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Cognitive Conflict Strategy and Simulation Practicum to Overcome Student Misconception on Light Topics

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ABSTRACT

One way to reduce misconceptions can be overcome by cognitive conflict learning strategies with the help of simulation practicum instead of actual practicum. This study aims to determine whether there are differences in students' misconceptions before and after learning with cognitive conflict strategies as an effort to reduce misconceptions on light material. Research sample of 31 students. Data on the degree of misconception before the study was 0,36 and after doing research was 0.17. The t-paired test results for the mean percentage of students' misconceptions on light material before and after learning differed at a significance level of 0.05. While, the results of N-Gain calculations to student achievement increase in overcoming misconceptions on light material were 0.3, that means the average students' achievement in dealing with misconceptions are in the medium category and cognitive conflict strategies combined with simulation practicum have a strong effect on reducing students' misconceptions on light material with a range of 2.91. Based on the results of the study it can be concluded that cognitive conflict strategies combined with simulation practicum can be used to reduce misconceptions that lead to increased student learning achievement. Further research is needed to explore students' misconceptions on other physics topics and can measure student misconceptions at each meeting so that students are more organized and developed in learning.

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1. INTRODUCTION

Education is one important aspect that supports the progress of a country. Quality education will produce quality human resources [1]. Physical learning in high school is usually only presented in abstract concepts and difficult to understand. Students tend to modify the physics formula according to the questions that the teacher presents to solve physical problems [2], [3]. As a result, students do not understand the whole concept of physics learning. Learning that is still abstract presents the concept of physics in the form of mathematics. As a result, students do not understand the concept of physics and can represent a concept with multi-representation well [4].

In fact, learning in school has a close relationship with what students know before. It must be kept in mind that there are two phases of concept change in the learning process, namely, assimilation and accommodation. An assimilation process that supports the student's learning process occurs when a student's experience or scheme has a match with the new concept he learned at school. However, if a student experiences a mismatch of new concepts or knowledge with what has been known beforehand then he must

accommodate that knowledge in his memory [5]. Students attend classes are generally not with empty heads, but they have brought a number of experiences or ideas that are preformed when they interact with their environment [6]. The ideas or ideas that students have before accepting a lesson are called preconceptions [7]. Students' conceptions sometimes has a conflict with new information or expert opinions. This is what is called misconception [8]. Misconception is a situation in which what is understood or believed is different from what experts say [9]. When a person experiences misconceptions or incompatibility between new information and an understanding that has been built before, the person will experience cognitive conflict. The concept that has been believed by students is contrary to the scientific concept, so that cognitive conflict will occur [10]. One of the strategies needed to overcome students' misconceptions is cognitive conflict strategies [11].

Learning with cognitive conflict strategies confronts students with situations that are conflicting or different from their initial knowledge. It is intended that students can improve the concepts that have been in their minds with the correct new concepts and students can reorganize cognitive structures so that there is a shift in misconceptions that are wrong towards the correct concept [12], [13]. The purpose of cognitive conflict strategy is as a bridge to change students' conceptual physics [5].

The results of previous studies found that the average student learning outcomes in the experimental class before the study was 35.05 while after the study was obtained the average learning outcomes were 62.78. The results of the analysis of the average degree of misconception prior to the study were quite high while after the research was carried out the average misconception was reduced [6]. The effectiveness of cognitive conflict strategies in changing students' misconceptions shows that cognitive conflict strategies are more effective than conventional strategies in learning the concepts of energy, effort and friction. Thus, cognitive conflict learning strategies have the effect of reducing misconceptions [14]

Nevertheless, cognitive conflict learning strategies that create contradictory situations through demonstrations or practicums are often difficult to implement because of the difficulty in obtaining the tools and materials used in the practicum. This certainly applies to light material, which in fact contains some abstract phenomena that are difficult to do through real practice. Therefore, the practicum in this research process is carried out in two ways, namely through practicum directly and through practicum simulation using a computer. Practicum through simulation also acts as a medium to strengthen students' correct conception of light material. Based on the description stated that, the purpose of this study is to describe the benefits of cognitive conflict and practical simulation to reduce students' physics misconceptions on the topic of light.

