



## Remediation of Misconceptions with Student Worksheets Based on Cognitive Conflict on Newton's Law Material

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**Abstract** – This study aims to describe the reduction in student misconceptions regarding Newton's Laws after remediation using student worksheets based on cognitive conflict. The research method used is a pre-experimental design with a One Group Pretest-Posttest format, involving 102 students from three classes at SMAN 12 Surabaya. Data collection was carried out through pretest and posttest, each consisting of five-tier format questions. Data analysis was assisted by SPSS version 25. The significance of the reduction in misconceptions was analyzed using the Wilcoxon test and the Kruskal-Wallis test, as the data were not normally distributed. The results indicated: 1) a significant improvement in understanding between the pretest and posttest, with a high categorization, and 2) all three classes showed comparable improvements in understanding. Based on these findings, it can be concluded that students experienced a significant reduction in misconceptions following remediation using student worksheets based on cognitive conflict.

**Keywords:** cognitive conflict; five tier diagnostic test; misconception; student worksheets

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### I. INTRODUCTION

Understanding concepts is crucial in learning physics because physics is an applied science that is constantly related to natural phenomena occurring in everyday life or the environment around us (Wahyuni, 2018). Students' ability to identify and interpret physics concepts is an essential prerequisite for using these concepts to draw more complex conclusions or solve physics problems (Mustari et al., 2020). When

students have an understanding of concepts that does not align with scientific concepts but are confident in their understanding, it can be said that they are experiencing misconceptions (Kaniawati et al., 2024). Misconceptions are a significant issue currently being faced in education. Therefore, it is important to assess students' levels of conceptual understanding and identify appropriate solutions to address these misconceptions (Haryono et al., 2021).

The basis for choosing Newton's Law material is because from literature studies it has been found that there are misconceptions experienced by students on Newton's Law material (Kaniawati et al., 2024). Newton's laws are one of the concepts that exist in the field of mechanics (Entino et al., 2022). The highest level of misconception experienced by students on Newton's Law material as much as 44.8% (Rosita et al., 2020). To determine the level of student misconceptions, identifying misconceptions is one of the first steps that need to be done immediately to deal with these misconceptions (Maharani et al., 2019). A five-tier diagnostic test is one of the diagnostic tests that can be used to detect the degree of misconception in more detail. The five-tier diagnostic test consists of questions, the confidence level of the answer, the reason, the confidence level of reason, and one additional open-ended question (Putri & Ermawati, 2021). The addition of one question item to the misconception diagnostic test can overcome the possibility of guesses made by students (Bayuni et al., 2018). To determine the level of student misconceptions, identifying misconceptions is one of the first steps that need to be done immediately to deal with these misconceptions (Maharani et al., 2019). Ways that can be done to detect misconceptions in these students with concept maps, interviews about concepts, and diagnostic tests (Ali, 2019). Among these three ways, diagnostic tests are a more efficient way to detect misconceptions

(Salsabila & Ermawati, 2020). A five-tier diagnostic test is one of the diagnostic tests that can be used to detect the degree of misconception in more detail. The five-tier diagnostic test consists of questions, the confidence level of the answer, the reason, the confidence level of reason, and one additional open-ended question. The addition of one question item to the misconception diagnostic test can overcome the possibility of guesses made by students (Bayuni et al., 2018).

The results of misconception identification become a reference for remediating misconceptions. Misconception remediation can be interpreted as an action or healing process for misconceptions experienced by students (Mufit et al., 2020). Remediation with a cognitive conflict approach to students requires media to facilitate the approach and can be of interest to students. One of the media to facilitate the approach of cognitive conflict to students is the student worksheets. Teaching materials that use cognitive conflict strategies allow students to develop assumptions or hypotheses, organize experiments, collect and analyze data, and make decisions or draw conclusions on their decisions (Haryono et al., 2021). In research from Sari et al. (2019) showed the results of increasing students who understood the concept to 47% from the initial test of 12.5% with the application of cognitive conflict strategies to energy and momentum matter. Research from Nurmartarina & Novita, (2021) shows a decrease in

misconceptions by 48.48% after learning with cognitive conflict strategies to remediate misconceptions in reaction rate material. There is also research from (Haryono et al., 2020) which proves that misconceptions in heat matter can be reduced from 47.8% to 30.3%. The value of student learning outcomes using student worksheets on average gets a good or higher value compared to the value of learning outcomes not using student worksheets (Annafi et al., 2015).

