Identification of Students Misconceptions in School and College on Kinematics

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Abstract: This study aimed to determine the misconceptions that are often experienced by students in school and college on kinematics. The method that was used is quantitative descriptive. The sample was 48 students and 144 college students in Singkawang that had studied the kinematics. The results showed that the average of students who have misconceptions still very high at 76.0%. The identification results showed that the average of students experienced misconceptions on several kinematics topics, that are (a) Position, Distance, Displacement, Velocity, and Acceleration, occurred a misconception of 67.7%, students assumed that the distance is traveled by objects is equal to the displacement magnitude, (b) Regular Straight Motion and Regular Straight-Changed Motion, occurred a misconception of 93.8%, students considered that objects are moving vertically upward, working two forces that are an upward force is greater than the gravitational force which downward direction, (c) Parabolic Motion, occurred a misconception of 92.7%, students assumed that slope of a tangent to the parabolic motion curve can be used to calculate the magnitude and direction of velocity, and (d) Circular Motion, occurred a misconception of 83.0%, students assumed that objects are moving horizontal circular with constant speed have a constant velocity.

1 INTRODUCTION

In learning to understand the concept of physics, students often experience difficulties. Students follow physics material not with an empty head, but actual student head is full of experience and knowledge about physics. In the experience formed preconceptions or early concepts of students about the events of physics in everyday life. This preconception is not necessarily true. If in the learning process the teacher did not pay attention to the preconception then in the head of students will occur mixing or preconception clash with the actual concept. This mixing will cause students to have difficulty in learning physics which will ultimately lead to misconceptions in students (misconception) (Berg et al., 1990).

Suhendi et al. (2014) stated in the process of learning educators/teachers are still a lot of use of learning that is informative and frequently asked questions, this can cause students to lack the scientific concept. Yuliana, Karyanto, and Marjono (2013) stated that the lack of mastery of the concept experienced by students can lead to misconception. Misconceptions are the initial concept possessed not in accordance with the scientific concept.

Many students argue that physics is difficult to learn because it is just a collection of mere formulas that cannot be understood the meaning. This opinion arises because the habit of learning physics students oriented to the formulas and discussion of the problem directly without learning the concepts first. Students only memorize the formula and only skillfully perform the calculations without understanding the meaning or concept that is being done/studied. Difficulties in understanding the concept of physics will lead to misconceptions.

Physical learning that is only based on textbooks or in other words textbook is still used as the main source of information in the learning process can cause some problems, because the mistakes that occur in textbooks can lead to misconceptions of the concept of self in students. In addition to the errors in textbooks, students often have difficulty in understanding the text contained in textbooks, and there are also science fiction books whose concepts deviate to attract readers. Negative things in the textbook can lead to misconceptions.

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From some facts above shows that there are several factors that cause misconception. According to Suparno (2005), in general, the cause of misconceptions there are five groups of students, teachers, textbooks, context and way of teaching.

There has been much research on misconceptions, one of which is done by Rahayu (2015). He studied misconceptions of students of SMAN 2 Kabupaten Tangerang and obtained the result that the percentage of students who experienced misconceptions of 44.25% of the 40 students studied. The misconception or misconception of two-dimensional motion study materials (parabolic motion and circular motion) is present in indicators analyzing position vectors, speed and acceleration of parabolic motion, and indicators formulating the relationship of position, velocity, and acceleration of parabolic motion. This misconception does not only occur in SMAN 2 Tangerang students but also experienced by high school students in general, and even can happen to students.

In physics, there is a branch of science that studies the motion of objects called mechanics. The branch of mechanics is divided into two namely Kinematics and Dynamics. Kinematics is always taught before it is taught Dynamics, Heat, Thermodynamics, Sound, Vibration and Waves, Electrics-Magnetism, Optics and Modern Physics or Quantum Physics, so kinematics becomes very important in physics learning before entering other branches of science from Physics. Therefore, selected kinematics material as the material of this research. Given that there are still misconceptions in physics, especially in the branches of kinematics, further research is needed on the types of misconceptions that occur to students in school and college.

