An analysis of students' physics misconceptions in online learning using the four-tier diagnostic test with certainty of response index (CRI)

Surmaini¹, Imam Syafe'i², Rahma Diani¹

¹Physics Education Study Program, Tarbiyah and Teacher Training Faculty, UIN Raden Intan Lampung
²Islamic Education Study Program, Tarbiyah and Teacher Training Faculty, UIN Raden Intan Lampung

*Corresponding author: Surmainimai@gmail.com

Abstract. This study was aimed to determine the level of students' physics misconceptions in online learning using a four-tier diagnostic test with Certainty of Response Index (CRI). The Certainty of Response Index (CRI) is a method used to measure students' misconceptions about the material taught by teachers. This research was conducted on 27 students of class X TJTL of SMK BLK Bandar Lampung City. The students worked on a four-tier diagnostic test on fluid material which consisted of 20 items. Based on the results of the research, 11 students knew the concept with an average score of 40.74% in the moderate category, 8 students who did not know the concept with an average score of 29.62% in the low category, and 8 students with misconceptions with an average score of 29.62% in the low category.

Keywords: misconceptions, CRI (certainty of response index), online learning.

1. Introduction

When the COVID-19 hitting the world, the learning process is hampered. The learning is carried out online (from home) because face-to-face learning is no longer permitted. Thus, the teacher is hampered in carrying out the teaching and learning process. Students need a teacher in explaining physics learning material. As a result, students experience a lot of misconceptions in the learning process because it is difficult to study. Physics learning is very difficult to understand, especially during a pandemic, because there is no direct practice in applying the concepts.

Online learning is learning that is done online (from home) without face-to-face meetings between the teacher and students. Online learning is very difficult for students to understand, especially in physics’s fluid learning material. This learning material contains concepts that must be practiced directly by the teacher so that students could understand.

Face-to-face face learning is not impossible to be replaced with a learning system that is integrated with the internet network (online learning). Online learning connects learners with learning resources (databases, experts, instructors, and libraries) who are physically separated or even far apart but can communicate with each other, interact, or collaborate (directly, synchronously, and indirectly and asynchronously). Online learning is a form of distance learning that utilizes telecommunications and information technology, for example, the internet and CD-ROOM (directly and indirectly) [1].
For some students at SMK BLK Bandar Lampung, physics is a difficult subject. Based on their mid-test score, 70.63% of the students have not reached the criteria of minimum mastery for physics which is 75. Thus, it can be said that the students’ mastery of physics concepts is still low.

Misconceptions are students' mistakes in understanding a concept [2]. This happens because students are unable to connect the phenomena found in everyday life with the knowledge obtained at school. Brown [3] describes misconception as a naive view and defines it as an idea incompatible with the scientific understanding currently accepted. The misconception is an error or incorrect relationship between concepts [4]. Misconceptions are inaccurate understanding of concepts, misuse of concepts, wrong classification of examples, the chaos of different concepts, and incorrect hierarchical relationships of concepts [5].

Misconceptions occur at the lowest to the highest levels of education, from elementary school to university. Misconceptions occur a lot, especially among students with poor analytical skills. The misconceptions usually occur when connecting several basic concepts that require a deeper understanding. A previously conducted study reveals that based on the results of a fluid concept test, the misconception was experienced by 8% of students, 48% of students did not understand the concept, and 44% of students understood the concept [6]. Students' misconception on fluid material was 45.8%. So, it can be concluded that the misconceptions experienced by students on fluid material were quite large [7].

There are several ways to help students reduce or overcome misconceptions. The misconceptions might vary so that different handling techniques are needed for each student. It is important for teachers to know and understand the misconceptions that students experienced. Several ways to detect student misconceptions are essay tests, multiple-choice tests, and multiple-choice tests with open reasons. According to Gurel's opinion, misconceptions can be measured in various ways, namely making concept maps, diagnostic tests, interviews, in-class discussion, and practicum through question and answer [8]. In this study, the researchers used an online test via Google Form to identify students' misconceptions [9]. The tests with a misconception approach are used to identify students’ ability in understanding a concept they build based on the learning experiences they have.

Based on the description, the researchers intended to analyze the students’ physics misconceptions in online learning using the four-tier diagnostic test with Certainty of Response Index (CRI) for class X TJTL of SMK BLK Bandar Lampung City on fluid material.

