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IDENTIFICATION OF STUDENT'S MISCONCEPTIONS ON STRAIGHT MOTION MATERIALS USING *FOUR-TIER DIAGNOSTIC TEST* AND *CERTAINTY OF RESPONSE INDEX* (CRI)

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ABSTRACT

Student's understanding that is not in accordance with scientific concepts becomes an obstruction in the process of studying and effect on the result of studying itself. Therefore, an effort is needed to fix and find out the students' misconception. Therefore, this study aims to identify the student's misconceptions on the material of straight motion in three schools of Padang city. This study is the descriptive research by using quantitative approach. The instrument used is the Four-Tier Multiple Choice Test with a Certainty of Response Index (CRI) scale with total questions are ten questions. The study population was all students of class X at School A Padang, School B Padang, and School C Padang in the academic year 2021/2022. The simple random sampling technique is used in 20% of the total population, so the number of samples was 135 students which 41 students from School A Padang, 58 students from School B Padang, and 36 students from School C Padang. The data analysis used is descriptive statistics with three levels of student's concept understanding. The results indicate that the level of student's concept understanding on the material of straight motion at School A Padang, School B Padang, and School C Padang was in the low category with the level of misconceptions in the medium category. It can be stated that the level of student's concept understanding is more dominant in the category of misconceptions in straight motion material.

Keywords : *M*isconceptions; Straight Motion; Four-Tier Multiple Choice Test; Certainty of Response Index

I. INTRODUCTION

Physics is one of the subjects that is often said to be a difficult subject to understand. Physics learning requires students to have thinking skills in analyzing problems related to natural phenomena, both qualitatively and quantitatively by using a mathematical approach [1]. Physics is also a subject that has a conditional nature. This conditional nature makes students think that the physics is a difficult lesson to study. In physics, there are many interrelated concepts. There are times when a new concept in physics requires an understanding of the previous concepts that have been studied. If the understanding of the previous concept is wrong, then the error will have an impact on understanding the following concepts. In understanding the concept of physics correctly, students must have a conception of physics that is suitable with the conception of experts.

In fact, students understanding of the concepts which have been studied are still not suitable yet with the agreed expert concept. Many factors influence this, such as experiences in everyday life felt by students before receiving lessons in formal education and terms used in everyday life which have different meanings from scientific concepts. Understanding the concept that is not in suitable with the conception of the experts is called a misconception. Misconception is a person's conception of a concept that is not in line with the conception of experts. Misconceptions include inaccurate understanding of concepts, use of wrong concepts, misclassification

samples of applying concept, different understanding of concept, the chaos of different concepts, and hierarchical relationships of incorrect concepts [2]. Misconception is a problem that must be found a solution as soon as possible because misconceptions are an obstacle that is not realized and can interfere and hinder students in the learning process. Overcoming misconceptions in physics learning is important to avoid continuous misconceptions.

One of the physics materials in the field of mechanics which is often a misconception is the straight motion material which is taught to students in class X high school in the first semester. The material of straight motion is very closely related to everyday life. In addition, the material of straight motion is an important basis in understanding the next material, namely the material of parabolic motion and circular motion. Based on the author's observations when carrying out the Field Experience Program in last semester, students have difficulty understanding the concept of parabolic motion and circular motion material because understanding the concept of straight motion material is not in accordance with the scientific concept. The results of initial observations of 28 students at School C Padang regarding the time in free fall for two objects with different masses reaching the ground, only two out of 28 students answered correctly but the reason for this student's answer was still not correct. The results of the observations also showed that only five of 28 students answered correctly regarding the value of velocity in non-uniform straight motion. It can be stated that many students have misconceptions on straight motion materials.

Based on the facts that have been described, it is necessary to make efforts to identify students' misconceptions on the material of straight motion so that students have a correct understanding of the concept. According to data on the website of the Education Assessment Center in 2019, there are still schools in Padang City whose percentage of correct answers on the National Examination in the field of mechanics is below the national average, which is below 45.51% [3]. Schools that still have relatively low achievement of physics learning outcomes need to make efforts to identify student misconceptions in order to improve student learning outcomes and not be left far behind with students in other schools.