2 LITERATURE REVIEW

2.1 Conceptual, Conception, Preconception, and Misconception

Theory of Tayubi (2005) stated, "concepts are things, events, situations, or traits that have distinctive features and are represented in every culture by an object or symbol". According to the Great Indonesian Dictionary, the concept is a mental picture of objects, processes or anything that is outside the language, which is used by reason to understand other things. By having a human concept will be easy in communicating with others.

Yuliana, Karyanto, and Marjono (2013) stated, "conception is a student's interpretation of a certain concept of science". Interpretations between individuals and other individuals will be different, this is due to the difference in capturing information at the time of the study. Conception is the interpretation of a student to a concept he obtained after obtaining information or studying a particular science in the formal class.

Suparno (2005) described the learner before the formal class has a preconception or concept of the concept. Preconception is an early concept that students have about a science. Preconception owned by learners often contains misconceptions. Pujianto, Nurjannah, and Darmadi (2014) explained that if the preconceptions of the students do not match the knowledge given by the expert or scientist, then the student will experience misconception. The misconceptions can come from parents, friends and the environment. The preconceptions that students have of the physics concepts that students learn themselves through their experiences in everyday life have a big role in shaping scientific concepts. The preconceptions of learners show that their thinking continues to be active in understanding something. If the misconceptions of misconceptions are not immediately corrected, they can disrupt the formation of scientific concepts.

The misconception is a conception contrary to the conception of physicists (Berg et al., 1990). From that understanding, misconception can be interpreted as a conception that is not in accordance with the scientific understanding or understanding received by scientists.

Kurniawan and Suhandi (2015) stated misconception is a failure in connecting or explaining the events that exist around with the concept possessed. According to Muliyani and Kaniawati (2015), misconceptions can be seen in concepts that do not fit with scientific concepts. Misconceptions due to errors of information that cause errors in the understanding of concepts and thoughts. Vakani et al. (2012) revealed that misconceptions tend to be possessed by students. Suhendi et al. (2014) described the term misconception associated with a different conception of students with generally accepted scientific concepts. Misconceptions are defined as strongly held conceptions and are stable cognitive structures but not the same as the conceptions of scholars or scientific concepts. Based on the understanding that has been described by the researchers can be concluded that misconception is a mistake in understanding the concept of learning materials that

can cause a mismatch between the concept possessed by the person with the scientific concept.

2.2 Conceptual Change

Conceptual change is a condition in which students make changes to their initial concept of being incorrect into actual concepts or scientific concepts. Makhrus, Mohammad, and Widodo (2014) described conceptual change can occur if prior knowledge is reunited or conflicted with new information. Discrepancies between the knowledge that learners have with new information can lead to cognitive conflict. By generating cognitive conflict a teacher or researcher can convince learners to make conceptual changes to their conceptions that are inconsistent with scientific concepts. New long-term concept changes can occur when students see the relevant and general matters of the scientific concept contextually. The essence of conceptual change is to change the concept of misconception into a scientific concept.

2.3 The Cause of Misconceptions

Suparno (2005) identified five main causes of misconception ie students, teachers, textbooks, context and teaching methods. Each of these common causes is caused by special causes, as listed in Table 1.

Table 1: The Causes of Misconceptions (Suparno, 2005)

Main Cause	Special Cause
Students	a. Preconception b. Associative Thinking c. Humanistic Thinking d. Wrong Intuition e. Development Stage of Students' Cognitive f. Students' ability g. Students' learning interest
Teacher	a. Not mastering the material, incompetent b. Not a graduate from the field of physics c. Not revealing students' preconceptions d. Relationship of teacher-students are not good
Textbook	a. Wrong explanation b. Wrong write especially on the formula c. The degree of difficulty of writing books is too high for students d. Students do not know the technique of reading a textbook
	e. The concept of science fiction books deviates to attract readers f. Cartoons who often make misconceptions
Context	a. Students experience b. Different language c. False conversational friends d. Confidence and religion e. Parental or other erroneous explanations f. Student life context (TV, radio, film that wrong) g. Feelings of pleasure or displeasure, free or depressed
How to Teach	a. It only contains lectures and writes b. Direct to mathematical form c. Not revealing student misconceptions d. Not correcting wrong homework e. Models of analogy f. Models of practical g. Models of discussion h. Models of narrow demonstration