Before the implementation of the study, an initial test was carried out to determine the level of student misconceptions. The initial test was conducted on 20 students. The initial test was carried out by giving 10 questions in the format of a two-tier test. Preliminary test results showed 60.21% of students experienced misconceptions caused by personal thoughts. The highest misconception occurs in question point number 5 at 75%. The concept of question number 5 is the application of Newton's Law III with regard to the action-reaction force that occurs in the event of pushing a nail with a hammer.

Research is also supported based on the results of an interview with one of the students from each class who stated that the material from the diagnostic test instrument tested there were differences from what was conveyed by the teacher such as the assumption that normal force and gravity are pairs of reaction action forces. In the delivery of Newton's Law material, students are immediately given formulas and practice

questions that are very easy so that it is difficult for students to solve problems on Newton's Law material.

Based on previous research, no one has focused on remediation with student worksheets based on cognitive conflict on Newton's Law material. Therefore, the novelty of this study is to describe the level of student conception from the results of a five-tier diagnostic test and describe the decrease in student misconceptions after remediation using student worksheets based on cognitive conflict. Related to this, the formulation of the problem proposed in this study is (1) what is the level of student conception after remediation with student worksheets based on cognitive conflict? (2) Is there a significant difference in conception improvement between the three classes?

## II. METHODS

The type of research used is exploratory descriptive quantitative research. The research used is pre-experimental, and applies a design design type one group pretest-posttest. The treatment in this study was given to the research subjects after which the effect of the treatment was detected (Agata et al., 2019). The use of descriptive-exploratory methods in this study aims to describe and interpret misconceptions that occur in students and find the causes of these misconceptions. The design of this study is illustrated in Table 1.

**Table 1.** Research diagram

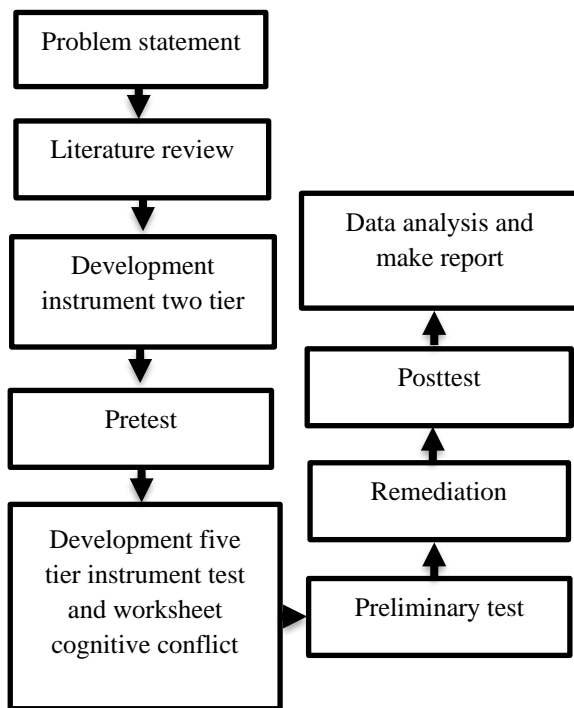
Pretest	Remediation	Posttest
O <sub>1</sub>	X	O <sub>2</sub>

**Note :**

- O<sub>1</sub> : pretest score
- O<sub>2</sub> : posttest score
- X : remediation with student worksheets based on cognitive conflict

The treatment in this study was given to the research subjects after which the effect of the treatment was detected (Yusuf et al., 2020). The research will be conducted at SMAN 12 Surabaya in May 2023. The research sample consisted of 3 classes, namely XI Science 3, XI Science 4, and XI Science 5 with the number of students in each class as many as 34 students so that the total participants were 102 students. In this study, the data collection steps carried out are listed in Figure 1.

The initial steps of this research are 1) compiling a problem formulation from the research, 2) looking for literature sources related to the research to be carried out, 3) developing two-tier format test instruments, 4) testing two-tier format test instruments on students to get a variety of answers from students, 5) developing five-tier format test instruments and student worksheets based on cognitive conflict, 6) conduct validation tests on five-tier format test instruments and cognitive conflict-based student worksheets, 7) conduct pretests with five-tier multiple-choice tests totaling 5 questions, 8) remediate with student worksheets based on cognitive conflict, 9) posttest with five-tier multiple-choice tests totaling 5 questions, 10) analyze research data, and the last step is 11) make conclusions and research reports. From the pretest and posttest results, students' conceptions are grouped based on the interpretation in Table 2.



