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Learn Physics Using Interactive Demonstration to Reduce The Students' Misconceptions on Mechanical Wave

Mukhayyarotin Niswati Rodliyatul Jauhariyah

Physics Education Program Study, Physics Department, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya, Indonesia

Zaitul Harizah, Indina Zulfa, Herlina Mulyastuti

Physics Education Program, Graduate Program, Universitas Negeri Malang, Indonesia

Woro Setyarsih, and Nadi Suprapto

Physics Education Program Study, Physics Department, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya, Indonesia

***Abstract*—In the learning process, students have conception and misconception, no exeption in mechanical wave learning. The aims of this study to reduce students misconceptions on mechanical wave using interactive demonstration. Interactive demonstration of physics learning applied to students of 16th State Senior High School of Surabaya using one group pretest-posttest design of research. The results of pretest and posttest show that students misconception on mechanical wave material can reduce using interactive demonstration learning on moderate category.**

Keywords— Interactive Demonstration, Student Misconseption, Mechanical Wave

I. INTRODUCTION

Misconceptions may take the form of an initial concept, inaccurate notions of concepts, the use of false concepts, the classification of false examples of the application of concepts, and the interpretation of different concepts. Suparno [1] stated that misconceptions exist in all areas of science, such as physics, chemistry, and biology. Misconceptions in physics include sub areas such as mechanics, thermodynamics, optics, sounds, waves, electricity and magnetism, as well as modern physics. There are many ways to identify misconception in physics such as interviews, open-ended test, multiple-choice test, multiple-tier test [2]. CRI (Certainty of Response Index) can be used to distinguish between students who understand concepts, do not understand concepts, and misconceptions [3-4]. However, through RCI it is not known whether students actually experience misconceptions or guesses. Using three-tier diagnostic test, it can be known the student who understand the concepts, do not understand the concepts, experience misconceptions, guesses, and false negative [5-8].

According to Suparno [1], misconceptions occur mostly because of the initial misconceptions that students have and are brought into the classroom. The initial concept has an important role in building an understanding of an object being studied. The learning process will run smoothly if the initial concepts that students have are in accordance with the new knowledge acquired. If the initial concept of students is not in accordance with the new knowledge gained, then there will be misconceptions which will later become obstacles in learning [9].

The material of the wave is one of the physics materials that allows students to experience misconception. Elfani stated that when students were asked about the speed ratio between two waves propagating on the same medium with the first wave frequency of 1000 Hz and the second wave frequency of 3000 Hz, some students answered 1: 3. Though the wave velocity does not depend on the frequency of the wave but on the nature of the medium. Students are fixated on the equation v=□.f and assume that f (frequency) is directly proportional to v (velocity). Whereas in these conditions, v is constant. Some of the students were convinced of the answer, so Elfani [10] concluded that students had misconceptions on mechanical wave material.

Based on the case found by Elfani, it was assumed that there were still many high school students who experienced

misconceptions in mechanical wave material. To prove this assumption, identification of students' misconceptions was carried out on the mechanical wave material by compiling a three-tier diagnostic test instrument. The process of developing test instruments is almost the same as when developing a three-tier diagnostic test instrument in the Gas Kinetic Theory material in our previous paper [6]. Based on a combination of students' answers when working on a three-tier diagnostic test instrument, students can experience misconceptions based on criteria adapted from Kutluay [6]. Misconceptions profiles can be analyzed using methods such as when determining the profile of students' misconceptions on the material of the Gas Kinetic Theory [7]. Based on the diagnosis, there were 40.30% of students in one class at 16th Senior High School of Surabaya who experienced misconceptions on mechanical wave material. Therefore, efforts are needed to reduce the misconception.

There are many ways to reduce student misconceptions on Physics material. Broadly speaking, the steps used to overcome misconceptions are by finding or uncovering misconceptions, trying to find the cause of the misconception, and then finding appropriate treatment to overcome the misconceptions experienced by students [1]. Students' misconceptions cannot be overcome simply by using the lecture method that the entire process of delivering knowledge is teacher-centered. Not all of the methods carried out by the teacher succeed to reduce misconceptions in students. This is because the teacher does not know for sure the cause of misconceptions experienced by students and sometimes the teacher gives inappropriate treatment to deal it. Teachers tend to repeat material that is considered difficult to understand by students. However, students who experience misconceptions will still not be helped because they do not know for certain the location of the error they experienced. Therefore, students must be actively involved in learning and directed to build their own knowledge through real experience in dealing with real physical phenomena.

