusion according to the concept requested at the first level and the third level. The results of this test can determine the level of students' conceptual understanding.

Based on the problems that have been described, it is necessary to have a test to analyse the concept understanding of high school students on the material of Newton's law of motion so that the level of understanding of students' concepts can be known. so that teachers can carry out learning by emphasizing materials that are difficult for students to understand and materials that often experience misconceptions.

Method

This research is a descriptive study with a quantitative approach. The population in this study were students in class XI High School in Padang City in the 2023/2024 school year. The sampling technique in this study was purposive sampling. The samples of this study were SMAN 4 Padang, SMAN 6 Padang, and SMAN 12 Padang. The number of samples in each school can be seen in Table 1.

Table 1. Sample Quantity

School	Code	Quantity of students in class
SMAN 4 Padang	A	216
SMAN 6 Padang	B	179
SMAN 12 Padang	C	179
Total		574

The research sample size was determined using the Isaac and Michael formula (Sugiyono, 2017):

$$\boldsymbol{S = \frac{\lambda^2.N.P.Q}{d^2(N-1)+\lambda^2.P.Q}} \quad (1)$$

Based on the calculation results according to equation (1), several samples for each school were obtained:

$$SMA\ A \quad = \frac{216}{574} x217 = 81{,}658 \approx 82 \text{ students}$$

$$SMA\ B \quad = \frac{179}{574} x217 = 67{,}67 \approx 68 \text{ students}$$

$$SMA\ C \quad = \frac{179}{574} x217 = 67{,}67 \approx 68 \text{ students}$$

The results of the sample calculation in the form of fractions can be rounded so that the sample size becomes 218 students consisting of 82 students of SMA A, 68 students of SMA B students, and 68 students SMA C students.

The research instrument is a five-tier multiple choice diagnostic test question. Before using the five-tier multiple choice test, it was validated by the expert and trial field testing was carried out to determine the validity, reliability, distinguishing power, and difficulty level of the items. The distribution of five-tier multiple choice questions on Newton's Law of Motion material based on competency achievement indicators is in Table 2.

Table 2. The Five-Tier Multiple Choice Test on the Newton's Law of Motion

Indicator of Competency Achievement		Number
3.7.1	Explain the definition of force and force resultant	1, 2
3.7.2	Explaining Newton's laws of motion	3, 4, 5, 6, 7
3.7.3	Explain the forces acting on objects	8, 9, 10, 11, 12, 13, 14
3.7.4	Analyze the interaction of forces and the relationship between force, mass, and acceleration according to Newton's laws	15, 16, 17, 18, 19, 20

Based on the results of the trial field testing, 14 questions were used as a test instrument for students' conceptual understanding, namely question numbers 1, 2, 3, 4, 7, 8, 9, 11, 12, 14, 15, 17, 18, 19. While the other 6 questions were discarded or not used, namely numbers 5,6,10,13,16,20. Valid questions can be used to analyze students' conceptual understanding. The example of the five-tier multiple choice instrument used is as shown in Figure 1.