Research on misconception has been widely practiced, as Helm (1980), on misconceptions physics among South African students. There is still much more research on misconceptions or preconceptions such as Clement (1982). Scientists see that misconceptions are disturbing but students often prefer the wrong concept because it is more perceived by students. Even after learning, these misconceptions remain inherent, thus preventing the learning process (Demirci, 2005). Research on some of the ways of picking misconceptions has not been fully overcome because these misconceptions are durable and difficult to change.

2.4 How to Overcome Physics Misconception

Although it is difficult to overcome misconceptions, there is still a way that can be done to overcome or at least reduce misconceptions in students. There are several steps that can be taken to overcome or at least reduce the misconceptions as put forward by Berg et al. (1990) below:

a. The first step is to detect students' preconceptions. Before the lesson begins, the teacher should know the preconceptions that are in the mind of the student. Preconception can be known from the literature, from diagnostic tests, from direct student activity observation, and from teacher experience.
b. The second step is to design a learning experience that starts with the preconceptions

and then refines the already good part and corrects the wrong part of the concept. The main principle in the correction of misconceptions is that students are given a learning experience that shows the contrast of their concepts with natural events. It is thus expected that the contradiction of new experiences with the old concept will lead to a correction of conception.

c. The third step is to practice questions and questions to train new concepts and refine them. The questions and questions to be used should be chosen so that the distinction between the correct conception and the false conception will arise clearly.

3 RESEARCH METHODS

The method used for this research is a method of misconception research on students in school and college by using the concept of kinematics problems consisting of 18 items of multiple choice questions with five choices of answers. Based on the five possible answers, there is only one correct answer and four other answers are wrong or misconception. This problem is adapted from Isliyanti and Rizal (2011), which has been tested with the legality test with the result 88.87%. This percentage informed that students who read the question and write the question of each item, 88.87% of students are able to know the purpose of the problem. Because students are able to know the purpose of the problem that tested then the misconception that occurred in the student is not because students are not able to know the purpose of the problem but it has happened misconception on the student if he answered the wrong problem.

The study population consisted of SMA/MA/equivalent students in the Education Department of Singkawang City and the Religious Affairs Department of Singkawang City and students at the existing universities in Singkawang city. All students are considered to have a heterogeneous ability, as well as on students. All students that become samples are students who have studied kinematics consisting of 48 students in school and 144 students in college. The study was conducted in Singkawang in 2016.

4 RESULTS AND DISCUSSION

Analysis of the answers of students who answered correctly and incorrectly for each question can be seen in Table 2. Based on Table 2, it can be seen that on average from all samples, only 24% of students who answered correctly every question given and as many as 76% of students answered wrongly.

Based on the analysis of each question, then in the list of misconceptions that often occur in students as shown in Table 3. Based on Table 3, the misconceptions experienced by students on kinematics can be said to be very large i.e. more than 50% of students experience misconceptions. This proves that the preconceptions that students have from their daily experience are largely incompatible with scientific concepts. Mismatch between preconceptions that students have with scientific concepts causes misconceptions among students (Berg et al., 1990; Pujianto, Nurjannah, & Darmadi, 2014; Suhendi et al., 2014; Kurniawan & Suhandi, 2015; Muliyani & Kaniawati, 2015) .

The students' misconceptions need to be resolved as early as possible so that they do not occur in the next generation. One way to do this is to compile a collection of discussions on misconceptions on kinematics. This collection of discussions can be used as a guide for teachers or lecturers in teaching physics, especially in the parts that most often occur misconceptions. After the teacher or lecturer knows the parts of kinematics that often occur misconceptions, teachers and lecturers are expected to be able to develop the most effective learning strategies so that students are able to understand the concept of kinematics correctly.

