

Study of students' conceptual understanding and misconceptions about motion and force

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Abstract. A research study on understanding concepts and misconceptions about motion and force has been conducted in high school students of Banjarmasin 6. This study aims to describe: (1) The level of understanding of SMA Negeri 6 Banjarmasin in the 2019/2020 academic year regarding the concept of motion and force. (2) The level of misconceptions among students of SMA Negeri 6 Banjarmasin in the 2019/2020 academic year regarding the concept of motion and force. (3) Causes of misconceptions in SMA Negeri 6 Banjarmasin in the 2019/2020 school year regarding motion and force. (4) Misconceptions what happened to the students of SMA Negeri 6 Banjarmasin in the 2019/2020 school year regarding motion and force. Data were analyzed quantitatively and qualitatively. For quantitative data were analyzed using CRI. This research was carried out on November 28, 2019 by taking a sample of SMAN 6 Banjarmasin schools in West Banjarmasin, amounting to 31 people. The instrument used was a written test problem to see students' understanding and misconceptions about the concepts of motion and force and find out the cause of the students' misconceptions. The results of this study are: (1) The level of understanding of students SMAN 6 Banjarmasin in 2019/2020 about the concepts of motion and force is lacking because the percentage of understanding is very low at only 64%. (2) The level misconception of SMAN 6 Banjarmasin students SMAN 6 Banjarmasin about motion and force is high because the highest percentage of misconceptions is 97%. (3) The causes of student misconceptions at SMAN 6 Banjarmasin in the 2019/2020 school year is the condition of the student, which includes wrong intuition, incomplete reasoning and low formal thinking ability of students by giving reasons for each step taken to get an incorrect answer. (4) Misconception in students of SMAN 6 Banjarmasin in 2019/2020 are about motion and force, namely the topic of free fall motion, forces when objects are in the air, Newton III's law and normal force. Differences in concepts inherent in students, students' memories and being believed to be true are not in accordance with the conceptions held by scientists.

1. Introduction

Humans as creatures who are given advantages by God with a form of reason in humans that other creatures do not have in life [1]. To process his mind, an educational pattern is needed through a learning process [2]. The learning process is a process that contains a series of actions of teachers and students on the basis of reciprocal relationships that take place in educational situations to achieve certain goals [3]. In this process, learning becomes a series of teacher actions, all of which take place in an educational situation [3–5].

This research was conducted at SMA Negeri 6 Banjarmasin. Mentioning that the data obtained from the basic data of Primary and Secondary Education of SMA Negeri 6 Banjarmasin received an A-

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accredited predicate. So that researchers can take samples that have good abilities in understanding subject matter, especially in physics subjects. Physics learning is essentially a product, process, and attitude as an application of knowledge. As a product, physics is in the form of facts, concepts, principles, and theories, while as a process it is in the form of skills and attitudes that must be possessed to obtain a product.

Physics learning is said to be successful if the objectives of physics subjects have been achieved [6,7], as stated in the function and objectives of physics subjects at the high school level which states that physics subjects are a means of: 1. Awareness of the beauty and regularity of nature to increase belief in God Almighty, 2. Cultivating a scientific attitude which includes: being honest and objective towards data, being open in accepting opinions based on certain evidence, being critical of scientific statements, and being able to cooperate with others, 3. giving experience to propose and test hypotheses through experiments: designing and assembling experimental instruments. Collect, manage and interpret data. Prepare reports, and communicate experimental results in writing and orally, 4. Develop inductive and deductive analytical thinking skills by using concepts and principles of physics to explain various natural events and solve problems both qualitatively and quantitatively, 5. Mastering knowledge, concepts and principles of physics, and have scientific knowledge, skills and attitudes [8]. Based on the description above, it is clear that the implementation of physics subjects in high school is a means to develop and train students to master the knowledge, concepts and principles of physics, and have scientific skills [9,10].