Berg [11] argued that the key to knowing the occurrence of misconceptions in students is to interact with students. According to Berg [11], students 'misconceptions can be overcome by (1) adjusting the syllabus sequence by students' thinking, (2) cognitive conflict, (3) analogy, (4) pair interaction, (5) meta-learning, meta-cognition, and (6) demonstration. To tackle misconceptions on students, appropriate learning methods are needed in order to create students' cognitive conflicts.

Interactive demonstration becomes one of the solutions to handle student misconception on the subject of physics. West and Ogden [12] stated that interactive demonstration was developed to help students in better learning to make it easier to understand some of the difficult concepts their face. Learning by way of traditional lectures combined with interactive demonstration learning is more effective than learning using traditional lectures [13]. Similar of this studies that the use of multimedia-assisted interactive demonstration learning models has an effect on student learning outcomes in the chemistry aspects of natural science [14]. Student learning outcomes have increased in each learning series after applying the interactive demonstration learning method [15]. The increase in students' understanding of concepts minimizes the possibility of differences in concepts that students have with scientific concepts so that expected physics learning using interactive demonstration can handle the problem of misconceptions in students.

The aim of this study is to apply interactive demonstration learning to reduce students' misconceptions on mechanical wave material. In this study several media were used to support the success of learning using interactive demonstration, namely demonstration learning videos, PhET interactive simulation, and real laboratories.

II. METHOD

Interactive demonstration learning was applied in physics learning on one class students of SMA Negeri 16 Surabaya. This learning had been doing on 11-15 April 2015. This is pre experimental design of research using one group pretest-posttest design. Students were given pretest to diagnose student misconceptions using a three-tier diagnostic test instrument. Furthermore, students are given mechanical wave materials using interactive demonstration learning. Students are given a posttest to determine the conception or misconception experienced by students after learning to use interactive demonstration.

The students combination answer of three-tier diagnostic test analyzed with criteria from adaptation of Kutluay [6]. Then, the combination answer clasified to UC (Understanding the Concept), LUC (Less Understanding the Concept), NUC (Do Not Understanding the Concept), M (Misconception), and G (Guessing). Furthermore, we have the classified answer for pretest and posttest. The data result of pretest and posttest analyzed statistically. The data of that test tested statistic using paired t-test to know the significant difference between misconception before and after learning using interactive demonstration. Data analyzed using t-test paired sample because the pretest and posttest data have met parametric statistical requirements which include normality and homogeneity test. Beside that, the data analyzed by n-Gain analyze to determine the category of reducing students misconception on mechanical wave after students learn physics using interactive demonstration. Based on data analysis can be drawn conclusion about the decrease in students misconceptions

III. RESULTS AND DISUCUSSION

Students learn physics using interactive demonstration with three phases, there are: (1) Predict, (2) Experience, and (3) Reflect [16]. In physics learning using interactive

demonstration, there are several examples of cases or phenomena. This phenomenon is chosen as a learning context and demonstrated by the teacher or one group of students so that students can witness and experience firsthand the concepts being studied. In the reflecting phase in interactive demonstration learning, students are directed to reflect back on the initial concept that they have had after watching the demonstration given. This is done to find out the suitability of the students' initial concept with the concept being demonstrated. Students who experience misconceptions will realize that the concept previously owned is wrong and will change the initial concept they have into the correct scientific concept based on the demonstrations that have been carried out. Based on the results of students pre-test and post-test, we got the percentage of students conception for each item test (see Table 1).

TABLE I. THE PERCENTAGE OF STUDENTS CONCEPTION FOR EACH ITEM TEST

Number of Item Test	Percentage (%)									
	UC		LUC		NUC		M		G	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1.	0.00	70.60	11.80	8.82	44.11	8.82	20.59	5.88	23.50	5.88
2.	20.60	73.53	2.94	5.88	47.10	2.94	11.76	2.94	17.60	14.71
3.	47.06	70.60	0.00	2.94	14.71	2.94	32.35	11.76	5.88	11.76
4.	52.95	91.18	2.94	2.94	11.76	0.00	29.41	5.88	2.94	0.00
5.	23.53	47.06	2.94	5.88	11.76	17.65	44.17	11.76	17.60	17.65
6.	11.76	94.12	0.00	0.00	20.59	2.94	67.65	0.00	0.00	2.94
7.	2.94	50.00	0.00	2.94	23.53	20.59	61.76	23.53	11.80	2.94
8.	17.64	26.47	0.00	0.00	47.05	23.53	32.35	41.18	2.94	8.82
9.	8.82	41.18	0.00	2.94	35.29	14.71	52.94	29.42	2.94	11.76
10.	8.82	11.76	0.00	0.00	41.18	35.29	50.00	44.12	0.00	8.82
average	19.41	58.25	2.06	2.94	29.70	41.18	40.30	17.94	8.53	8.23