2. RESEARCH METHOD

a. Type of Research

This study used a Mixed Method research design of Embedded Experimental Design type [15]. Data collection in this study uses quantitative data and qualitative data as its support.

b. Variables, Populations, and Samples

There are two important variables in this study. The first variable is the cognitive conflict learning strategy combined with the simulation practicum as dependent variable. The second variable is misconception as an independent variable. The study was conducted at a junior high school in Singosari, Indonesia. Sampling used was purposive sampling. This is because the characteristics of students who are subject to research are very diverse (heterogeneous) because of class division based on value. In addition, the experimental class is a class recommended by the class teacher with several considerations. The sample used is one class with a total of 31 students.

c. Instruments and Procedures

Data in this study were collected through test and non-test instruments, which means both quantitative and qualitative. Quantitative data is collected through pretest and posttest. Qualitative data is collected through observation and interviews of the results of the initial and final tests.

d. Data Analysis

Data analysis techniques in this study used two methods, quantitative and qualitative. Qualitative method analysis is carried out using purposive sampling based on the stages. Quantitative data analysis is used to see changes in the level of misconception before and after being treated. The data will be analyzed and tested hypothesically by paired T-test. To simplify data calculation and analysis, the SPSS 16.0 for Windows application will be used. However, before testing the hypothesis, the research data must meet the requirements of the analysis, namely testing the normality of the data. The next step is the calculation of N-

gain and Effect Size. The N-Gain calculation is done to find out how much the student's misconception decreases in light material after learning. Calculation of Effect Size is used to find out how much influence of cognitive conflict strategies use that is combined with simulation practicum as a treatment in learning

3. RESULTS AND ANALYSIS

This study aims to overcome students' misconceptions on light material through learning with cognitive conflict strategies, so that the learning process is carried out based on the cognitive conflict learning steps. The average understanding percentage of 31 students at pretest and posttest can be seen in Table 1.

Table 1. The Average Percentage of Student Understanding

Degree of understanding	Average	
	Pretest	Postest
PK	0.32	0.72
M	0.36	0.17
TP	0.32	0.10

The following is explained the results of students' misconceptions each item before and after treatment.

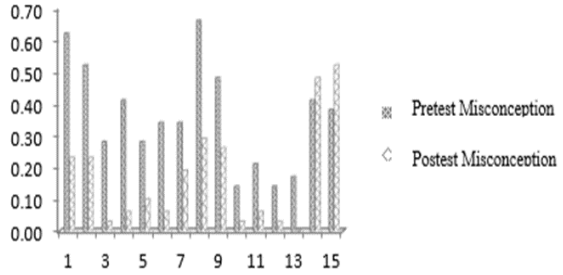


Figure 1. Comparison of Misconceptions in each Question Item

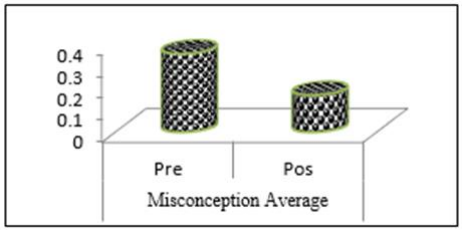


Figure 2. Comparison of the Average Percentage of Students' Misconceptions in Each Question Item