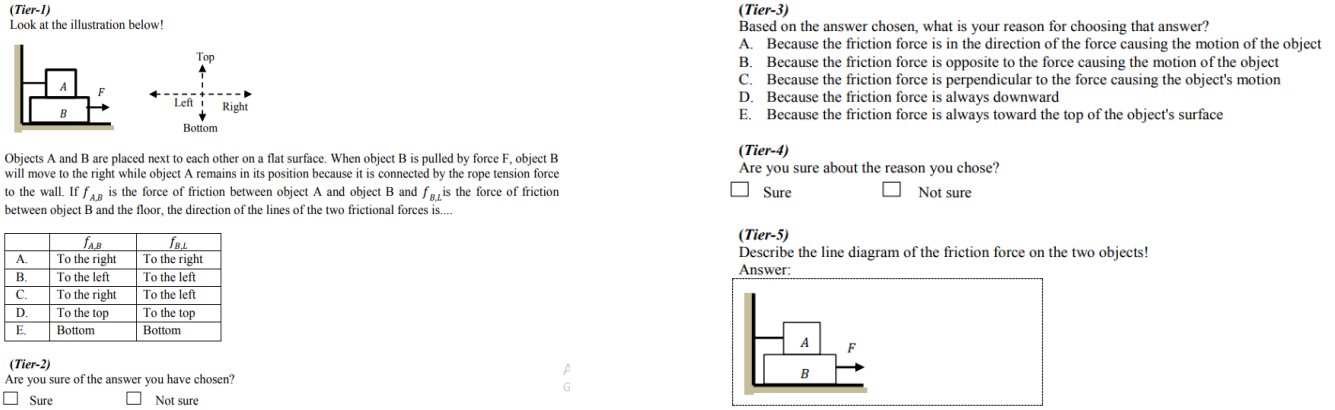
The data analysis technique in this study first grouped student test results into various levels of conceptual understanding using the interpretation guidelines by Anam et al.(2019). An explanation of each level of student conceptual understanding is in Table 3.

After grouping students based on the conception category, it is continued by calculating the percentage of each level of students conceptual understanding by using the following equations (Patriot, 2019).

$$P = \frac{f}{N} x\ 100\% \quad (2)$$

P is the percentage value of student conception categories, f is the number of students in a particular

conception category, and N is the total number of students. The percentage value of students' conceptions is made in a table and describes the data obtained.



(Tier-1)
Look at the illustration below!

Objects A and B are placed next to each other on a flat surface. When object B is pulled by force F, object B will move to the right while object A remains in its position because it is connected by the rope tension force to the wall. If $f_{A,B}$ is the force of friction between object A and object B and $f_{B,L}$ is the force of friction between object B and the floor, the direction of the lines of the two frictional forces is....

	$f_{A,B}$	$f_{B,L}$
A.	To the right	To the right
B.	To the left	To the left
C.	To the right	To the left
D.	To the top	To the top
E.	Bottom	Bottom

(Tier-2)
Are you sure of the answer you have chosen?
☐ Sure ☐ Not sure

(Tier-3)
Based on the answer chosen, what is your reason for choosing that answer?
A. Because the friction force is in the direction of the force causing the motion of the object
B. Because the friction force is opposite to the force causing the motion of the object
C. Because the friction force is perpendicular to the force causing the object's motion
D. Because the friction force is always downward
E. Because the friction force is always toward the top of the object's surface

(Tier-4)
Are you sure about the reason you chose?
☐ Sure ☐ Not sure

(Tier-5)
Describe the line diagram of the friction force on the two objects!
Answer:

Figure 1. Instrument five-tier multiple choice

Table 3. Students' Level of Conceptual Understanding

Level of Conception	Explanation
Scienctific Conception (SC)	Students answer tier-1 and choose reasons in tier-3 correctly. Students are confident with the answers and reasons chosen, and make descriptions/conclusions in tier-5 in accordance with physics concepts
Almost Scientific Conception (ASC)	Students answer tier-1 and choose reasons in tier-3 correctly. Students are confident with the answers and reasons chosen, but are incomplete in making a description/conclusion in tier-5 that is in accordance with physics concepts.
Lack of Confidence (LC)	Only one of the students' answers in tier-1 and reasoning in tier-3 were correct. Students may or may not be confident in the answer choices and reasoning, and the figure/conclusion in tier-5 is reasonably consistent with the physics concept.
Misconceptions (M)	Students answered tier-1 and chose the reasoning in tier-3 incorrectly. Students are confident with their answers and reasoning, but the drawings/conclusions made in tier-5 are not in line with the physics concept.
Have no conception (HNC)	Students answered tier-1 and chose the reason in tier-3 incorrectly. Students are unsure of their answer and reasoning, and the drawing/conclusion in tier-5 is not in line with the physics concept.

The research flow is summarized in Figure 2.