2. Research Method

This research was carried out at SMK BLK Bandar Lampung on September 15, 2020. The research employed the quantitative descriptive method. Descriptive research is research that attempts to describe symptoms and events that are currently happening [10] The result of this research is a description of the number of participants who experienced misconceptions on fluid material. The sample was taken from the whole students of class X TJTL of SMK BLK Bandar Lampung through the purposive sampling technique. The sample was 1 class that had been taught fluid material.

The data collecting technique used was a written test. The instrument used was in the form of a four-tier test with CRI. The four-tier diagnostic test is a combination of a two-tier test and the Certainty of Response Index (CRI).
Table 1. The Combination of Answers of Four-Tier Diagnostic Test [11,12]

| Category                | Answers | Answers Combination | Responses’ Confidence Level |
|-------------------------|---------|---------------------|----------------------------|
| Know the concepts       | Correct | Certain             | Correct                     |
|                         | Correct | Uncertain           | Correct                     |
|                         | Correct | Certain             | Correct                     |
|                         | Correct | Uncertain           | Correct                     |
|                         | Correct | Uncertain           | Incorrect                   |
|                         | Incorrect| Uncertain           | Correct                     |
|                         | Incorrect| Uncertain           | Correct                     |
|                         | Incorrect| Uncertain           | Incorrect                   |
| Do not know the concept | Correct | Certain             | Incorrect                   |
|                         | Incorrect| Uncertain           | Correct                     |
|                         | Correct | Uncertain           | Incorrect                   |
|                         | Incorrect| Certain             | Correct                     |
|                         | Incorrect| Certain             | Incorrect                   |
|                         | Incorrect| Certain             | Incorrect                   |
| Misconception           | Incorrect| Certain             | Incorrect                   |
|                         | Incorrect| Uncertain           | Incorrect                   |
|                         | Incorrect| Certain             | Incorrect                   |

Table 2. Confidence Level

| CRI | Criteria          |
|-----|-------------------|
| 0   | Guessing          |
| 1   | Really Uncertain  |
| 2   | Uncertain         |
| 3   | Certain           |
| 4   | Really Certain    |
| 5   | Extremely Certain |

The four-tier test consisted of 20 questions that had been validated by expert lecturers and had been tested by students. In calculating the percentage of students who understood the concept, misconception, and did not understand the concept, the formula proposed by Suijono 2010 was used [13].

\[ P = \frac{F}{N} \times 100\% \]

Description:
P: The percentage of students who experienced misconceptions.
F: The number of students who understand misconceptions.
N: The total number of test-takers.

Furthermore, the calculation results were described and identified by classifying the level of students’ misconceptions according to the percentage contained in table 3.
Table 3. The Level of Misconception [14]

| Percentage       | Category |
|------------------|----------|
| 61% – 100%       | High     |
| 31% – 60%        | Moderate |
| 0% – 30%         | Low      |

3. Result and Discussion
The researchers conducted the online test to students after all the material had been given. Based on the data processing, the percentage of concept understanding was released, namely knowing the concept (KC), not knowing the concept (NKC), and Misconception (MC).

Table 4. Students' Misconceptions Results

| No  | Categories |
|-----|------------|
|     | KC | NKC | MC  |
| 1   | ✓  |     |     |
| 2   | ✓  |     |     |
| 3   | ✓  | ✓   | ✓   |
| 4   | ✓  | ✓   |     |
| 5   | ✓  | ✓   | ✓   |
| 6   | ✓  | ✓   | ✓   |
| 7   | ✓  | 🍁  | ✓   |
| 8   | ✓  |     |     |
| 9   | ✓  |     | ✓   |
| 10  | ✓  |     | ✓   |
| 11  | ✓  |     |     |
| 12  | ✓  |     |     |
| 13  | ✓  |     |     |
| 14  | ✓  |     |     |
| 15  | ✓  |     | ✓   |
| 16  | ✓  | ✓   | ✓   |
| 17  | ✓  | ✓   |     |
| 18  | ✓  | ✓   |     |
| 19  | ✓  |     |     |
| 20  | ✓  |     |     |
| 21  | ✓  |     | ✓   |
| 22  | ✓  | ✓   | ✓   |
| 23  | ✓  | ✓   |     |
| 24  | ✓  | ✓   | ✓   |
| 25  | ✓  | ✓   | ✓   |
| 26  | ✓  | ✓   | ✓   |
| 27  | ✓  | ✓   | ✓   |
Based on table 4, 11 students knew the concept with an average score of 40.74% in the moderate category, 8 students did not know the concept with an average score of 29.62% in the low category, and 8 students experienced misconceptions with an average score of 29.62% in the low category.