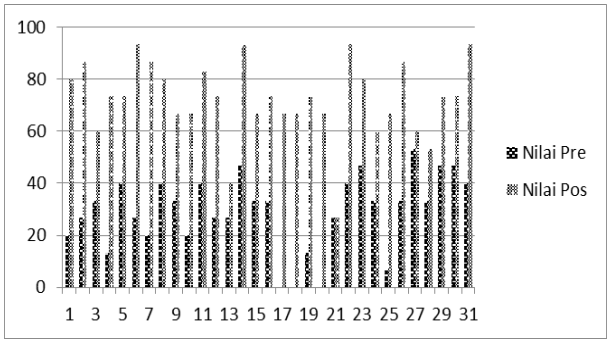


Figure 3. Comparison of Student Academic Achievements

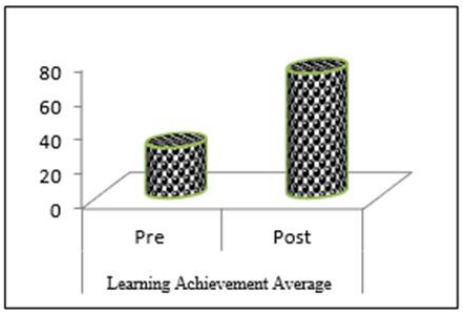


Figure 4. Comparison of Average Student Learning Achievement

Based on Figure 1, the grade of students' misconceptions at post-test was reduced from the degree of misconception at the time of the pretest on items Number 1, 2, 3, 4, 5, 6, 7,8, 9, 10, 11, 12, and 13. Nevertheless, there were two items, which actually experienced an increase in misconceptions after the post-test. The reason of this can happen is described in the discussion chapter. Data on test results are then

averaged. The average results of students' misconceptions before and after learning are illustrated by the following histogram.

Based on Figure 2, the average percentage comparison of students' misconceptions on each item decreased from 0.36 when the initial test to 0.17 in the final test. Student learning achievement before and after learning is shown in Figure 3.

Based on Figure 3, the academic achievement of several students before and after being given permission has increased. The 17^{th},18^{th} and 20^{th} students who did not take the initial test to compare their learning achievement with the final test. For the 21st student, it was found that there was no increase in learning achievement. Furthermore, the data of the pretest and posttest results are averaged. The average results can be shown in Figure 4.

Based on Figure 4, the average student achievement has increased from 29.3 at pretest to 72.11 at posttest.

The following is the presentation of the results of the pretest and posttest tests and interviews consisting of 15 two-level multiple-choice questions (Two Tier Multiple Choice) or often called multiple-choice reasoned closed.

1. The following objects that are not sources of light are..
   a. Sun
   b. Fireflies
   c. Month
   d. Star

The reason for my answer is that objects are said to be sources of light if. . .

   a. The object has its own light
   b. The object receives light from other objects
   c. The object emits light obtained from other objects
   d. The object is classified as a dark object.

The understood students answered the moon are not sources of light due to reflecting the light obtained from the sun. Some students experienced misconceptions in this matter. Students assumed that fireflies are not a source of light because they do not appear during the day. Some assumed that stars and fireflies have a small light source compared to the sun and moon. Thus, they assumed that the moon is a source of light.

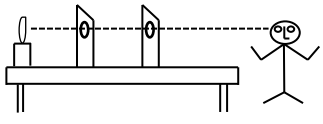
2. Below which is the nature of light, except ...
   a. Light is a transverse wave
   b. Light travels straight
   c. Light can be reflected
   d. Light requires a medium in its propagation

The reason for my answer is because:

   a. Light is not a transverse wave but a mechanical wave
   b. Light can propagate in a winding path (not straight)
   c. Light is a transverse wave so it can propagate in a vacuum, in other words light can propagate without a medium
   d. Light cannot be reflected when it comes to clear objects

The understood students answered light are transverse waves that are classified as electromagnetic waves so they can propagate without a medium. Some students who experienced misconceptions in this problem assumed that light is not a transverse wave but a mechanical wave. Some students answered that light can propagate on a winding path (not straight). The group of students who did not understand explained they did not know what was meant by transverse waves and mechanical waves.