Efforts that can be made are to conduct a diagnostic test called the Four-Tier Diagnostic Test with a Certainty of Response Index (CRI) scale. This diagnostic test consists of four levels, namely: the first level of students choosing the answer that is considered correct, the second level is a scale of confidence in the selected answer, the third level is the reason students choose the answer to the question, and the fourth level is a scale of confidence in the reason for the chosen answer [4]. The CRI scale shows the level of student confidence and the percentage of guesswork in choosing answers and reasons. The CRI scale starts from zero (0) to five (5). A low CRI indicates a lack of concept confidence in students who usually determine answers on the basis of more guesses. On the other hand, a high CRI reflects high confidence and certainty in the concept of students, so that the element of guesswork in choosing answers is very small.

Four-Tier Diagnostic Test accompanied by a scale (CRI) it has a possible combination of 16 possible answers for each question number [4], so that more accurate results are obtained compared to other types of diagnostic tests. The results of this diagnostic test can distinguish students who understand the concept, they who do not understand the concept, and those who have misconceptions. These results can also be used as a basis or consideration for teachers in determining follow-up in learning and can assist students in improving learning outcomes.

II. METHOD

This study is the descriptive research by using quantitative approach. In descriptive research, the researcher does not give special treatment to the object being studied and can be carried out in a short period of time or a long period of time. The quantitative approach is an approach by recording and analyzing research data using statistical calculations. This study will show the level of understanding of students' concepts on the material of straight motion. Descriptive research method with a quantitative approach is used if it aims to describe or explain an event or an event that is happening at the present time in the form of meaningful numbers [5]. The location of the research was carried out in three schools in the city of Padang, namely: School A Padang, School B Padang, and School C Padang. The time for conducting the research is in the odd semester of the 2021/2022 academic year starting from October 11 to October 30, 2021.

The population in this study is all students of class X MIA School A Padang, School B Padang, and School C Padang in the academic year 2021/2022. The research population was determined based on the achievement of the Senior High School National Examination scores of Padang city on physics subjects which were classified as the three lowest school which was obtained from the website of the Education Assessment Center. The number of

students in class X MIA at School A Padang is 207 students, at School B Padang is 290 students, School C Padang is 180 students, so the total population is 677 students. The number of samples taken in this study was 20% of the total population of 135 students which is 41 students from School A Padang, 58 students from School B Padang, and 36 students from School C Padang. The simple random sampling technique is used in this study because the sample is selected randomly from the population so that each member has an equal chance to be a sample. Taking the sample can be done randomly by selecting individual samples that will be used randomly to represent the whole population [6].

The instrument used is a diagnostic test of the Four-Tier Multiple Choice Test type developed by Heru Erwinsyah (2019) with total questions are ten questions. The results of the validation test on the Four-Tier Multiple Choice Test instrument are in the valid category and are appropriate to be used to analyze students' misconceptions on the straight motion material [7].

The descriptive statistics is used as a data analysis technique. The stages of the data analysis technique are the first to determine the CRI value used based on a scale that has been prepared with the CRI confidence criteria as shown in Table 1.

Table 1. *Certainty of Response Index (CRI)* Scale

CRI	Criteria		Confidence Level
0	*Guessing*	The percentage of guess elements is 100%	
1	*Very Unconfident*	The percentage of guess elements is between 75%-99%	Low
2	*Unconfident*	The percentage of guess elements is between 50%-74%	
3	*Confident*	The percentage of guess elements is between 25%-49%	
4	*Very Confident*	The percentage of guess elements is between 1%-24%	High
5	*Highly Confident*	There is no element of guessing at all (0%)	

(Source: Ref [8])

The CRI scale starts from zero (0) to five (5). A scale of zero (0) to two (2) is a relatively low level of confidence, while a scale of three (3) to five (5) is for a high level of confidence scale. Next, identify student test results based on the category of answer combinations listed in Table 2.