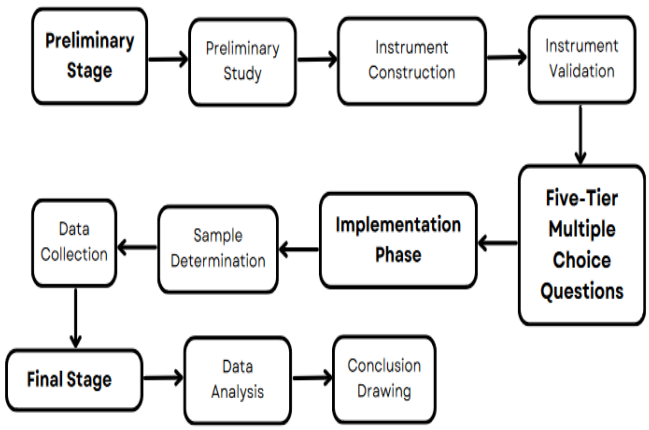


Figure 2. Research flow chart

Result and Discussion

The data obtained from the results of the five-tier multiple choice test were analyzed in accordance with the objectives of the research, namely analyzing the understanding of students' physics concepts on the Newton's law of motion at High School in Padang city. This research data was obtained from the results of a five-tier multiple choice diagnostic test given to 218 students in three schools namely SMA A, SMA B, and SMA C. Data analysis was carried out quantitatively which aims to determine the percentage of students' conceptual understanding on the material of Newton's law of motion. The data obtained were grouped into several levels of understanding, namely scientific conception (SC), almost scientific conception (ASC), lack of confidence (LC), misconceptions (M), have no conception (HNC), and undefined (Un-Code). The number of students and the percentage of students' conceptual understanding level on questions number 1 to 14 that have been given to 218 students at three SMAN Padang City obtained the results as in Table 4.

Profile of Students' Understanding of Physics Concepts on the Newton's Law of Motion for each indicators

Conceptual understanding is an important foundation or goal in physics learning (Juita et al., 2023). Students certainly have different conceptual understanding due to several factors. Conceptual understanding in students can be caused by internal factors in the form of their respective thinking abilities and external factors in the form of environmental conditions, social, economic, and educational conditions of each student (Yulianti, 2017; Kaniawati et al., 2019). The following will explain the level of understanding of student concepts on all indicators of competency achievement.

Indicator 3.7.1. Explain the Definition of Force and Force Resultant

This indicator is about explaining the definition of force and resultant force which consists of two items, represented by questions number 1 and 2. On average, students in the three schools are at the level of not understanding the concept. This can be seen from the answers of students who are mostly correct in determining the direction of motion of objects contained in tier-1 but they are wrong in choosing the reasons contained in tier-3. Each student chose a variation of reasons and on average students answered that the direction of motion of an object is in the direction of the largest force. The reason chosen by students is an incorrect choice because the correct choice is the direction of motion of the object following the resultant force experienced by the object. Student mistakes are caused by students' initial knowledge of vector analysis is not well understood by students so that students experience misconceptions (Muna, 2016).

Indicator 3.7.2. Explain the Concept of Newton's Laws

Indicator 3.7.2 consists of three items, namely numbers 3, 4, and 5. In the three questions students are asked to explain Newton's laws from several events in everyday life. Based on the data analysis conducted, on average, students experience misconceptions that reach 42.5%. The misconceptions experienced by students are known from the variations in the answers given. Many students are wrong in choosing answers and reasons but they are confident in the answers they make. This conceptual error, known as misconception, is caused by students not fully understanding the concept of Newton's law. Examples of misconceptions that occur are students who believe that Newton's first law is only for objects that are at rest, while in physics concepts on objects moving at constant speed also apply Newton's law as long as there is no external force affecting them. The event of the passenger being pushed forward when the car is braked is an example of an event in Newton's first law. The pushing of passengers forward when the car is braked occurs because passengers tend to maintain their state of motion with the car, but students consider passengers who are pushed forward to be a reaction force from the braking force of the car.