3. The picture on the side shows a child who sees a candle light through the hole in each carton that is not translucent. Why do you think the child can see the candle light?
   a. The cartons have holes
   b. The position of the holes in each carton is parallel to each other
   c. The cardboard position is parallel to each other
   d. Bright candle light



The reason for my answer was due

a. The cartons are aligned so that if the holes in each carton are not aligned, the child can see the candle light.
b. Light propagates through the holes in each carton in a parallel position.
c. There is a hole in each carton so that even though the position of the hole is not parallel to each other, the child can see the candle light.
d. The presence of bright candlelight can make the child's eyes directly capture the candle light through the carton even though each carton is not perforated

The understood students answered that light travels straight through the position of a hole parallel to each other. It causes the child see the light of the candle and if one of the cartons is shifted or if the position of the carton is parallel to each other but the hole where the light passes is not parallel to each other, the child cannot see the candle light. Some students experienced misconceptions in this matter. Students assumed that even though the holes in each carton are not parallel to each other, the child could still see the candle light.

4. We can see things around us because of ...
   a. Light
   b. Color of objects
   c. Eyes
   d. Shadow

The reason for my answer is because:
   a. Our eyes emit light so we can see these objects.
   b. These objects reflect the light that befell them into our eyes.
   c. Objects have bright colors that can be seen by the eyes.
   d. Shadows of objects produce objects themselves

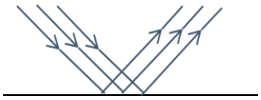
The understood students answered that we can see things around us because there was light. They reasoned that things reflect light that is abundant in our eyes so that even though our eyes are in good condition without light, like in a dark room, we cannot see. Students who experienced misconceptions assumed we can see things around us because of the eyes. Some answered that there is light coming out of our eyes so we can see these objects. Some students even said without eyes, we cannot see. This is indeed true; it is just that despite having eyes, we will not be able to see without light.

5. Reflection that occurs on a flat surface, called ...
   a. Irregular Reflection
   b. Regular reflection
   c. Perfect Reflection
   d. Less Perfect Reflection

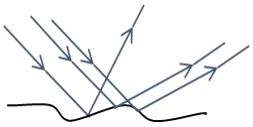
The reason for my answer was due
   a. Irregular reflection occurs on a flat surface causing light reflected to all direction.
   b. Regular reflection occurs on a flat surface causing light reflected to one direction.
   c. Perfect reflection occurs on rough (irregular) surfaces, which result in perfect reflected light.
   d. Reflection is less than perfect due to the presence of light on the flat surface.

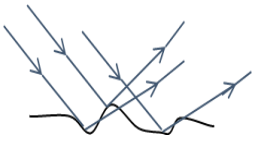
The understood students explained that reflecting on a flat surface and reflected in one direction is called regular reflection. The students who experienced misconceptions explained that reflection occured on a flat surface and reflected to all direction is called irregular reflection, while students who did not understand the concept tend to answer carelessly.

6. Pay attention to the following reflection image.

1) 

2) 

3) 

4) 

Irregular reflection is shown in the figure number. . .

a. 1) and 3) b. 2) and 3)
c. 3) and 4) d. 1) and 2)

The reason for my answer is because:

a. Irregular reflection occurs on a flat surface causing light reflected to all direction.
b. Irregular reflection occurs on a flat surface causing light reflected to one direction.
c. Irregular reflection occurs on uneven surfaces causing light reflected to all directions.
d. Irregular reflection occurs on flat surfaces and rough (irregular) surfaces cause light not only reflected to one direction but also reflected to all directions.

The understood students explained that diffuse reflection occurs on uneven surfaces resulting reflected light to all directions. Students who experienced misconceptions explained that irregular reflection occurs on a flat surface causes reflected to one direction, while others answered irregular reflection occured on a flat surface and an uneven surface causes light not only reflected to one direction but also to all directions. Students who did not understand explained irregular reflection occured on a flat surface causing light reflected to all direction or vice versa.