Information: Pre (pretest), Post (posttest), UC (Understanding the Concept), LUC (Less Understanding the Concept), NUC (Do Not Understanding the Concept), M (Misconception), G (Guessing)

Table 1 show the percentage of UC (Understanding the Concept), LUC (Less Understanding the Concept), NUC (Do Not Understanding the Concept), M (Misconception), and G (Guessing) experienced by students at pretest and posttest. Overall, the average value of UC percentage increased from 19.41% at pretest to 58.24% at posttest. The percentage increase was also shown by LUC which was from 2.06% at pretest to 2.94% at posttest. The percentage increase in the LUC category was not significant, which was only 0.88%. Unlike the case with UC and LUC, the NUC, M, and G categories indicate the opposite condition. NUC, M, and G categories experience a decrease in the percentage value at posttest. The NUC category which initially had a percentage of 29.70% at pretest was 12.94% at posttest. Likewise with the M and G categories which had a decrease in the percentage values at pretest and posttest respectively 8.53% to 8.23% and 40.30% to 17.64%. Decreasing the average value of percentage M shows that there has been a reduction in students misconceptions. However, this decrease in misconceptions did not occur in all items.

The students answer analyzed to describe the cause of students misconception. There some cause of students misconception, there are: (1) preconception, (2) associative thinking, (3) humanistic thinking, (4) reasoning, and (5) intuition [1]. Table 2 shows the percentage value of the causes of student misconceptions for each item.

TABLE II. THE PERCENTAGE OF THE CAUSES OF STUDENTS MISCONCEPTIONS FOR EACH ITEM TEST

Number of Item Test	Percentage (%)									
	P		AT		HT		R		I	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1.	0.00	0.00	14.28	0.00	14.28	0.00	0.00	0.00	28.60	0.00
2.	50.00	0.00	25.00	0.00	25.00	0.00	0.00	0.00	0.00	0.00
3.	18.18	0.00	27.27	40.0	18.18	0.00	0.00	0.00	0.00	40.00
4.	20.00	0.00	0.00	0.00	30.00	100.0	0.00	0.00	20.00	0.00
5.	13.33	50.00	13.33	0.00	0.00	0.00	53.30	0.00	0.00	25.00
6.	34.78	0.00	34.78	0.00	17.39	0.00	4.35	100.0	4.35	0.00
7.	19.05	25.00	47.62	37.50	23.81	0.00	4.71	12.50	0.00	25.00
8.	45.45	7.14	36.36	0.00	18.18	14.28	0.00	64.28	0.00	7.14
9.	16.67	0.00	27.78	18.18	38.89	36.36	0.00	0.00	16.70	27.27
10.	35.29	33.33	0.00	20.00	17.64	26.67	17.6	0.00	23.50	20.00

Information: Pre (pretest), Post (posttest), P (Preconception), AT (Associative Thinking), HT (Humanistic Thinking), R (Reasoning), I (Intuition)

Based on Table 2, the percentage value of misconceptions cause decreased almost in all criteria. This is influenced by the level of misconceptions that decrease or the reduction of misconceptions. Not all causes of misconceptions experience a percentage reduction, there are still several criteria that cause misconceptions in each question that increase during posttest compared to the pretest. This can be caused by students who initially do not understand the concept or cannot answer questions correctly at level 1, 2, or 3. After getting physics learning with interactive demonstration, students can answer questions correctly at level 1. However at level 2, students choose reasons which is included in the criteria for the

cause of misconceptions and students are sure of the answers so that students enter the category M (misconception) and are included in the criteria for the cause of misconception in accordance with the reasons chosen by students. In addition, students who were initially unable to answer questions correctly at level 1, 2 and 3. After getting physics learning using interactive demonstration, students still chose the wrong answer at level 1 and level 2 students also choose the reasons included in the criteria cause of misconception, but students remain confident in the answer. So that students are included in the category M (misconceptions) and included in the criteria for the cause of misconception in accordance with the reasons chosen by students.