Students do not understand the concept of action-reaction forces in accordance with Newton's third law, which is exemplified in the collision between a car and a parapet. The amount of force exerted by the car to the parapet will be equal to the amount of force exerted by the parapet to the car but in the opposite direction. However, students' answers varied, with some answering that the force of the car was greater and others answering that the force of the wall was greater.

Table 4. Frequency and Percentage of Students' Conceptual Understanding Level

No	Level of Concept Understanding											
	Scienctific Conception (SC))		Almost Scientific Conception (ASC)		Lack of Confidence (LC)		Misconceptions (M)		Have no conception (HNC)		Un-Code	
	n	%	n	%	n	%	n	%	n	%	n	%
1	42	19.27%	9	4.13%	123	56.42%	40	18.35%	0	0.00%	4	1.83%
2	41	18.81%	42	19.27%	113	51.83%	17	7.80%	0	0.00%	5	2.29%
3	20	9.17%	2	0.92%	123	56.42%	70	32.11%	0	0.00%	3	1.38%
4	11	5.05%	14	6.42%	69	31.65%	120	55.05%	0	0.00%	4	1.83%
5	45	20.64%	35	16.06%	31	14.22%	88	40.37%	11	5.05%	8	3.67%
6	39	17.89%	53	24.31%	93	42.66%	25	11.47%	0	0.00%	8	4.13%
7	45	20.64%	82	37.61%	49	22.48%	33	15.14%	0	0.00%	9	4.59%
8	19	8.72%	16	7.34%	101	46.33%	66	30.28%	6	2.75%	10	5.96%
9	46	21.10%	9	4.13%	108	49.54%	41	18.81%	1	0.46%	13	5.96%
10	37	16.97%	4	1.83%	101	46.33%	68	31.19%	0	0.00%	8	3.67%
11	6	2.75%	5	2.29%	107	49.08%	83	38.07%	7	3.21%	10	4.59%
12	23	10.55%	0	0.00%	72	33.03%	107	49.08%	3	1.38%	13	5.96%
13	10	4.59%	12	5.50%	83	38.07%	99	45.41%	1	0.46%	13	5.96%
14	24	11.01%	8	3.67%	109	50.00%	63	28.90%	1	0.46%	13	5.96%

Indicator 3.7.3. Determine the Types of Forces Acting on Objects

Indicator 3.7.3 consists of five items, namely 6, 7, 8, 9, and 10. In this indicator, most students are at the level of lack of conceptual understanding with a percentage of 41.5%. Students are asked to be able to determine the types of forces in a case and can determine the cause of the force and the direction of the force. Students know the forces acting on objects but when asked about the cause and direction of the appropriate force, many students are still wrong. This is known from the various answers given by students who have many mistakes. In this indicator, there are still many students who are wrong in describing the free diagram of the object.

According to Taqwa et al. (2018), the errors experienced by students in describing force vectors are due to an incomplete understanding of the concept of force. Students' understanding of the definition of a force can help them in describing the diagram of the force acting on an object. After students understand the definition of a force, then students are directed to be able to identify forces. The most important part that students go through in identifying forces is building interaction diagrams. In this process, students are invited to think about identifying other objects that interact with the object that is the focus of the problem. Furthermore, students are directed to understand what forces arise and where the direction of the force is. This is a very important part because if students are wrong in describing the direction of the force then they will find it difficult to understand and solve the problem given.

Indicator 3.7.4. Analyze the Interaction of Forces and the Relationship between Force, Mass, and Acceleration

Indicator 3.7.4 consists of four items, namely numbers 11, 12, 13, and 14. In this indicator, students are required to be able to analyze the interaction of forces and be able to relate the relationship between force, mass, and acceleration from phenomena in everyday life. In this indicator, most students lack conceptual understanding with a percentage of 42.5% and followed by misconceptions of 40.4%. Students do not understand the concept of motion in an elevator according to Newton's Law. Students assume that the gravity and normal force will always be equal, which is a wrong understanding. When the elevator is at rest or moving at a constant speed or acceleration equal to zero, in this condition Newton's Law I applies, namely $\Sigma F_Y = 0$. In this condition, the compressive force of the load acting on the elevator floor (or normal force) is equal to the weight of the load. When the elevator moves with a certain acceleration either up or down, the weight of the load is not equal to the normal force of the elevator on the load. This is explained by using Newton's Law II, $\Sigma \overrightarrow{F_Y} = m.\vec{a}$.