7. A light comes at an angle of 30^o to the mirror surface. The reflection angle is ...
   a. -30^o b. 30^o
   c. 60^o d. -60^o

The reason for my answer is because:

a. The angle of arrival (i) = the magnitude of the angle of reflection, the magnitude of the angle of reflection is 30o
b. The size of the incoming light forms an angle of 30o to the mirror surface, so i = 90o - 30o so that i = 60o because the angle of arrival (i) = the angle of reflection (r) then the angle of reflection is 60o
c. The size of the incoming light forms an angle of 30o to the mirror surface, so i = 30o - 90o so that i = -60o because the angle of arrival (i) = the angle of reflection (r) then the angle of reflection is -60o
d. The angle of arrival (i) = - the angle of reflection, then the magnitude of the angle of reflection is -30o

The understood students explained that the angle formed is 60^o because the incoming light forms an angle of 30^o to the mirror surface not to the normal line. Students who experienced misconceptions explained that the angle formed is 30^o because the magnitude of the angle of arrival = the magnitude of the angle of reflection. Some students who experienced misconceptions also explain the angle of arrival = - angle of reflection. Students who did not understand the concept tend to answer without relating the choice of answers and the reasons for choosing those choices.

8. How high is your shadow on your height in a flat mirror if your distance is farther from the mirror?
   a. Same with your height.
   b. Different from your height.
   c. Half of your height.
   d. Change depending on your distance to the mirror.

The reason for my answer is that it corresponds to the nature of the shadow on the flat mirror then:

a. Shadow height = object height
b. Shadow height ½ height of object
c. The height of the shadow always changes depending on the distance of the object to the mirror
d. Shadow height is not the same as object height

The understood students explained that the height of the shadow on a flat mirror is always equal to the height of the object. Students who experienced misconceptions explained that the height of the shadow on objects in a flat mirror always changes depending on the distance of the object to the mirror. The farther the distance of the object to the flat mirror, the image produced by the mirror is smaller than the size of the object. Some students who experienced misconceptions also explained that the shadow formed on a flat mirror is half the size of the object.

9. A 1 cm tall object in front of a concave mirror with a focus of 2 cm. If the object is at a distance of 4 cm in front of the mirror, what is the distance of the shadow and how the shadow's characteristics are. .
   a. -4 cm; virtual and upright

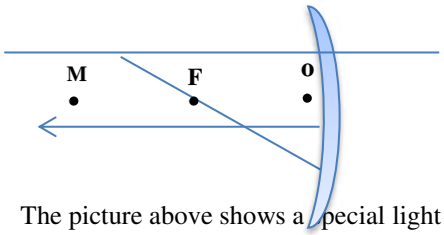
b. 4 cm; real and reversed
c. -4 cm; real and upright
d. 4 cm; real and upright

The reason for my answer was due to

a. Shadow is worth (+) then the shadow will be real & upright.
b. Shadow is worth (+) then the shadow will be real & reversed.
c. Shadow is worth (-) then the shadow will be virtual & upright.
d. Shadow is worth (-) then the shadow will be real & upright.

The understood students explained that the shadow distance is 4 cm. The sign (+) shows a real shadow and reverses in other words the real shadow is always reversed. Students who experienced misconceptions explained that the shadow distance is 4 cm. The sign (+) shows a real and upright shadow.

10.



The picture above shows a special light to ... on a concave mirror.

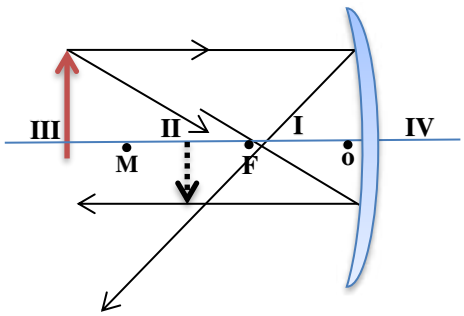
a. 1 b. 2
c. 3 d. 4

The reason for my answer was because the special light painted on the picture stated:

a. The light comes through the focal point and is reflected parallel to the main axis
b. Light comes parallel to the main axis and are reflected through the focal point
c. Light comes through the center of the curvature and are reflected through that point as well
d. Light comes through the center of the curvature reflected as if coming from a focal point

The understood students answered the special light of the concave mirror painted are the 2nd special light that comes through the focal point and is reflected parallel to the main axis. Students who experienced misconceptions assumed that the light that is painted is the 1st light through the focal point and is reflected parallel to the main axis. Students who did not understand answered the lights are the 1st or 2nd light but give reasons that were not according to their choice

11.