Table 2. Category *Four-Tier Diagnostic Test* Answer Combinations

Answer	Confidence Level Answer	Reason	Reason Confidence Level	Category
Right	High	Right	High	Understand Concept (U)
Right	Low	Right	Low	
Right	High	Right	Low	
Right	Low	Right	High	
Right	Low	Wrong	Low	Not Understand the Concept (NU)
Wrong	Low	Right	Low	
Wrong	Low	Wrong	Low	
Right	High	Wrong	Low	
Wrong	Low	Right	High	
Right	Low	Wrong	High	
Right	High	Wrong	High	
Wrong	High	Right	Low	
Wrong	High	Right	High	Misconception (M)
Wrong	High	Wrong	Low	
Wrong	Low	Wrong	High	
Wrong	High	Wrong	High	

(Source: Ref [4])

Four-Tier Diagnostic Test has a possible combination of 16 possible which can distinguish students who understand the concept, they who do not understand the concept, and those who have misconceptions. The next step is to calculate the level of students' understanding. There are three level of it: first, understanding concepts, second not understanding concepts, finally have misconceptions using Equation 1.

$$P = \frac{f}{N} \times 100\% \qquad (1)$$

P is the percentage number of student answers. f is the number of students in every group. N is the total number of students who are the research subjects. The next step is to make a recapitulation of the average percentage of

students' understanding categories such as Table 3. The last step is to describe the data obtained from the test results and draw conclusions.

Table 3. Category Percentage of Student Understanding

Percentage	Category
0% - 30%	Low
31% - 60%	Currently
61% - 100%	High

(Source: Ref [9])

III. RESULTS AND DISCUSSION

The results of the diagnostic test at School A Padang obtained the percentage for each category of students' conceptual understanding level for each number of questions and each indicator of competency achievement as shown in Table 4.

Table 4. The Percentage of Students' Concept Understanding Level at School A Padang

No	Indicators of Competence Achievement	Question Number	Category (%) U	M	NU
1	3.4.1 Explaining about motion	1	49	27	24
		2	17	66	17
	Average		**33**	**46.5**	**20.5**
2	3.4.2 Explaining quantities in straight motion	3	27	27	46
		4	10	54	37
	Average		**18.5**	**40.5**	**41.5**
3	3.4.3 Determining the characteristics of uniform straight motion	5	10	44	46
		6	20	51	29
	Average		**15**	**47.5**	**37.5**
4	3.4.4 Analyzing the characteristics of non-uniform straight motion	7	2	39	59
		8	2	51	46
	Average		**2**	**45**	**52.5**
5	3.4.5 Analyzing free fall motion, vertical upward motion, and vertical downward motion	9	2	44	54
		10	2	46	51
	Average		**2**	**45**	**52.5**
	Total Average		**14.1**	**44.9**	**40.9**

The graph of the percentage of diagnostic test results at School A Padang for each category of students' conceptual understanding level for each competency achievement indicator as seen in Figure 1.

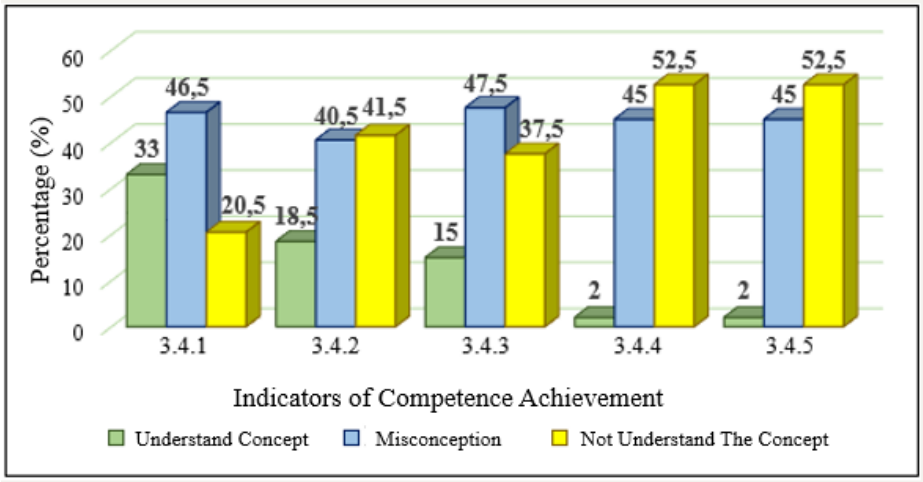

Fig. 1. Graph of Percentage of Students' Concept Understanding Level Based on Competency Achievement Indicator at School A Padang

Based on Table 4 and Figure 1 above, the level of students' concept understanding at School A Padang shows a misconception (M) with the highest average percentage of 47.5% on the 3.4.3 indicator. The category of not understanding the concept (NU) has the highest average of 52.5% on two indicators, namely indicator 3.4.4 and indicator 3.4.5. The concept understanding category (U) has the highest average of 33% on the 3.4.1 indicator.