Based on the explanation above, it can be seen that most students are at the level of lack of conceptual understanding. This is because students do not have complete understanding of Newton's law material about motion (Hau & Nuri, 2019). Students lack understanding of concepts due to poor conceptual understanding of physics concepts (Eraikhuemen & Ogumogu, 2014). Newton's law is one of the important materials in physics that examines forces and their interactions so that conceptual understanding is very important to be developed in learning and becomes the main focus for students to learn. Students' lack of understanding of the concept of Newton's law can be seen in tier-5 which contains conclusions or drawings. The drawings that students write are free-body diagrams. Students draw force vectors without understanding the physical meaning of where the forces come from and what they work on. Many students draw the force vectors irregularly and there are even students who draw outside the system.

Description of Students' Conceptual understanding in SMA A

Based on the analysis of the results of research that has been conducted using a five-tier multiple choice instrument with 14 questions given to 82 students at SMA A, students can be classified based on the level of conceptual understanding shown in the following Figure 3.

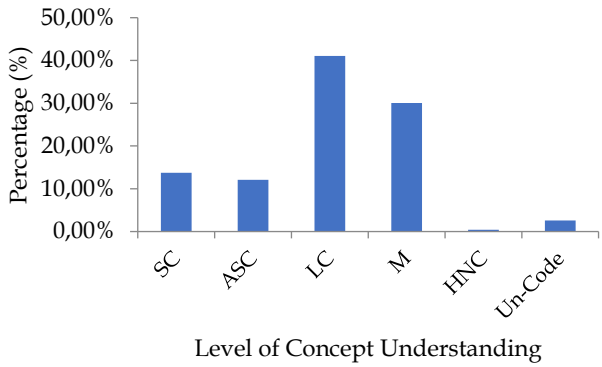


Figure 3. Average percentage of students' conceptual understanding level in SMA A

Figure 3 shows that overall students in SMA A had a scienctific conception level of 13.76%, almost scientific conception of 12.11%, lack of conceptual understanding of 41.03%, misconceptions of 30.01%, have no conception of 0.44%, and undefined of 2.61%. In SMA A, most students are at the level of lack of conceptual understanding.

Description of Students' Concept Understanding in SMA B

Based on the analysis of the results of research that has been conducted using a five-tier multiple choice instrument with 14 questions given to 68 students at SMA B, students can be classified based on the level of conceptual understanding shown in Figure 4.

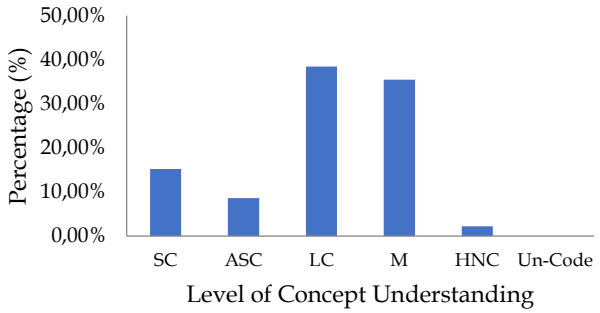


Figure 4. Average percentage of students' conceptual understanding level in SMA B

Figure 4 shows that overall students in SMA B had a scienctific conception of 15.23%, almost scientific conception of 8.61%, lack of conceptual understanding of 38.45%, misconceptions of 35.50%, have no conception of 2.21%, and undefined 0.00%. Students have the most lack of conceptual understanding and misconceptions. In line with research conducted by Sundaygara et al. in his research, students' understanding of Newton's Law material is relatively low Relatively low, namely understanding the concept by 21%, partially understanding the concept by 16%, not understanding the concept by 9%, and the wrong concept by 54% (Sundaygara et al., 2021).