The purpose of learning physics will be achieved if the learning process goes well. In fact what is happening in the field is still not in accordance with the expected function. Students are still difficult to solve problems related to physical and mathematical concepts, this may occur because students only know physics formulas without a good understanding of concepts [11]. The way the teacher conveys the material can also lead to different understanding of students' concepts [12]. As a result, there are students who understand concepts, do not understand knowledge and misconceptions. Students who lack this knowledge have received the material but do not understand the concepts being taught [13]. The concepts studied are about motion and force.

Based on some of these problems, it is necessary to have a survey to determine the level of student understanding that is expected and can support the learning outcomes of all students as well. Based on this, the researcher is interested in conducting research with the title "Study of Understanding Concepts and Misconceptions About Motion and Force in Students of SMA Negeri 6 Banjarmasin. The formulation of the problem is: (1) What is the level of understanding of the students of SMA Negeri 6 Banjarmasin for the 2019/2020 academic year about the concept of Motion and Force? (2) How is the level of misconception among students of SMA Negeri 6 Banjarmasin for the 2019/2020 academic year about the concept of Motion and Force? (3) What are the causes of misconceptions in students of SMA Negeri 6 Banjarmasin for the 2019/2020 academic year regarding Motion and Force? (4) What misconceptions occur in students of SMA Negeri 6 Banjarmasin for the 2019/2020 academic year regarding Motion and Force. The purpose of the study is to describe: (1) The level of understanding of the students of SMA Negeri 6 Banjarmasin in the 2019/2020 academic year about the concept of Motion and Force. (2) The level of misconception in SMA Negeri 6 Banjarmasin students for the 2019/2020 academic year about the concept of Motion and Force. (3) Causes of misconceptions in students of SMA Negeri 6 Banjarmasin for the 2019/2020 academic year regarding Motion and Force. (4) What misconceptions occur in students of SMA Negeri 6 Banjarmasin for the 2019/2020 academic year regarding Motion and Force.

2. Method

This research is a type of quantitative descriptive research (quantitative research). In quantitative research, the data obtained are in the form of numbers. While in descriptive qualitative research the data obtained are in the form of information or qualitative data. This research was conducted by giving questions about the concept of force and motion. Test results on students will be analyzed to determine whether there is a student understanding of the concepts of force and motion. This study began by giving

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students a multiple choice test accompanied by CRI. However, the CRI scale only relies on students' honesty. The written test in the form of multiple choice was conducted with the aim of knowing the level of students' understanding of the concepts of motion and force. Students are expected to complete the test based on their ability to understand the concepts of motion and force. To find out whether students answered the questions according to their understanding or guessing, for each question students were asked to fill out the CRI with the following conditions:

Table 1. Confidence of Students' Answers Based on CRI

Scale	Criteria
1	The answer is guessing by considering the knowledge possessed
2	Answer by using knowledge and mind but not sure of the truth of the answer
3	Answer by using knowledge and mind and believe in the truth of the answer

The test used in this study is a test with multiple choice questions. The choice of multiple choice questions must have an influence on students in choosing answers. Therefore, the answer choices in this question must consist of a correct answer and a distracting answer. Deceptive answers are answers that students might choose if they do not master the material. The form of this written test is multiple choice questions equipped with CRI (Certainty of Response Index). Validity determines or measures whether the test really measures what it wants to measure, namely whether it is in accordance with the objectives, especially students' understanding of the concepts of motion and force. Reliability shows the internal consistency of the measuring instrument over time. Reliability is often referred to as the consistency of the scores obtained for each individual. the number of misconceptions from each question and each sub-topic. To obtain the level of misconception in percent.

After calculating the percentage level, the category of students' level of understanding and misconceptions about the material being tested is determined by using group frequency distribution statistics (interval). Based on the data on the percentage level of students' understanding and misconceptions about the concepts of motion and force, we will divide them into three categories including high, medium and low categories.

Table 2. Category of student understanding [14]

Score	Criteria
35 - 50	High
17-34	Medium
0-16	Low

3. Result and Discussion

This research was conducted at SMAN 6 Banjarmasin on November 28, 2019. The school is located at Jalan Belitung Darat No.130, Rt.19/ Rw.02 North Belitung, West Banjarmasin District. In this study, written test data was collected. In this study, the researcher did not do any treatment so that the researcher did not affect the results of the written test obtained. Based on the calculation results obtained.