The percentage graph of student's concept understanding level for every item on the straight motion material as seen in Figure 2.

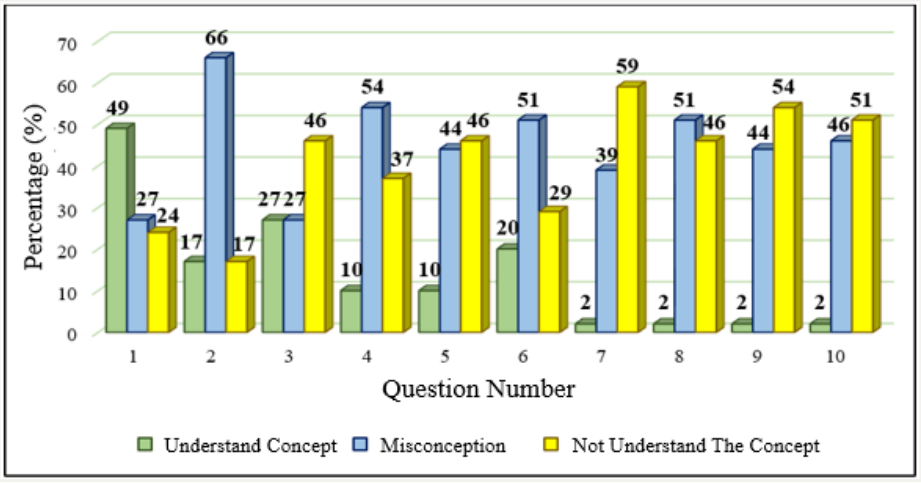

Fig. 2. Graph of Percentage of Students' Concept Understanding in Each Item at School A Padang

Figure 2 shows that the results of the Four-Tier Multiple Choice Test diagnostic test with the CRI scale on the straight-motion material obtained the highest percentage of misconceptions (M) in question number 2 of 66%. The highest percentage for the category of not understanding the concept (NU) is in question number 7 at 59%. The category of understanding concept (U) has the highest percentage on question number 1 at 49%.

The results of the diagnostic test at School B Padang obtained the percentage for each category of students' conceptual understanding level for each question number and each indicator of competency achievement as shown in Table 5.

Table 5. The Percentage of Students' Concept Understanding Level at School B Padang

No	Indicators of Competence Achievement	Question Number	Category (%)		
			U	M	NU
1	3.4.1 Explaining about motion	1	66	21	14
		2	21	59	21
	Average		**43.5**	**40**	**17.5**
2	3.4.2 Explaining quantities in straight motion	3	16	40	45
		4	3	57	40
	Average		**9.5**	**48.5**	**42.5**
3	3.4.3 Determining the characteristics of uniform straight motion	5	5	53	41
		6	5	66	29
	Average		**5**	**59.5**	**35**
4	3.4.4 Analyzing the characteristics of non-uniform straight motion	7	2	38	60
		8	9	59	33
	Average		**5.5**	**48.5**	**46.5**
5	3.4.5 Analyzing free fall motion, vertical upward motion, and vertical downward motion	9	2	50	48
		10	3	34	62
	Average		**2.5**	**42**	**55**
	Total Average		**13.2**	**47.7**	**39.3**

The graph of the percentage of diagnostic test results at School B Padang for each category of students' conceptual understanding level on each competency achievement indicator is shown in Figure 3.