Some learning strategies that can be considered to be applied in learning include learning with experimental methods. The learning provides a direct learning experience to students in conducting scientific investigations so that it helps students gain a deeper understanding of the concepts learned (Murdani & Sumarli, 2019). In addition, multiple representation based learning also helps reduce students' misconceptions. This is because the learning is designed to uncover the students' preconceptions with various representations that are given in stages so as to help students understand concepts correctly in accordance with scientific concepts (Kusumawati et al., 2019).

Table 2: Analysis of True and False Answers of Every Problem

Question Number	False		Total	False Total (%)	True		Total	True Total (%)	True and False Total (%)
	High School Students and MA	Students who have received kinematics			High School Students and MA	Students who have received kinematics			
1	26	75	101	52.6	22	69	91	47.4	100.0
2	29	108	137	71.4	19	36	55	28.6	100.0
3	37	78	115	59.9	11	66	77	40.1	100.0
4	40	95	135	70.3	8	49	57	29.7	100.0
5	47	122	169	88.0	1	22	23	12.0	100.0
6	45	118	163	84.9	3	26	29	15.1	100.0
7	42	115	157	81.8	6	29	35	18.2	100.0
8	46	132	178	92.7	2	12	14	7.3	100.0
9	28	79	107	55.7	20	65	85	44.3	100.0
10	31	89	120	62.5	17	55	72	37.5	100.0
11	33	101	134	69.8	15	43	58	30.2	100.0
12	46	130	176	91.7	2	14	16	8.3	100.0
13	42	116	158	82.3	6	28	34	17.7	100.0
14	47	126	173	90.1	1	18	19	9.9	100.0
15	35	127	162	84.4	13	17	30	15.6	100.0
16	37	132	169	88.0	11	12	23	12.0	100.0
17	27	88	115	59.9	21	56	77	40.1	100.0
18	40	119	159	82.8	8	25	33	17.2	100.0
Average	37.7	108.3	146.0	76.0	10.3	35.7	46.0	24.0	100.0

Table 3: The Misconception that Often Occurs in Students

Topics of Kinematics	The Misconception that Often Occurs in Students	Question Number	Total of Misconceptions	Correct Concept
Position, distance, displacement, velocity, and acceleration	An object can overtake another object if the acceleration is equal.	1	53.1%	An object can overtake another object only if both have the same position.
	The distance traveled by objects is always the same as the displacement.	2	67.7%	The distance traveled by objects can be equal to the displacement and can also be greater than the displacement.
	If the speed is zero then the acceleration is always zero.	3	65.6%	If the speed is zero then the acceleration is not necessarily zero, likewise if the acceleration is zero then the speed is not necessarily zero.
Regular straight motion (GLB) and straight motion change regularly (GLBB)	From the position graph to time, if two objects are in the same position then must have the same speed.	4	74.7%	From the chart, A train moves GLB (v fixed or a = zero). Train B moves GLBB (a negative = slowed). After reaching time t_B, train A can overtake the B train marked with the position of train A equal to the position of train B. Both trains have the same speed at some time before t_B
	Heavy objects will get to the floor earlier than light objects (on systems that are only influenced by the force of gravity).	5	91.3%	Objects of mass and small objects will reach the floor simultaneously (in gravitational influence only systems).