Table 3. Descriptive Characteristics of Students' Understanding of SMAN 6 Banjarmasin

Aspect	Number
Responden	31
Average	19,5
Max score	44,0
Min Score	0,0
Dev Standar	10,6

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Based on the table shows that the respondent is 31, the average is 19.5, the highest score is 44.0, the minimum value is 0.0, and the standard Dev is 10.6. The data from the calculation of the students' level of understanding is based on the range of scores, categories and amounts (percentages).

Table 4. Students' Level of Understanding

Percentage	Criteria
6	High
29	Medium
64	Low

Based on the calculation results obtained the percentage of understanding for each question. shows that of the 25 questions, the percentages of the categories that include the high level of understanding are 64%, 58%, and 48%. The cause of understanding is seen from the students' answers, namely in question no. 2 the average student answered correctly, on question no. 9 the average student answered that was correct, and in question no. 19 the average student answered correctly, for them no one answered and for the average confidence level choose the sure answer. The category of level of understanding that is included in the medium is 32%, 29% and 26%. The cause of understanding is seen from the student's answers, namely on question no. 24 the average student answered wrong, on question no. 9 the average student answered wrong, and on question no. 15 on average, students answered wrong, for the reason they did not answer and for the average level of confidence choose the answer doubtful and sure. And the category of low level of understanding is 22%, 19%, 16%, 13%, 10%, 3% and 0%. The cause of understanding is seen from the students' answers, namely on questions no. 6 and 16 on average students answered wrong, on questions no. 7, 11 and 23 the average student answered wrong, on questions 14 and 17 the average student answered wrong, on questions No. 3, 10, 18 and 25 on average answered incorrectly, on questions no. 5, 12, 20, 21 and 20 on average they answered incorrectly, on question no. 8 the average number of students answered incorrectly and on question no. 1 on average they answered incorrectly. , for their reason no one answered and for the average confidence level they chose very doubtful, undecided and sure.

Table 5. Description Characteristics SMAN 6 students' misconceptions Banjarmasin.

Aspect	Number
Responden	31
Average	62,6
Max score	84
Min Score	28
Dev Standar	15,62

There are 19.5% of students who do not understand concepts and misconceptions, 18.5% of students who do not understand the concept of adab and 62% of students who have misconceptions. It is known that the most participants experience misconceptions in question number 1 with a percentage of 97%. Meanwhile, students experienced the least misconceptions in question number 2 with a percentage of 19%. This shows that for each question there are students who experience misconceptions.

Tabel 6. Jumlah Pemahaman Konsep, Tidak Paham Konsep, dan Miskonsepsi untuk Setiap Soal

No Soal	Paham Konsep (Jawaban Benar, CRI Tinggi)	Tidak Paham Konsep (Jawaban Salah, CRI Rendah)	Miskonsepsi (Jawaban Benar, CRI Rendah)	Miskonsepsi (Jawaban Salah, CRI Tinggi)
1	0%	3%	0%	97%
2	64%	6%	10%	19%
3	13%	6%	3%	77%
4	58%	10%	10%	22%

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5	10%	19%	3%	68%
6	22%	13%	10%	55%
7	19%	19%	6%	55%
8	3%	13%	6%	77%
9	29%	16%	6%	48%
10	13%	10%	0%	77%
11	19%	22%	13%	45%
12	10%	0%	6%	84%
13	13%	6%	3%	77%
14	16%	6%	13%	64%
15	26%	16%	0%	58%
16	22%	10%	0%	68%
17	16%	26%	0%	58%
18	13%	6%	3%	77%
19	48%	6%	3%	42%
20	10%	13%	0%	77%
21	10%	3%	3%	84%
22	10%	10%	3%	77%
23	19%	10%	3%	68%
24	32%	22%	0%	45%
25	13%	13%	10%	64%

From the table it is shown that the highest understanding of concepts is 64%, those who do not understand concepts are 35% and the highest misconception is 97%. While the highest number of understanding concepts is 0%, the lowest is not understanding concepts is 3% and the lowest misconception is 19%.