**Table 5. The Percentage of Students’ Misconceptions Per Item Question**

| No. | Indicators                                                                 | Misconception | Category |
|-----|----------------------------------------------------------------------------|----------------|----------|
| 1   | Distinguish between pressure and surface area.                             | 25.92%         | Low      |
| 2   | Explain that hydrostatic pressure is affected by the depth of an object.   | 29.62%         | Low      |
| 3   | Give reasons to explain one application of hydrostatic pressure.           | 25.92%         | Low      |
| 4   | Pay attention to images and determine the events caused.                   | 18.51%         | Low      |
| 5   | Pay attention to images and determine the cause.                           | 14.81%         | Low      |
| 6   | Describe pressure in liquids.                                              | 29.62%         | Low      |
| 7   | Determine the graph which shows the upward force related to the depth of an object. | 33.33%         | Moderate |
| 8   | Determine the correct position of an object in the vessel containing liquid. | 40.74%         | Moderate |
| 9   | Explain the cause of the floating object when placed on the surface of the water in a glass. | 44.44%         | Moderate |
| 10  | Determine the effect of liquid viscosity.                                   | 59.25%         | Moderate |
| 11  | Specifies events related to the symptoms of the capillary.                 | 40.74%         | Moderate |
| 12  | Describe events that occur in shallow and deep river flows.                | 14.81%         | Low      |
| 13  | Pay attention to images and determine equations.                           | 18.51%         | Low      |
| 14  | Cite examples of Bernoulli’s principle.                                    | 25.92%         | Low      |
| 15  | Explain the pressure of an aircraft.                                       | 29.62%         | Low      |
| 16  | Calculate the speed of water entering the venturi meter pipe.              | 18.51%         | Low      |
| 17  | Pay attention to an image and determine the flow velocity in a pipe.       | 11.11%         | Low      |
| 18  | Explain and calculate the cross-                                          | 25.92%         | Low      |
sectional discharge.

19  Explain the water spray event from inside the faucet.  33.33%  Moderate

20  Explain the effect of leakage tanks.  22.22%  Low

The data indicated that misconceptions almost occurred in every given question. Based on the results of data processing analysis, the question with the highest level of misconception was number 10 because it was difficult to understand, namely determining the effects of liquid viscosity. Meanwhile, the problem with the lowest misconception was number 17 because it was easy to understand, namely paying attention to an image and determine the velocity flow in the pipe.

Table 6. Students’ Misconceptions

| No. | Misconceptions | Concept |
|-----|----------------|---------|
| 1   | Most of the students' answers were correct and according to the concept, but the level of confidence was lacking. | The pressure is directly proportional to the force and inversely proportional to the surface area. |
| 2   | Hydrostatic pressure in a connected vessel on a plane has the same density but different pressure. | The hydrostatic pressure in a connected vessel on a plane has the same density and pressure |
| 3   | The problem with applying hydrostatic pressure. The student's answer did not match the concept, namely, the infusion bottle is hung so that the pressure of the liquid is the same as the patient's body. | The infusion bottle is hung so that the liquid pressure in the infusion is greater than the patient's body so that blood can flow to the patient's body |
| 4   | The problem regarding Archimedes' law. However, the students' answers were not in line with the concept, namely if an object is immersed in water, then the object will have an unequal buoyancy force. | If an object is immersed in liquid, then the object will get a force called buoyancy (upward force) equal to the weight of the liquid it transfers. |
| 5   | The problem regarding the effect of hydrostatic pressure on a hole. The students’ answers were not in line with the concept. The students answered that it was influenced by the greater hydrostatic pressure in the hole than B and C. | It is influenced by the hydrostatic pressure of hole C which is the biggest compared to B and A. |
| 6   | Questions about water pressure in closed spaces. Students' answers did not match the concept. The students answered that the liquid pressure in a closed room will not be equally distributed in all directions. | The pressure of the liquid in a closed space will be equally distributed in all directions. |
| 7   | In Archimedes' law, the upward force depends on the depth of the object and the density. | In Archimedes' law, the upward force depends on the depth of the object. |
| 8   | Mass states how dense particles are arranged whereas density shows the number of particles found in an object. | Mass shows the number of particles found in an object while density states how dense the particles are |
Questions about water surface pressure. Students’ answers did not match the concept. The student answered that the mass of water and the clip increased. The surface tension of the water decreased.