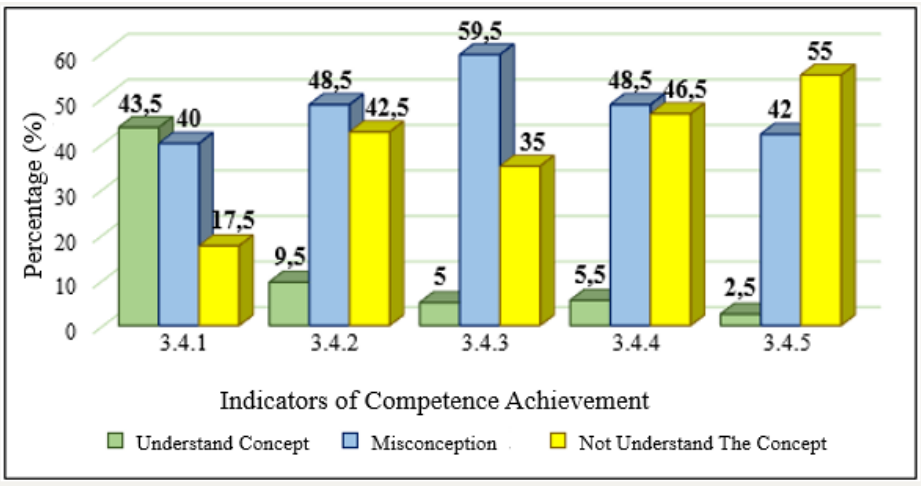

Fig. 3. Graph of Percentage of Students' Concept Understanding Level Based on Competency Achievement Indicator at School B Padang

Based on Table 5 and Figure 3 above, the level of students' concept understanding at School B Padang shows a misconception (M) with the highest average percentage of 59.5% on indicator 3.4.3. The category of not understanding the concept (NU) has the highest average of 55% on the 3.4.5 indicator. And the concept understanding category (U) has the highest average of 43.5% on the 3.4.1 indicator.

The percentage graph of students' concept understanding level for every item on the straight motion material as seen in Figure 4.

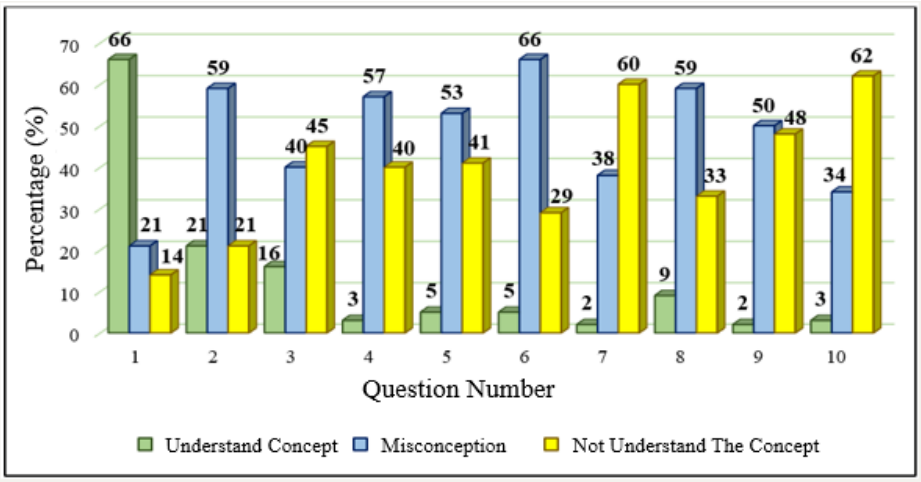

Fig. 4. Graph of Percentage of Students' Concept Understanding Level in Each Item at School B Padang

Figure 4 indicates that the results of the Four-Tier Multiple Choice Test diagnostic test accompanied by the CRI scale on the straight motion material obtained the highest percentage of misconceptions (M) in question number 6 of 66%. The highest percentage for the category of not understanding the concept (NU) is in question number 10 at 62%. The category of understanding concept (U) has the highest percentage on question number 1 at 66%.

The results of the diagnostic test at School C Padang obtained the percentage for each category of students' conceptual understanding level for each question number and each indicator of competency achievement as shown in Table 6.