Forms of Understanding and Misconceptions. First, on the topic of free fall motion, there are two questions, namely questions number 1 and 5. In question number one, namely the case of objects with different masses being dropped from the same height, it is known that no students understand the concept and 91% of the 31 participants experienced misconceptions. The participant thinks that when objects with different masses are dropped from the same height and at the same time, the object with the larger mass will hit the floor first. In question number 5, which is about a true statement about an object that is dropped from a certain height. There are participants who understand that the mass of an object does not affect the acceleration. However, quite a lot of participants experienced misconceptions. The participants thought that when an object was dropped the object's velocity did not change or remain; the falling motion of an object is not affected by the acceleration of gravity; and the initial velocity of the object is not equal to zero.

Second, regarding Newton's third law, which was tested in test questions numbered 13 and 14. In question number 13 there was a case that the table was pushed but the table did not move. Participants were asked to explain the event in physics. There were participants who understood that the table pushed by the child did not move because the force exerted by the child on the table was equal to the force exerted by the table on the child. However, there are more students who experience the misconception that they assume that the table does not move because the force exerted by the table is less than the force exerted by the table on the child. In question number 14 there is a case of a car hitting a wall but the wall does not move at all. Participants were asked to give reasons why the wall did not move. Some understood that the wall did not move even an inch. However, quite a lot of participants experienced misconceptions. They think that the wall doesn't move because the car exerts a force of 0 N; the car exerts a less force that opposes the frictional force; the car exerts a greater force and is in the same direction as the frictional force.

Third, regarding the topic of vertical upward motion, there is question number 3 in the written test. When a ball is thrown up and then falls down, what kind of force acts on the ball. There are participants

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who understand that the working force is the force of hand, gravity, and friction with air. There are also participants who experience misconceptions. They think that there is a normal force acting on an object that is thrown up and then falls down.

Fourth, regarding the direction of linear velocity which is tested in problem number 6. In this problem there is a case of an object tied to a rope and then rotated. If the rope suddenly breaks, where is the object going? There are participants who understand that the object will move in the direction (B) which is perpendicular to the rope. Meanwhile, participants who had misconceptions thought that the ball would move in the direction of the others who thought that the object would move toward (E) because the object would move perpendicular to the center point, perhaps because the participant thought that the central point was a large black dot.

Fifth, the topic of the resultant force and frictional force which in the test question is tested on question number 12. The case in this problem is a book is placed on a table then the table is tilted but the book remains still. In the case of someone who understands that a book is placed on an inclined table, the frictional force is parallel to the upward direction. Meanwhile, participants who experience misconceptions think that the frictional force is parallel to the plane and the direction is downwards; the frictional force is the same as the normal force; and the frictional force is equal to the earth's gravity.

Sixth, the topic of Newton's First Law which is tested in problem number 18 is about the cause of objects remaining at rest when placed on a table. There are participants who understand that it is not true if no one works on the object. Meanwhile, according to participants who experienced the misconception the object remained silent because it did not experience a very large frictional force.

Seventh, the topics of deceleration and friction are tested in questions number 19 and 20. In question number 19 there is a case of a toy car that is moved with a constant force, so the car moves with a constant speed. Suddenly stopped, so what happened to the car? There are participants who understand that the car will slow down and eventually stop moving. Meanwhile, participants who experienced misconceptions thought that the car would stop instantly. In question 20, the question asked is what event fits the case of a bus that travels for 2 seconds a distance of 10 m and in the third minute it travels a distance of 12 m. None of the participants understood the concept. but there are those who have misconceptions. Participants who experience misconceptions think that a car that experiences a change in speed must experience a uniform speed change.

Eighth, the topic of parabolic motion tested in question number 10. The case in this question is a bomb dropped from a moving plane, so in which direction does the bomb fall. None of the participants understood the concept. However, there were participants who experienced misconceptions. They think that the bomb will fall in a half parabola in the opposite direction to the plane's motion (D). There are also those who think that the bomb will fall perpendicular to the ground (B).