Questions regarding the viscosity of liquids. The students’ answers did not match the concept, namely the force that works because the viscosity of the fluid is only affected by the working force. Kinetic energy because the viscosity of the fluid equals the fluid friction.

The student's answers were not in line with the concept of capillarity which is an event that thickens a liquid. Capillary is an event that causes surface tension.

Most of the students' answers were correct but the level of confidence was lacking. The depth of water is directly proportional to the speed. Pipe 1 is bigger than pipe 2 and smaller than pipe 3.

Bernoulli’s principle states that small fluid pressure has small flow velocity and large fluid pressure has large flow velocity. Bernoulli's principle states that the pressure exerted in a closed space is forwarded unequally to all directions.

The airflow velocity under the wing is greater than the velocity of the airflow over the wing while the force under the wing is greater than the force over the wing. The airflow velocity under the wing is greater than the velocity of the airflow over the wing while the force under the wing is greater than the force over the wing. The correct answer is 1.5.

Most of the students answered correctly which is 1.5. The correct answer is 1.5.

The velocity of a large pipe is regular and the velocity of a small pipe is irregular. The velocity of a large pipe is small and the velocity of a small pipe is large.

Students' answer was Q₁ = 4 m³/s and Q₂ = 16 m³/s. Calculation error due to a lack of accuracy. The answer should be Q₁ = 4 m³/s and Q₂ = 40 m³/s

The velocity is high in the large section of a pipe and the velocity is low in the small section of a pipe. The velocity is high in the large section of a pipe and the velocity is also high in the small section of a pipe.

The height of the hole to the surface of the liquid and the height of the hole to the surface of a plane. The height of the hole to the surface of the liquid. The velocity of flow and density.

Based on the results of interviews with the physics teacher, misconceptions occurred due to the lack of practicum. In the fluid material, there is a lot of material that must be practiced. Also, misconceptions occur due to students’ lack of understanding of the material. Physics learning should
be done offline because there are many difficult concepts to understand. Offline physics learning is hard to understand which makes online learning even more difficult.

In this research, students experienced misconceptions if they had wrong answers and reasons but had a high level of confidence. Broadly speaking, the causes of misconceptions experienced by students can be grouped into 5, namely: students, teachers, textbooks, context, and teaching methods [15]. Several causes are originated from students, among others, the abilities, interests, and ways of thinking as well as the influence of peers. The causes of teacher errors are the lack of mastery of concepts, lack of teaching preparation, inaccurate teaching methods, and lack of teacher attitudes resulting in a lack of relationship with students.

Teaching methods that only emphasize one aspect of thinking can also lead to misconceptions, especially on fluid learning material. There are many steps or ways that can be used by students to solve fluid-related problems.

Students, in online learning, produced less misconceptions because they utilized many learning media, such as Google and others. Through the media, students understand better and look for ways to understand the material so that when the researchers asked questions using Google Form, they looked for solutions correctly using the media they had.

Based on the results of research in class X TJTL of SMK BLK Bandar Lampung, 11 students knew the concept with an average score of 40.74% in the moderate category, 8 students who did not know the concept with an average score of 29.62% in the low category, and 8 students with misconceptions with an average score of 29.62% in the low category.

4. Conclusion

Students, in online learning, produced fewer misconceptions because they utilized many learning media, such as Google and others. Through the media, students understand better and look for ways to understand the material so that when the researchers asked questions using Google Form, they looked for solutions correctly using the media they had. The research was conducted on 27 students of class X TJTL 0f SMK BLK Bandar Lampung. Students worked on a four-tier diagnostic test on fluid material which consisted of 20 items. Based on the results of the research, 11 students knew the concept with an average score of 40.74% in the moderate category, 8 students who did not know the concept with an average score of 29.62% in the low category, and 8 students with misconceptions with an average score of 29.62% in the low category.

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