Table 3 shows the data on the number of student misconceptions at the pretest and posttest. The pretest and posttest data were then statistically tested using the t-test to determine wether there were significant differences between students' misconceptions at pretest and posttest. Before analyzed by t-test, the result of normality and homogeneity test showed that data is normal and homogenous. Based on these data, the t-test is calculated. The results of t-test calculation is obtained the t_{count} of 2.27, this value is greater than the t_{table} value of 2.04. It can be interpreted that there is a significant difference between students' misconceptions at the pretest and the posttest after students learn physics using interactive demonstration. Based on the average, it can be seen that the students' misconceptions at pretest were greater than at the posttest. This means that there is a reduction in student misconceptions on mechanical wave material after students learn using interactive demonstration. The results of this study are in accordance with Wenning's research which states that learning using interactive demonstration can reduce students' misconceptions and can improve students' conceptual understanding of a material [17].

TABLE III. THE NUMBER OF STUDENTS MISCONCEPTION AT PRETEST AND POSTTEST

Name	The number of misconception at pretest	The number of misconception at posttest
Student 1	5	2
Student 2	5	3
Student 3	6	3
Student 4	5	1
Student 5	3	4
Student 6	2	2
Student 7	3	1
Student 8	7	1
Student 9	1	0
Student 10	2	1
Student 11	7	3
Student 12	9	3
Student 13	5	1
Student 14	7	4
Student 15	2	2
Student 16	3	1
Student 17	7	6
Student 18	0	0

TABLE III. CONT.

Name	The number of misconception at pretest	The number of misconception at posttest
Student 19	1	0
Student 20	6	3
Student 21	0	0
Student 22	6	0
Student 23	4	2
Student 24	1	1
Student 25	3	1
Student 26	0	0
Student 27	4	2
Student 28	3	2
Student 29	6	2
Student 30	6	3
Student 31	7	4
Student 32	3	2
Student 33	5	2
Student 34	0	0

To determine the category of reducing students misconception on mechanical wave after students learn physics using interactive demonstration, the data analyzed by n-Gain analysis. Table 4 show the result of n-Gain analysis for reduction of students misconception on mechanical wave physics learning. Based on this table, 6 students included in the high criteria, 19 students included in the medium criteria, and 9 students included in the low criteria.

TABLE IV. THE STUDENT REDUCING MISCONCEPTION CRITERIA BASED ON N-GAIN ANALYSIS

Name	Si	Sf	<g>	Criteria
Student 5	50.00	40.00	0.20	Low
Student 6	20.00	20.00	0.00	Low
Student 15	20.00	20.00	0.00	Low
Student 17	70.00	60.00	0.14	Low
Student 18	0.00	0.00	0.00	Low
Student 21	0.00	0.00	0.00	Low
Student 24	10.00	10.00	0.00	Low
Student 26	0.00	0.00	0.00	Low
Student 34	0.00	0.00	0.00	Low
Student 1	50.00	20.00	0.60	Medium
Student 2	50.00	30.00	0.40	Medium
Student 3	60.00	30.00	0.50	Medium
Student 7	30.00	10.00	0.67	Medium
Student 10	20.00	10.00	0.50	Medium
Student 11	70.00	30.00	0.57	Medium
Student 12	90.00	30.00	0.67	Medium
Student 14	70.00	40.00	0.42	Medium
Student 16	30.00	10.00	0.67	Medium
Student 20	60.00	30.00	0.50	Medium
Student 23	40.00	20.00	0.50	Medium
Student 25	30.00	10.00	0.67	Medium
Student 27	40.00	20.00	0.50	Medium
Student 28	30.00	20.00	0.33	Medium
Student 29	60.00	20.00	0.67	Medium
Student 30	60.00	30.00	0.50	Medium
Student 31	70.00	40.00	0.43	Medium
Student 32	30.00	20.00	0.33	Medium
Student 33	50.00	20.00	0.60	Medium
Student 4	50.00	0.00	1.00	High
Student 8	70.00	10.00	0.85	High
Student 9	10.00	0.00	1.00	High
Student 13	50.00	10.00	0.8	High
Student 19	10.00	0.00	1.00	High
Student 22	60.00	0.00	1.00	High

The number of students in each category of reduction of misconception, it can be stated that the percentage of students who experienced a reduction in misconception in the low criteria was 26.47%. while for the reduction category misconception in the medium criteria is 55.90%, and in the high criteria is 17.64%. Based on this percentage, it can be stated that physics learning using interactive demonstration has a moderate influence on the reduction of students' misconceptions on mechanical wave material

IV. CONCLUSION

The conclusion of this study is students' misconceptions on mechanical wave material can reduce using interactive demonstration learning, eventhough one item test show the enhancement of students' misconception. It is advisable to further researchers when selecting demonstration media in interactive demonstration learning to conduct live demonstrations, not only with video or simulation.

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