Topics of Kinematics	The Misconception that Often Occurs in Students	Question Number	Total of Misconceptions	Correct Concept
	Heavy objects that touch the ground with a speed greater than a light object (on a system that is only affected by the force of gravity)	6	87.8%	Acceleration of falling objects is equal and independent of the mass of objects (on the system only affected by the force of gravity).
	The dropped object will get to the floor earlier than the object being fired horizontally (on a system affected only by gravity).	7	83.7%	Objects dropped and horizontal fired objects will reach the ground at the same time (on the system only affected by gravity)
	It can be seen from the picture that on an upward-moving vertical object works two styles of force that is a larger upward force of a downward-gravitational force (on a system affected only by gravity).	8	93.8%	The force acting on an upwardly moving vertical object is a downward gravitational force (the system is affected only by the force of gravity).
	Objects moving upward vertically lose the force as a result of the force of gravity, but the force of gravity is greater than the force that is directed upwards because the ball loses its speed.	9	56.6%	The ball is moving upward, there is a force of gravity that acts on the ball causing the ball to decrease.
	Objects that are moving vertically upwards have speeds that go upward but have no acceleration.	10	63.2%	When an object moves vertically upwards the direction of velocity and opposite acceleration (upward speed direction and downward acceleration direction).
	There is no force acting on the object when the object is at its highest point (vertical motion up).	11	69.4%	The object remains influenced by the force of gravity when the object is at its highest point of motion (upward vertical motion).
	With the air friction being negligible, the thrown balls have a bigger ground pounding speed than the ball thrown up.	12	93.1%	By ignoring the air friction, if a ball is thrown up and another ball is thrown down with the same initial speed then both balls will reach the ground with the same speed.
Parabolic motion	At the highest point of parabolic motion, the object has a vo sin θ velocity (negligible air friction).	13	84.0%	In a parabolic motion (with negligible air friction), the speed of the bullet when at the highest point of the path is $v_o \cos \theta$.
	In the parabolic motion, the slope of the tangent to the curve at a given price x can be used to calculate the magnitude and direction of speed.	14	92.7%	In the parabolic motion, the slope of the tangent to the curve at a given price x can only be used to calculate the direction of velocity but not the magnitude.
	Objects that experience parabolic motion with greater elevation angle will pound the ground with greater speed (air friction can be ignored).	15	80.6%	Objects with parabolic motion with greater elevation angle will pound the soil after moving objects with smaller elevation angles (with negligible air friction).

Topics of Kinematics	The Misconception that Often Occurs in Students	Question Number	Total of Misconceptions	Correct Concept
	When the object reaches the highest point of the parabola path then the velocity and acceleration are zero.	16	84.4%	When the object reaches the highest point of the parabola path then the minimum velocity and constant acceleration velocity but both are not equal to zero.
Circular motion	Objects that are farther away from the rotary axis have a larger angular rate.	17	58.7%	People who are farther away from the rotary axis have a larger linear rate.
	Horizontal circular motion with constant speed has a fixed speed.	18	83.0%	A horizontally circular moving object of constant speed will have a constant acceleration.

5 CONCLUSIONS

From the research result, it is found that the average of students in school and college experiencing misconception is still very high, that is 76.0%. The results of the identification of the average students most misconception on each topic of kinematics are: (a) Position, Distance, Displacement, Velocity, and Acceleration, misconception of 67.7%, most students assumed that the distance traveled by objects (b) Regular Straight Motion and Regular Straight-Changed Motion, a misconception of 93.8%, students considered that objects are moving vertically upward, working two forces that are an upward force is greater than the gravitational force which downward direction. (c) Parabolic Motion, a misconception occurs of 92.7%, students assumed that slope of a tangent to the parabolic motion curve can be used to calculate the magnitude and direction of velocity (d) Circular Motion, a misconception occurs of 83.0%, the students assumed that objects are moving horizontal circular with constant speed have a constant velocity.

Suggestion from this research are (1) after the teacher know the kinematical parts which often happened misconception then it is suggested/expected to the teacher able to arrange the most effective learning plan so that the student is able to understand the concept of kinematics correctly, and (2) on kinematics, it is advisable to further research on the types of misconceptions in other physical materials and supplemented by a collection of discussions of misconceptions that have been found.