Based on the light painting on the concave mirror above, the shape of the shadow formed is ...

a. Real, reversed, enlarged
b. Real, reversed, reduced
c. Real, reversed, equal
d. Real, upright, enlarged

The reason for my answer is because:

a. If the object is in room III and the shadow is in room II then the nature of the shadow is real, reversed, and reduced.
b. If the object is in room II and the shadow in room III, the nature of the shadow is real, reversed and enlarged.
c. If the object is at the point M and the shadow is at point M, the nature of the shadow is Real, inverse, and equal.
d. If objects are in room 1 and shadows in room IV, the shadow properties are virtual, upright and enlarged.

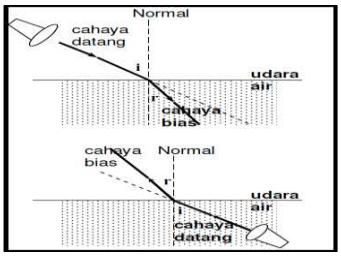
The understood students explained that the nature of the shadow formed was real, reversed and minimized. They paid close attention that the position of the object is in room III and the position of the shadow in room II. Students who experienced misconceptions explained the position of objects at point M and the position of the shadow is also located at point M so that the resulting shadow was real, reversed and equal. Students, who did not understand, tend to answer carelessly and do not know exactly which are called objects and which are called shadows based on images.

12. An object is at a distance of 5 cm in front of a convex mirror with a focus of 5 cm. What is the distance of the shadow and how are the shadow's characteristics. .
    a. 2,5 cm ; Real, upright
    b. -2,5 cm ; Maya, reversed
    c. 2,5 cm ; Real, reversed
    d. -2,5 cm ; Maya, upright

The reason for my answer is because:

    a. Because S '(-) the shadow is virtual and upright
    b. Because of S '(-) the shadow is virtual and reversed
    c. Because of S '(+) the shadow is real and reversed
    d. Because S '(-) the shadow is real and upright

The understood students explained that the shadow distance is as long as -2.5 cm behind the mirror so that the shadow formed is virtual and upright. Negative signs also show that the resulting shadow is virtual and upright. Some students forgot that focusing on convex mirrors negatively results in errors in obtaining calculation results. Students who do not understand the concept tend to answer questions without regard to the relationship between choices and reasons for their choices.

13. 

The light phenomenon described by the picture above is. . .

    a. Reflection of light
    b. Refraction of light
    c. Irregular reflection
    d. Regular reflection

The reason for my answer is because the image states:

    a. Angle of arrival = Angle of reflection
    b. The light coming from the less dense medium to the more tightly medium refracted to approach the normal line. Conversely, the light coming from the denser medium leads to a less dense medium refracted to move away from the normal line
    c. The incoming light will be reflected to all direction
    d. The incoming light will be reflected to one direction.

The understood students explained that the image is a representation of refraction or deflection of light due to differences in density from air and water. The group of students who experienced misconceptions assumed that the picture depicted the reflection of light with a large angle of light = the magnitude of the reflected light angle. Some even replied that the picture depicted a regular reflection phenomenon that was passed in one direction.

14. An object that is 2 cm tall stands 6 cm in front of a convex lens with a 4 cm focal distance. where is the shadow. . .
    a. 12 cm in front of the lens
    b. 12 cm behind the lens

c. 12 cm in the middle of the lens
d. 12 cm behind the lens

The reason for my answer is because:

a. A shadow (+) location indicates the shadow is in front of the lens.
b. A valuable (-) shadow location shows the shadow behind the lens
c. A valuable (+) shadow location shows the shadow behind the lens
d. A valuable (-) shadow location indicates that the object is in front of the lens.