**Figure 1.** The flowchart of data collection

**Table 2.** Student conception level on five-tier diagnostic test (Anam et al., 2019).

No	One-Tier	Two-Tier	Three-Tier	Four-Tier	Five-Tier	Conception Level	
					SD/SC	SC	
1	C	S	C	S	PD/PC MD/MC UD/UC	ASC LK	
2	C	S	C	NS	ND/NC	UnC	
3	C	NS	C	S	PD/PC/ MD/MC/ UD/UC/ ND/NC		
4	C	NS	C	NS			
5	C	S	W	NS			
6	C	S	W	S			
7	C	NS	W	S			
8	C	NS	W	NS			
9	W	S	C	S		LK	
10	W	S	C	NS			
11	W	NS	C	S			
12	W	NS	C	NS			
13	W	S	W	NS	PD/PC/	NU	
14	W	NS	W	S	MD/MC/		
15	W	NS	W	NS	UD/UC/ ND/NC		
16	W	S	W	S	MD/MC	MSC	
17	When there is a “tier” that is not answered by students or they answered more than one option						UnC

**Note :**

- |              |                                       |              |                                   |
|--------------|---------------------------------------|--------------|-----------------------------------|
| <i>C</i>     | : Correct                             | <i>UD/UC</i> | : Undefined<br>Drawing/Conclusion |
| <i>W</i>     | : Wrong                               | <i>ND/NC</i> | : No Drawing/Conclusion           |
| <i>S</i>     | : Sure                                | <i>SC</i>    | : Scientific Conception           |
| <i>NS</i>    | : Not Sure                            | <i>ASC</i>   | : Almost Scientific Conception    |
| <i>SD/SC</i> | : Scientific<br>Drawing/Conclusion    | <i>UnC</i>   | : Un-Code                         |
| <i>PD/PC</i> | : Partial Drawing/Conclusion          | <i>LK</i>    | : Lack of Knowledge               |
| <i>MD/MC</i> | : Misconception<br>Drawing/Conclusion | <i>NU</i>    | : No Understand a Concept         |
|              |                                       | <i>MSC</i>   | : Misconception                   |

Data analysis technique using SPSS Version 25. The first analysis performed was the normality test and homogeneity of pretest and posttest scores. The normality test uses the Kolmogorov Smirnov test and the Levene Statistics homogeneity test. Kolmogorov Smirnov's normality test was chosen because

the number of study samples was more than 100. If the significant value of the normality test is greater than the value of 0.05, the data from the study will be declared to be normally distributed (Kohar et al., 2017). If the data from the study are not normally distributed, then the next step will be

continued through the Wilcoxon Test. The basis for decision making in the Wilcoxon test is if the value of Asymp. Sig. (2- tailed) is smaller than 0.05 the hypothesis will be accepted and if the value of Asymp. Sig. (2-tailed) is greater than 0.05, the hypothesis will be rejected (Agata et al., 2019).

The next analysis technique is data processing using N-Gain scores from each student in each class that has been averaged, then classified based on Hake analysis (Wahyuni, 2018). If the data obtained is not normally distributed, it will be further tested using the Kruskal Wallis test. Wallis' Kruskal test is a rank-based nonparametric test whose purpose is to determine whether there is a statistically significant difference between two or more groups of independent variables on the dependent variable on numerical data scales (intervals or ratios) and ordinal scales (Priyatno, 2013). The basis for making decisions of the Kruskal Wallis test by comparing sig values. against probability

0.05. If the value of sig. > 0.05 then  $H_0$  is accepted while  $H_a$  is rejected but if the value of sig. < 0.05 then  $H_0$  is rejected while  $H_a$  is accepted (Assegaf et al., 2019). In this study,  $H_0$  is that there is no difference in student learning outcomes in the three classes while  $H_a$  is that there are differences in student learning outcomes in the three classes.

### III. RESULTS AND DISCUSSION

The initial conception level of learners before being given remediation treatment is obtained through the pretest. The results of the combination of answers to each question item in each student will be grouped into misconception, lack of knowledge, no understand a concept, almost scientific conception, and scientific conception. The following is a percentage diagram showing students' answers to the level of conception in each question item on the pretest listed in Figure 2.