Description of Students' Conceptual understanding in SMA C

Based on the analysis of the research results that have been carried out using a five-tier multiple choice instrument with 14 questions given to 68 students at SMA C, students can be classified based on the level of conceptual understanding shown in Figure 5.

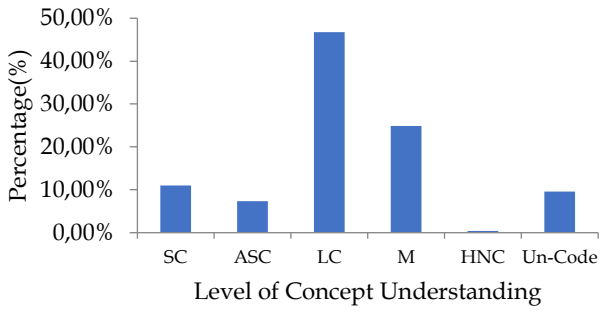
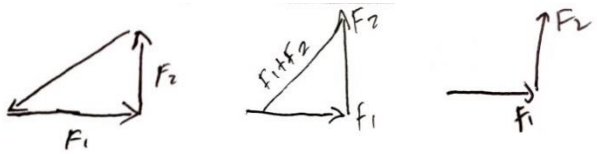


Figure 5. Average percentage of students' conceptual understanding level in SMA C

Figure 5 shows that overall, students in SMA C had a scienctific conception of 11,03%, almost scientific conception of 7.35%, lack of conceptual understanding level of 46.74%, misconceptions level of 24.89%, have no conception of 0.42%, and could not be coded 9.56%. Most students are at the level of lack of conceptual understanding.

Students' Mistakes in Drawing the Free-Body Diagram

Drawing is something that involves students in three processes that occur in their minds: selecting, organizing, and integrating (Anam et al., 2019). From these three processes students will make a decision to create a drawing. The addition of tier-5 in the form of writing drawings or conclusions can provide information to the teacher about what students are thinking. In tier-5 students are asked to draw a free-body diagram which aims to determine whether students understand the concept of force. The questions that ask students to draw free-body diagrams are found in indicator 3.7.1, indicator 3.7.3, and indicator 3.7.4. The following will describe student errors in describing the free-body diagram. Student mistakes in creating force vectors in indicator 3.7.1 can be seen in Figure 6.



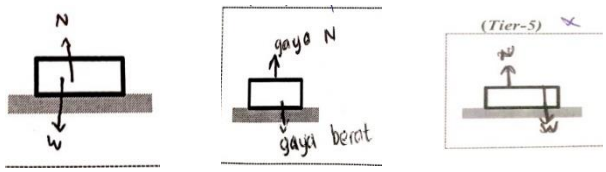
(SMA A) (SMA B) (SMA C)

Figure 6. Example of student answer on tier-5 of question number 2

Based on Figure 5, it can be seen that there are still students who are still wrong in describing vectors. Students' difficulty in determining the direction of the resultant force is due to their lack of understanding in analyzing force vectors. A vector is expressed by an arrow that has a base and an end. In physics concepts, the depiction of two vectors is done by connecting the tip of the first vector with the base of the second vector and for the depiction of the resultant vector is obtained by pulling the arrow from the base of the first vector to the tip of the second vector (Radjawane et al., 2022). The basic concept of vectors must be understood by students in order to understand the concepts of physics (Barniol & Zavala, 2014).

Students' mistakes in describing the free-body diagram also occur in indicator 3.7.3 Students are asked to describe the free-body diagram in questions number 6, 9, and 10. In question number 6, many students understand the forces acting on objects at rest on a surface, namely normal force and gravity. Whereas in tier-5 students experienced many mistakes in describing

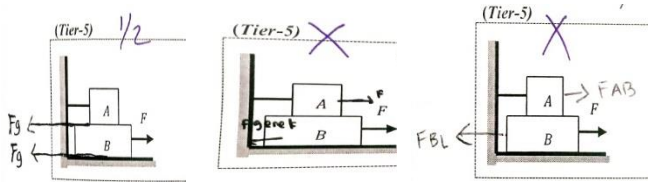
the diagram of the forces acting on an object at rest on a surface.