The understood students explained that the shadow is located 12 cm behind the lens, while students who experienced misconceptions explained that the shadow is 12 cm in front of the lens. Most students experienced misconceptions about the sign agreement that applies to the lens. This was evidenced by their opinion regarding the sign (+) for objects in front of the lens and the sign (-) for objects behind the lens. They tend to equate the (+) and (-) marked on the lens with the (+) and (-) marks on the number line as they had known.

15. A concave lens has a focal length of 6 cm. If an object is placed 3 cm in front of the lens, where is the shadow. . .
    a. 6 cm behind the lens
    b. 2 cm in front of the lens
    c. -6 cm behind the lens
    d. -2 cm in front of the lens

    The reason for my answer is because:

    a. Because the shadow distance is worth (+) indicating the shadow is located in front of the lens
    b. Because the shadow distance is worth (-), the shadow is located behind the lens
    c. Because the shadow distance is worth (+) indicating the shadow is located behind the lens
    d. Because the shadow distance is worth (-), the shadow is located in front of the lens

The understood students who understand the answer to the shadow lie at -2 cm in front of the lens because of the distance of the shadow (-). Conversely, the same as the case with no. 14, most students experienced misconceptions about sign agreements that apply to the lens. This was evidenced by their opinion regarding the sign (+) for objects in front of the lens and the sign (-) for objects behind the lens. They tend to equate the (+) and (-) marks on the lens with the (+) and (-) marks on the number line as they had known. Groups of students who do not understand the concept answered without considering the choice of answer relationship and the reason for choosing the answer.

The results of the study prove that cognitive conflict learning strategies combined with simulation practicum have an effect on reducing students' misconceptions. This is supported by the average percentage of students' misconceptions per item after learning. Based on these averages, student misconceptions were reduced from 0.36 during the initial test to 0.17 at the end of the test and had a significant difference based on statistical tests. The above findings are in accordance with the research conducted by Kristianti (2011) who found that the average degree of misconception before the research was 46.68% while after the research was carried out the average misconception was 23.15%. This means that there is an average decrease in the level of students' misconceptions after being given learning by cognitive conflict strategies. Previous research results also found a decrease in students' misconceptions after learning with cognitive conflict strategies on straight motion material. Another thing revealed that cognitive conflict learning strategies can lead to conceptual changes in students and also found that cognitive conflict learning strategies can lead to conceptual changes in students [16], [17], [18].

Cognitive conflict strategy can reduce student misconception because this strategy is a conceptual change strategy that allows it to destabilize students' misconceptions towards scientific concepts and scientific conceptions that students have will lead to learning achievement through the provision of counter-examples, analogy, demonstrations and experiments [19]. This is also supported through several advantages possessed by this strategy, including paying attention to the wrong conception of students, paying attention to the relationships between concepts, actively engaging students, helping students in understanding a concept and embedding new concepts correctly or long-lasting [10].

The results of this study also found that students' misconceptions on items 14, 15 were apparently increased. This was due to the limited time of the study that make the learning process not optimal. The last material contained in items 14 and 15 could be explained and did not undergo the steps of learning cognitive conflict perfectly, which resulted in no changes in students' misconceptions towards understanding the real concept. This is in accordance with the weaknesses of learning cognitive conflict, which requires a lot of time in its implementation (Kieslich & Hilbig, 2014) [20]. The description above shows that there are differences

in students' misconceptions before and after cognitive conflict, learning that is combined with simulation practicum in line with previous studies. It is just that, in practice, learning with this strategy needs to be adjusted between the number of submissions in the lesson and the amount of time needed in the lesson.

4. CONCLUSION

Based on the results of the study it can be concluded that cognitive conflict strategies combined with simulation practicum can be used to reduce misconceptions that lead to increased students' learning achievement. Thus, cognitive conflict strategy and simulation practicum can be recommended to reduce misconceptions and change students' conceptualities in a better direction. Further research is needed to explore students' misconceptions on other physics topics and can measure students' misconceptions at each meeting so that students are more interested in learning physics so that it is far more developed. The limitation is the study only saw students' misconceptions in the experimental class. Thus, in other studies can compare two different classes with different learning strategies or models.

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