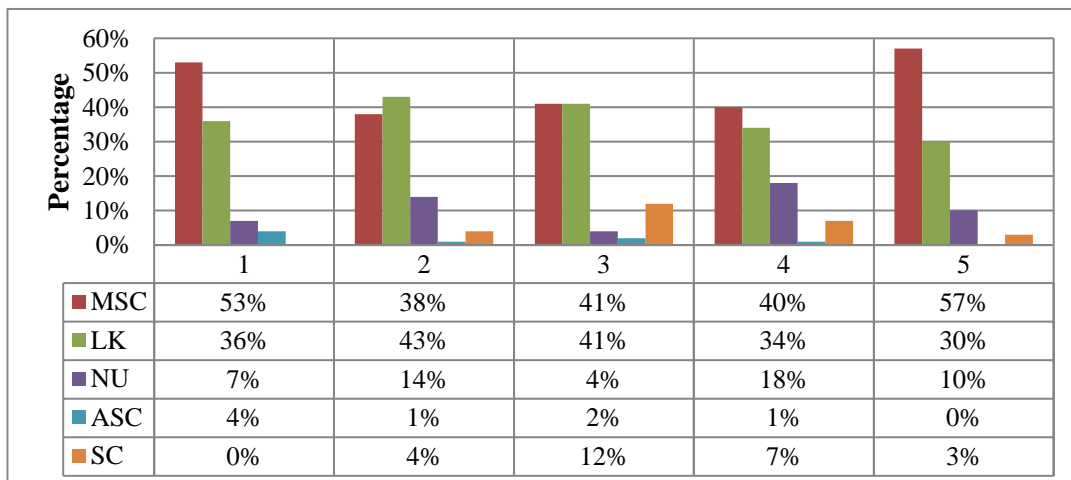


Figure 2. Conception of students on the pretest

Based on Figure 1 shows that the highest misconception occurs in question number 5 with a misconception rate of 57%. In question number 5, an illustration is presented between a nail and a hammer, then students are asked to analyze the magnitude of the action-reaction force acting on the two objects. Students assume that the magnitude of the force of the hammer is always greater than the nail because of the larger size of the hammer. The exact concept according to Newton's Law III is that the magnitude of the action-reaction force exerted by two objects is equal and is not affected by the size of the object.

Next is question point number 2 with a misconception rate of 53%. In question number 2, students are asked to analyze the relationship between maximum static friction, frictional force, and thrust on objects that remain stationary even though they have been pushed. Students consider the frictional force to be equal to the maximum static friction force. The correct concept according to Newton's Law I in the event is that the magnitude of the thrust and the frictional force are equal while the thrust is less than the maximum static friction force so that the object remains stationary even though it has been pushed.

At the third level, misconceptions occur in question number 3 with a misconception rate of 41%. Two events are presented pushing a cart with the same thrust but the mass on both carts is different.

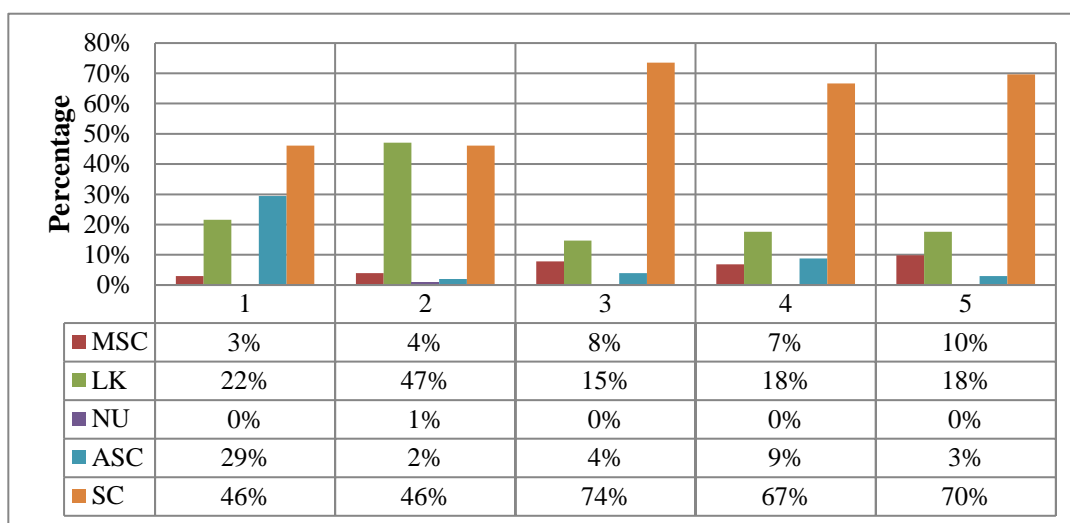
Students are asked to determine the acceleration of both events. Students assume an empty cart has no mass. In addition, students assume the acceleration in the two carts is equally large because the thrust that works is equally large. Concept number 3 relates to Newton's Second Law which states that the magnitude of acceleration is equal to the quotient between force and mass.