Ninth, the topic of friction on a stationary object is tested in problem number 15. The case is a cupboard that is pushed on a rough floor but does not move. There are participants who understand that the cupboard does not move because the frictional force is equal to the force exerted by the pusher. Meanwhile, according to those who have misconceptions, the cupboard does not move because the driving force is smaller than the frictional force. There are also those who think that because the frictional force is zero, the cupboard doesn't move. In addition, there is another misconception, namely that participants assume that if the force applied is less, the magnitude of the force is equal to zero.

Tenth, the topic of the frictional force on a moving object is tested in problem number 23. The case is a true statement regarding the frictional force on an object moving on a rough plane, except. There are participants who understand that the wrong statement about friction is that friction is in the same direction as the object's force. Meanwhile, according to the misconception that friction has a value that is always in the opposite direction to the motion of objects.

Eleventh, the topic of action-reaction force tested in questions number 24 and 25. The case in this question is which is an action-reaction pair. There are participants who understand this concept. Answers which are action and reaction pairs are FA and FB. Meanwhile, according to the misconception, WB and NB mean the action-reaction pairs are opposite forces on the same object. FA and F mean the action-reaction pairs are forces from objects that are different and in the same direction. . In question number

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25 In this case, two objects with the same mass are suspended on a pulley as shown above, if the system is in equilibrium, then the action-reaction is in this concept there are participants who understand and answer The action-reaction pairs are T1 and T3 meaning on different objects and in opposite directions. But there are also participants who have misconceptions that T1 and T2 are action-reaction pairs and T4 and T5 are action-reaction pairs.

Twelfth, the topic of the forces in circular motion tested in problem number 7. The case is an object moving in uniform circular motion, so the correct statement is. In this case, there are participants who understand this concept and answer that an object moving in a circle has a constant angular velocity and velocity. And there are also participants who have misconceptions and answer that the normal force acting on an inclined plane is influenced by gravity.

Thirteenth, the topic of the resultant force on an object on a plane that is tested in problem number 11. The case in this problem is a book placed on a table, a true statement of the event. In this case, there are participants who understand this concept and answer that the gravitational force is as large as the normal force. However, there were also participants who had misconceptions and answered that when an object moves in a circle, the velocity is constant, the angular velocity is constant, the acceleration is constant and the speed is constant.

Fourteenth, the topic of normal force that is tested on questions number 16 and 17. In question number 16 the case is which statement is true about normal force. In this case, there are participants who understand this concept and answer that the normal force is always perpendicular to the plane. And there are also participants who have misconceptions and answer that the normal force acting on an inclined plane is influenced by gravity. The normal force always has the same magnitude as the gravity, the normal force always moves in a straight line with the gravity. In problem number 17 the case is which statement is true regarding the normal force acting on an inclined plane. In this case, there are participants who understand this concept and answer that the normal force is always perpendicular to the plane. And there are also participants who have misconceptions and answer that the normal force always has the same magnitude as gravity, the normal force acting on an inclined plane is greater than the weight of the object, the normal force acting on an inclined plane is equal to the weight of the object and the normal force acting on the object. The inclined plane has the same magnitude as the frictional force.

Fifteenth, the topic of forces when objects in the air are tested in questions number 21 and 22. In question number 22 the case is a tennis player hitting the ball so that the tennis ball bounces into the air. When the ball is in the air, what force acts on the ball. In this case, there are participants who understand this concept and answer that the forces acting on objects that bounce in the air are the gravitational force of the earth and the frictional force of the air. And there are also participants who have misconceptions and answer that the thrust of object 1 and the frictional force of object 2 are also the forces acting on object 2 that soar in the air. In problem number 22 the case is when a bullet is fired into the air, there are several forces that affect the bullet while it is in the air. Which of the following forces actually affects the bullet. In this case, there are participants who understand that the forces acting on objects in the air are the gravitational force of the earth and the frictional force of the air. And there are also participants who have misconceptions and answer that the thrust and friction are the forces acting on object 1 in the air.