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REFERENCES

Berg, E., R. Berg, C. S. Arum, K. S. Boko, C. Huis, N. Katu, P. Licht, J. Minstrell, Sundaru, P. Taylor, and D. Treagust. 1990. Misconception of Physics and Remediation. *An Introduction Based Workshop held at Satya Wacana Christian University*, Berg, E., Eds. Salatiga: Satya Wacana Christian University. pp. 8-60.

Clement, J. 1982. Students' Preconceptions in Introductory Mechanics. *American Journal of Physics, 50*(1), 66-70.

Demirci, N. 2005. A Study of Students' Misconceptions in Force and Motion Concepts by Incorporating a Web-assisted Physics Program. *The Turkish Online Journal of Educational Technology – TOJET, 4*(3), 40-48.

Helm, H. 1980. Misconceptions in physics amongst South African students. *Physics Education*, *15*, 92-105.

Isliyanti, A., and K. Rizal. 2011. Pembuatan Kumpulan Pembahasan Miskonsepsi pada Beberapa Topik Materi Mekanika. *Prosiding Simposium Nasional Inovasi dan Pembelajaran Sains*. Magister Physics Teaching FMIPA ITB, Bandung.

Kurniawan, Y., and A. Suhandi. 2015. The Three-Tier Test for Identification The Quantity of Student's Misconception on Newton's First Law. *GlobalIlluminators Publishing,* 2.

Kusumawati, I., Sumarli, Sutopo, and Kusairi, S. 2019. Development of multiple representation learning model based on HOTS students in straight motion material. In *AIP Conference Proceedings, 2194*(1), 020052. AIP Publishing LLC.

Makhrus, M., N. Mohammad and W. Widodo. 2014. Model Perubahan Konseptual dengan Pendekatan Konflik Kognitif (MPK-PKK). *J Pijar Mipa*, *9*(1).

Muliyani, R., and I. Kaniawati. 2015. Identification of Quantity Students' Misconception on Hydrostatic

Pressure With Three Tier-Test. *Global Illuminators Publishing*, 2.

Murdani, E., and Sumarli, S. 2019. Student learning by experiment method for analyzing the dynamic electrical circuit and its application in daily life. In *Journal of Physics: Conference Series*, *1153*(1), 012119. IOP Publishing.

Pujianto, A., Nurjannah, and I.W. Darmadi. 2014. Analisis Konsepsi Siswa pada Konsep Kinematika Gerak Lurus. *Jurnal Pendidikan Fisika Tadulako (JPFT), 1*(1).

Rahayu, Sri 2015. Pengembangan Tes Diagnostik Pilihan Ganda Dua Tingkat untuk mengidentifikasi Miskonsepsi pada konsep Gerak Dua Dimensi. *Thesis*. Education Physics, Department of P.MIPA, FITK UIN Syarif Hidayatullah, Jakarta. Unpublished.

Suhendi, H. Yuniarti, I. Kaniawati, and J. Maknun. 2014. Peningkatan Pemahaman Konsep dan Profil Miskonsepsi Siswa Berdasarkan Hasil Diagnosis Menggunakan Pembelajaran ECIRR Berbantuan Simulasi Virtual dengan Instrument Three-Tier Tes. *Prosiding Mathematic and Sciences Forum.*

Suparno, P. 2005. *Miskonsepsi dan Perubahan Konsep dalam Pendidikan Fisika*. Jakarta: PT Grasindo.

Tayubi, Y. R. 2005. Identifikasi Miskonsepsi pada Konsep-konsep Fisika Menggunakan Certainty of Response Index (CRI). *Mimbar Pendidikan*, *24*(3).

Vakani, F., F. Jafri, M. Sheerani, and W. Jafri. 2012. Misconceptions in Students: How To Resolve Them?. *J Job Med Coll Abbottabad*, 24.

Yuliana, R., P. Karyanto, and Marjono. 2013. Pengaruh Pemanfaatan Concept Map dalam Model Kontruktivisme Tipe Novick terhadap Miskonsepsi pada Konsep Sistem Pernapasan Manusia. *BIO-PEDAGOGI*, *2*(2).