The fourth order is question number 4 with a misconception rate of 40%. In question number 4 is presented a diagram of the force acting on two objects. Students are asked to determine the action-reaction force pairs contained in the force diagram. Most students assume the normal force and the force of gravity acting on an object are a pair of action-reaction forces because their directions are opposite. The correct concept according to Newton's Law III is that the pair of action-reaction forces must meet several conditions including having the same magnitude of force, opposite directions of force, acting on two different objects, and working at the same capture point. However, normal force and gravity do not act at the same capture point and act on the same object so these two forces are not an action-reaction force pair.

The lowest order of misconceptions occurred in question number 2 with a misconception rate of 38%. In question number 2, three events are presented that have been accompanied by a relationship between maximum static friction force and thrust. Students were asked to analyze which events

caused the object to remain stationary despite being pushed. The correct concept is that an object will remain stationary when the amount of thrust is equal to or less than the maximum static frictional force, and the object will move when the applied thrust is greater than its maximum static frictional force. After analyzing the students'

conception with the pretest, the next step is to remediate with cognitive conflict-based student worksheets. In order to find out the level of student conception after remediation, students are tested again with posttest questions. The conception of students during the posttest is listed in Figure 3.



**Figure 3.** Conception of students on the posttest

Based on Figure 2, it shows the results of misconceptions in number 5 which were originally 57% to 10% and the level of understanding of concepts that were originally 3% to 70%. Then misconceptions in question number 1 with a misconception rate of 53% to 3%. Furthermore, in question number 3 with a misconception rate of 41% decreased to 8%. In question number 4 with a misconception of 40% to 7%. Finally, on question number 2, which was originally

38% to 4%. These results show the effect of remediation with student worksheets based on cognitive conflict to reduce the level of misconceptions and increase the percentage of understanding concepts.

The next step is to conduct statistical tests to prove the rate of decline in misconceptions. First, conduct normality and homogeneity tests on pretest and posttest scores. The results of the normality and homogeneity test are shown in Table 3.



**Table 3.** Normality & homogeneity test

Class	Test	Normality Test (Kolmogorov-Smirnov)	Homogeneity Test ( <i>Levene</i> <i>Statistic</i> )
		Sig.	Sig.
XI Science 3	<i>Pretest</i>	.001	.000
	<i>Posttest</i>	.000	
XI Science 4	<i>Pretest</i>	.022	
	<i>Posttest</i>	.000	
XI Science 5	<i>Pretest</i>	.003	
	<i>Posttest</i>	.005	

The test results show that the data is not normally distributed and is not homogeneous because the value of sig.< 0.05 so as to analyze the data using a non-parametric test, namely the Wilcoxon test. Wilcoxon's test results are shown in Table 4.

**Table 4.** Wilcoxon test results

Class	Rank	N	Mean Rank	Asymp Sig. (2-tailed)
XI Science 3	<i>Negative Ranks</i>	0	0,00	0,000
	<i>Positive Ranks</i>	34	17,50	
XI Science 4	<i>Negative Ranks</i>	0	0,00	0,000
	<i>Positive Ranks</i>	34	17,50	
XI Science 5	<i>Negative Ranks</i>	0	0,00	0,000
	<i>Positive Ranks</i>	34	17,50	

Based on Table 4, showing that the negative ranks of the pretest and posttest values in all classes are 0, this result shows no decrease from pretest to posttest values after remediation. The positive ranks of the pretest and posttest scores in each class contained 34 positive data (N) with a mean obtained of 17.50, meaning that all students in each class experienced improved learning outcomes and decreased misconceptions after remediation with student worksheets based on cognitive conflict. The value of Asymp Sig. (2-tailed) < 0.05, this means that the hypothesis is accepted that there is a significant increase in conception between before and after being remediated with Worksheet based on cognitive conflict in Newton's Law material.