Sixteenth, the topic of straight motion and force being tested in questions number 4 and 9. In question number 4 the case is Nina pushing a table on the floor. The table moved straight to the right away from Nina. In order for the table to keep moving to the right, what Nina has to do is: In this case, there are participants who understand this concept and answer that the object being pushed will continue to move if it is given an external force on the object or is pushed continuously and there are also participants who have misconceptions and answer that to keep the object being pushed moving, what must be done is to reduce the force. floor friction, air friction, object friction and reduce all forces acting on objects. In question number 9 the case is Anton kicking a ball so that the ball rolls over the ground, so that the ball continues to move, what should be done. In this case, there are participants who understand and answer that when the ball is kicked, the ball will still move if it is given an external force. And there are also

participants who have misconceptions and answer that the thing that must be done to keep the kicked ball moving is to reduce the frictional force of the ball, reduce the ground force, and the air friction force.

Seventeenth, the topic of displacement tested in question number 2 is if Rena's house is at point A, then Rena wants to visit her friend at point H, how many moves did rena make. There were participants who understood this concept and answered Rena's displacement of 25 Km. and there are also poor participants misconception and answer which is displacement is the number of lines parallel to points A and H which is 44 Km.

Eighteenth, The topic of the centripetal force being tested in problem number 8 is that an object is rotated so that it moves around a point. The correct statement about the centripetal force is. In this concept there are participants who understand and answer the direction of the centripetal force perpendicular to the ink to the center point. And there are also participants who have misconceptions and answer that the direction of the centripetal force follows the trajectory.

The cause of the participants' misconceptions cannot be clearly identified due to the limitations of the measuring instruments used in the study. Broadly speaking, the causes of misconceptions can be summarized in five groups, namely: students, teachers, textbooks, life experiences and teaching methods [14]. Of the five groups, the most common causes of misconceptions are students themselves. Based on the results of the written test, the researchers observed during the research and associated it with expert opinion, there are several possibilities that cause misconceptions including: Student conditions that cause misconceptions from students include: wrong preconceptions, namely incorrect initial concepts where the concept has already been owned by students. The cause of such misconceptions occurs in free fall motion, where according to students, objects with a weight of 2 times will fall to the ground first.

In addition to wrong preconceptions, the cause of misconceptions is also due to wrong incompatibility, where students express their ideas about a concept spontaneously before learning it first. Students also tend to follow feeling or just their feelings in determining answer choices or reasons. Another cause is due to incomplete reasoning. Students experience wrong reasoning, causing reasoning or incomplete reasoning. This incomplete reasoning dominates the causes of students' misconceptions. Students make conclusions that are too general and on almost all concepts. Another cause that comes from students is the ability of students to lead to wrong answers. The low misconception caused by the low ability of students is that students are still unable to distinguish heavy objects 2 times earlier than light objects. Each cause of misconception requires a way to overcome its own misconception. Therefore, based on the possible causes of misconceptions about the concepts of motion and force in students of SMAN 6 Banjarmasin in 2019/2020.

4. Conclusion

Based on the results of research on understanding concepts and misconceptions about the concepts of motion and force in SMAN 6 Banjarmasin students, it can be concluded that: (1) The level of understanding of SMAN 6 Banjarmasin students in 2019/2020 about the concepts of motion and force is lacking because the percentage of their understanding is very low, which is only 64 %. (2) The level of misconceptions of SMAN 6 Banjarmasin students about motion and force is high because the highest percentage of misconceptions is 97%. (3) The cause of student misconceptions at SMAN 6 Banjarmasin for the 2019/2020 academic year regarding the concept of motion and force is the student's condition, which includes wrong intuition, incomplete reasoning and low formal thinking skills of students by giving reasons for each step taken to obtain incorrect answer. (4) The misconceptions for students of SMAN 6 Banjarmasin for the 2019/2020 academic year are about motion and force, namely the topic of free fall motion, forces when objects are in the air, Newton's third law and normal forces. Differences in concepts that are attached to students' minds and are believed to be true are not in accordance with the conceptions held by scientists.

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