Table 6. The Percentage of Students' Concept Understanding Level at School C Padang

No	Indicators of Competence Achievement	Question Number	Category (%) U	M	NU
1	3.4.1 Explaining about motion	1	58	39	3
		2	25	64	11
	Average		**41.5**	**51.5**	**7**
2	3.4.2 Explaining quantities in straight motion	3	6	58	36
		4	3	53	44
	Average		**4.5**	**55.5**	**40**
3	3.4.3 Determining the characteristics of uniform straight motion	5	6	58	36
		6	0	69	31
	Average		**3**	**63.5**	**33.5**
4	3.4.4 Analyzing the characteristics of non-uniform straight motion	7	8	47	44
		8	14	56	31
	Average		**11**	**51.5**	**37.5**
5	3.4.5 Analyzing free fall motion, vertical upward motion, and vertical downward motion	9	0	69	31
		10	6	44	50
	Average		**3**	**56.5**	**40.5**
	Total Average		**12.6**	**55.7**	**31.7**

The graph of the percentage of diagnostic test results at School C Padang for each category of students' conceptual understanding level for each competency achievement indicator as seen in Figure 5.

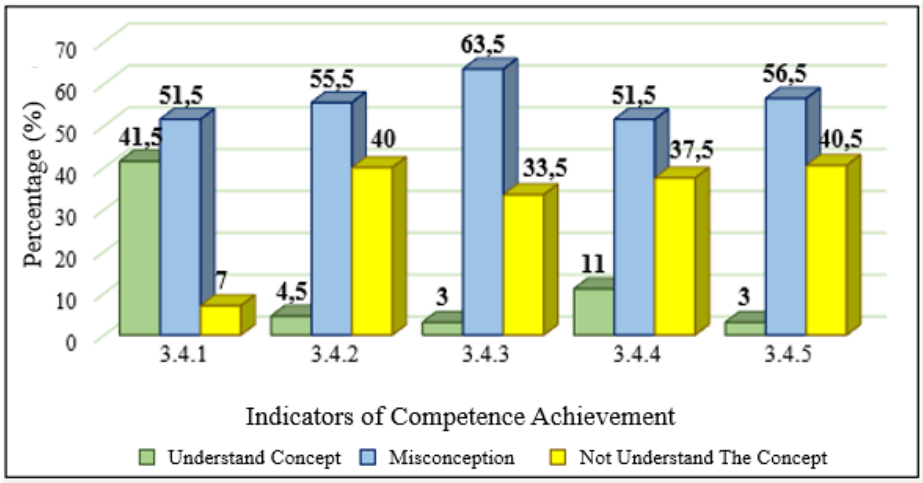

Fig. 5. Graph of Percentage of Students' Concept Understanding Level Based on Competency Achievement Indicator at School C Padang

Based on Table 6 and Figure 5 above, the level of students' concept understanding at School C Padang shows a misconception (M) with the highest average percentage of 63.5% on indicator 3.4.3. The category of not understanding the concept (NU) has the highest average of 40.5% on the 3.4.5 indicator. The concept understanding category (U) has the highest average of 41.5% on the 3.4.1 indicator.

The percentage graph of student's concept understanding level for each item on the straight motion material as seen in Figure 6.

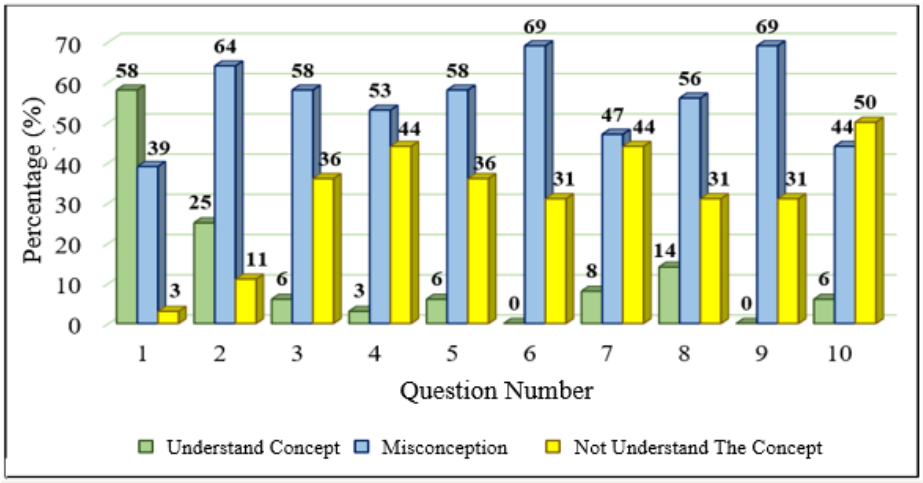

Fig. 6. Graph of Percentage of Students' Concept Understanding Level in Each Item at School C Padang