SMA A SMA B SMA C

Figure 7. Example of student answer on tier-5 of question number 6

Based on Figure 7, it can be seen that there are student mistakes in describing the diagram of gravity and normal force. Students assume that the gravity always points downwards and they do not pay attention to how to draw the right gravity vector. In the physics concept, the correct depiction of the gravity vector is the base point of the gravity vector starting from the center of mass of the object and its direction to the center of the earth. In addition, students also assume that the normal force always points upwards and they do not pay attention to the correct depiction of the force vector. Students should have drawn the normal force from the surface of the object touching the table because the normal force is also called the contact force, which is the force caused when two surfaces of the object touch each other. Student errors in describing the free diagram of objects also occur in question number 9. In question number 9 students are asked to describe the exact direction of the friction force. An example of student errors in describing the friction force vector can be seen in Figure 8.

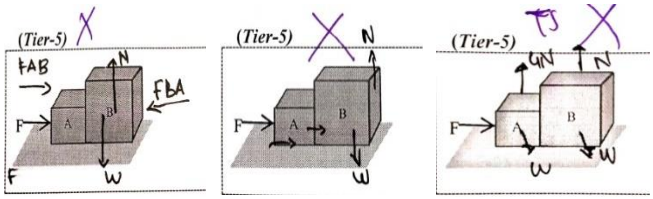


SMA A SMA B SMA C

Figure 8. Example of student answer on tier-5 of question number 9

Based on Figure 8, it can be seen that there are students' mistakes in describing the friction force vector. Friction force occurs when an object is launched over a rough surface so that the object's motion will be restrained by friction between the object and the surface. This resistance is considered as a single force $(\vec{f})$ which is called the friction force. The direction of the friction force will always be opposite to the direction of motion of the object.

Student mistakes in describing the free-body diagram also occur in question number 10. Students are asked to describe the action-reaction force pair. Action-reaction forces occur on different objects/systems. The concept of action-reaction forces is explained in Newton's Law III that the magnitude of the action force is equal to the magnitude of the reaction force but in the opposite direction (Abdullah, 2016; Hermanto et al., 2019) .



SMA A SMA B SMA C

Figure 9. Example of student answer on tier-5 of question number 10

Based on Figure 9, there are students who think that normal force and gravity are action-reaction pairs and are also incorrect in describing the force vector. Normal force and gravity are not action-reaction pairs, but the two forces interact on the same axis.

The next error also occurred in indicator 3.7.4 in question number 13. Students were asked to describe the direction of normal force and gravity on a person in an elevator moving with a certain acceleration. Students' errors in describing the free-body diagram are as shown in Figure 10.

SMA A SMA B SMA C

Figure 10. Example of student answer on tier-5 of question number 13

Based on Figure 10, it can be seen that students do not understand in describing forces on an object/system. The given problem asks students to make the direction of the gravity and normal force that arises in the above event and students are also asked to describe the direction of acceleration of the elevator. In this event, an elevator moves with a certain percept to the top. Students in SMA A and SMA B had quite fatal errors in describing the force because they did not describe the force vector outside the system. While the students in SMA C were correct in describing the weight force and the direction of acceleration of the elevator motion but were wrong in describing the normal force.

Conclusion

Based on the results of research and data analysis on the level of understanding of students' concepts on the material of Newton's law of motion in public high schools in Padang City, it can be seen that 13.37% of students scienctific conception, 9.53% of almost scientific conception, 42.01% of students lack of confidence, 30.14% of students have misconceptions, 0.98% of students have no conception, and 3.96% of students have undefined conceptual understanding. Based on these results, it can be concluded that students' conceptual understanding on the material of Newton's law of motion is still low.

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