The next step is to perform N-Gain tests on all three classes. The results of the N-Gain test in all three classes are categorized according to Hake's analysis.

**Table 5.** N-Gain test results

Class	N-Gain Score	Category
XI Science 3	0.74	High
XI Science 4	0.81	High
XI Science 5	0.75	High

The results of the N-Gain test in all three classes showed a high category. This shows

the effect of increasing conception after remediation. The next step is to perform a normality test and an N-Gain score homogeneity test. The results of the normality and homogeneity test against the N-Gain score are listed in Table 6.

**Table 6.** N-Gain normality and homogeneity test results

Class	Normality of N-Gain (Kolmogorov-Smirnov)	Homogeneity of N-Gain (Levene Statistic)
XI Science 3	.017	.394
XI Science 4	.012	
XI Science 5	.000	

Based on Table 6, the normality test results on the N-Gain score are not normally distributed but homogeneous. Therefore, the next test is a non-parametric test with the Kruskal Wallis test. The Kruskal Wallis test was chosen because there were three samples to be tested. The results of the Kruskal Wallis test are shown in Table 7.

**Table 7.** Kruskal Wallis test results

Class	N	Mean Rank	Asymp Sig. (2-tailed)
XI Science 3	34	48.09	.701
XI Science 4	34	53.28	
XI Science 5	34	53.13	

The results of the Kruskal Wallis test in Table 7 show asymp sig. (2-tailed) more than 0.05. This means that  $H_0$  is accepted while  $H_a$  is rejected. These results showed no difference in student learning outcomes in the three classes because the results of the three classes improved overall.

The overall results of this study are relevant to research conducted by [Nurmartarina & Novita, \(2021\)](#) the study showed a 48.48% reduction in misconceptions after learning cognitive conflict strategies to remediate misconceptions on reaction rate material. This is also in accordance with research from [Nana, \(2018\)](#) which showed a decrease in misconceptions by 22.2% and 25.2% in each class after remediating misconceptions with a cognitive conflict approach to temperature and heat matter. As well as research from [Haryono et al. \(2020\)](#) which showed the decrease misconceptionis 37,58% with the application of cognitive conflict strategies on calor and heat. Supported by the results of research that has been carried out, the results of previous research, and the theories of relevant experts, this study can prove that students experience a decrease in

misconceptions and an increase in understanding of concepts after being given misconception remediation with student worksheets based on cognitive conflict.

There are several implications in this study. With this research, students can find out the level of their ability to understand the material Newton's Laws that have been given. The results of student conception are not only an evaluation for students but also an evaluation for teachers in delivering their learning material. This research not only develops problems to determine the level of student conception but also provides solutions to student conception problems. Furthermore, although the questions developed are not about the entire material on Newton's Laws, but the questions developed from the results of this research become interesting problems and are rarely realized by teachers. Cognitive conflict student worksheets is also a new method and is still rarely used as a step to remediate misconceptions. The hope is that students can understand the concept of Newton's Law better and the teacher also understands the concept of Newton's Law correctly.

#### IV. CONCLUSION AND SUGGESTION

The results of the research obtained include: 1) Wilcoxon test results show the probability value of asymp sig. (2-tailed) all three classes  $0.000 < 0.005$ . This shows a significant increase in conception between before and after remediation, 2) Kruskal

Wallis test results asymp sig probability value. (2-tailed) all three classes  $0.701 > 0.005$ . This shows that there is no difference in learning outcomes from the three classes because all three classes have decreased misconceptions. The conclusion of this research is that remediation of misconceptions using student worksheets based on cognitive conflict can reduce students' misconceptions on Newton's Law material, characterized by a significant increase in understanding of concepts.

Suggestions for further researchers include: 1) the next researcher who conducts research with the same title is expected to be able to use cognitive conflict remediation methods in the implementation of learning and learning media, 2) to obtain accurate data related to this study, a large number of samples are needed not only two classes so that the results of the implementation can be concluded, and 3) for evaluation of the school or research subject, Then the results of the research can be discussed back to the teacher concerned.

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