Figure 6 indicates that the results of the Four-Tier Multiple Choice Test diagnostic test accompanied by the CRI scale on the straight motion material obtained the highest percentage of misconceptions (M) on question number 6 and question number 9 which was 69%. The highest percentage for the category of not understanding the concept (NU) is in question number 10 at 50%. The category of understanding concept (U) has the highest percentage on question number 1 at 58%.

The results of diagnostic tests that have been executed in three schools, it can be summarized that the overall level understanding draft student which are grouped into 3 categories, namely understanding the concept (U), misconception (M), and not understanding the concept (NU) in straight motion material as shown in Figure 7.

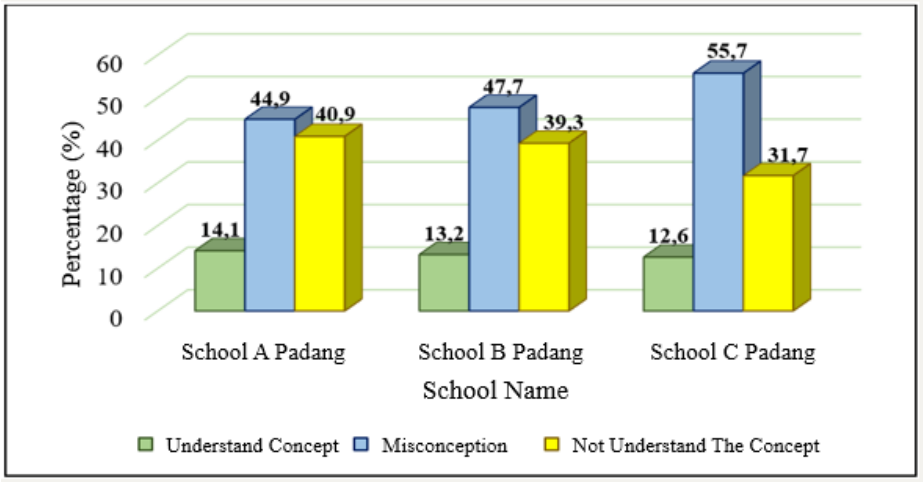

Fig. 7. Graph of Recapitulation of Total Average Percentage of Students' Concept Understanding Categories on Straight Motion Material

From the recapitulation results shown in Figure 7 above, School A Padang obtained a total average percentage in the misconception category (M) of 44.9%, in the category of not understanding the concept (NU) of 40.9%, and in the category of understanding concept (U) of 14.1%. It can be stated that the level of understanding of students' concepts at School A Padang for the Four-Tier Multiple Choice Test questions accompanied by the CRI scale on the straight motion material is low with the level of students' misconceptions in the medium category.

The results at School B Padang obtained a total average percentage in the category of misconceptions (M) of 47.7%, in the category of not understanding the concept (NU) of 39.3%, and in the category of understanding concepts (U) of 13.2%. It can be stated that the level of understanding of students' concepts at School B Padang for the Four-Tier Multiple Choice Test questions accompanied by the CRI scale on the straight motion material is low with the level of students' misconceptions in the medium category.

The results at School C Padang obtained a total average percentage in the category of misconceptions (M) of 55.7%, in the category of not understanding the concept (NU) of 31.7%, and in the category of understanding concepts (U) of 12.6%. It can be stated that the level of understanding of students' concepts at School C Padang

for the Four-Tier Multiple Choice Test questions accompanied by the CRI scale on straight motion material is low with the level of students' misconceptions in the medium category.

The results of the diagnostic test show only question number 1 had a concept understanding percentage (U) above 30% in three schools. For the misconception category (M) at School A Padang there are eight questions with a percentage above 30% except for questions number 1 and 3, at School B Padang there are nine questions with a percentage above 30% except for question number 1, and at School C all questions have a percentage above 30%. In the category of not understanding the concept (NU), School A Padang and School B Padang contained seven questions with percentages above 30% except for questions number 1, 2, and 6, while at School C Padang there were eight questions with percentages above 30. % except for questions number 1 and 2.

Student who experience misconceptions in questions number 1 and number 2 have the concept that a person is said to be moving if he experiences a change in velocity or a change in speed from the initial position to the final position. Incorrect or incorrect reasoning makes students assume the velocity or speed that is the reason a person is said to be moving, regardless of the concept of a reference point. While the correct concept is that a person is said to be moving if he experiences a change in position with respect to the reference point.

Student who have misconceptions in problem number 3 have the concept that distance is a vector quantity, while displacement is a scalar quantity. Students are wrong about the difference between vector quantities and scalar quantities. The results of research conducted by Linawati also shows that students also think that distance is the same as displacement. Distance and displacement have different meanings, distance does not pay attention to direction while displacement pays attention to direction [10].

Students who experience misconceptions in question number 4 have the concept that speed is related to position and velocity is related to distance. This misconception is caused by students' associative thinking that the terms speed and velocity have the same meaning in the daily life. However, in physics both speed and velocity have different meaning, speed is related to the distance traveled by the object, while velocity is related to the displacement traveled by the object. The same thing is also seen in the results of research conducted by Muhammad Nasir, as many as 34.03% students experience misconceptions in distinguishing between speed and velocity [11].

Students who have misconceptions in questions number 5 and number 6 have the concept that in uniform straight motion the velocity depends on the time it takes for objects to move and objects can experience acceleration or deceleration. The velocity of an object does not only depend on the time it takes needed, but also the displacement experienced by the object. In uniform straight motion, the object's velocity has the same value, which causes the object to neither accelerate nor decelerate.

In questions number 7 and number 8, it requires students' ability to calculate problem solving based on equation of non-uniform straight motion. In question number 8, students have difficulty proving the motion illustration presented in the question. In addition to understanding the concept of non-uniform straight motion, students' skills in linking questions and determining how the steps in solving problems are also very influential.

On questions number 9 and 10 also require students' ability to calculate problem solving based one quality free fall motion, vertical upward motion and vertical downward motion. In question number 9 students assume that if the velocity is twice the original speed, then the height of the object will also be twice its initial height. In question number 10 students tend not to pay attention to the height that is asked in the question. Students' skills in linking questions and determining how the steps in solving questions are very influential on questions that require a calculation process. The results of research conducted by Murdani also shows that misconceptions about uniform straight motion and non- uniform straight motion are very high, reaching 93.8% [12].

The results also show that students' interest in studying is still low. Students who have less interest in studying tend not to pay attention and listen to the overall material taught by teacher. They tend ignore what is explained by teacher. Furthermore, some textbooks are difficult to understand. The available explanations are not suitable with the actual concept. In addition, it is also caused by teaching methods that are inappropriate to the material being taught.

The results showed that students' misconceptions were higher than students' understanding of concepts. The percentage of misconceptions (M) has a high score compared to the percentage of not understanding the concept (NU), and the percentage of understanding the concept (U) always has a low score in the three schools where the research was carried out. These facts are same with the results of research conducted by Aifah Fauziah which shows the percentage of misconceptions is 45.8%, understands the concept well by 25%, understands the concept but is not sure at 3%, and does not understand the concept by 26.2% [13] . In contrast to the results of research conducted by Milisa Triastutik who obtained a low percentage of misconceptions, namely 28.96%. But the percentage of not understanding the concept has the highest score of 62.754%. The percentage of understanding the concept is 7.927% and the error is 0.344% [14].

IV. CONCLUSION

The results indicate that the level of understanding of students' concepts on the material of straight motion at School A Padang, School B Padang, and School C Padang was in the low category with the level of misconceptions in the medium category. At School A Padang the percentage of understanding concepts is 14%, misconceptions is 45% and not understanding concepts is 41%. At School B Padang the percentage of understanding concepts is 13%, misconceptions is 48% and not understanding concepts is 39%. And at School C Padang the percentage of understanding concepts is 13%, misconceptions is 56% and not understanding concepts is 32%. It can be summarized that the level of students' concept understanding is more dominant in the category of misconceptions in straight motion material.

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