ECIRR (Elicit, Confront, Identify, Resolve, Reinforce) learning model

by Yuberti Dkk 4

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ECIRR (Elicit, Confront, Identify, Resolve, Reinforce) learning model with the pictorial riddle method: is it effective in reducing physics misconceptions?

R Diani[1*], Y Yuberti[1], S Anggereni[2], G N Utami[3], A Iqbal[4] and I Kurniawati[1]

[1]Department of Physics Education, Faculty of Education and Teacher Training, Universitas Islam Negeri Raden Intan Lampung, Indonesia
[2]Department of Physics Education, Faculty of Education and Teacher Training, Universitas Islam Negeri Alauddin Makassar, Indonesia
[3]Department of Chemistry Education, Faculty of Education and Teacher Training, Universitas Lampung, Indonesia
[4]Department of Chemistry Education, Faculty of Education and Teacher Training, Universitas Islam Negeri Raden Intan Lampung, Indonesia

*rahmadiani@radenintan.ac.id

Abstract. Misconception is one of the problems that often happen in learning physics. The solution that can be offered in overcoming or reducing misconceptions is by improving the physics learning process. This study aims to determine the effectiveness of the ECIRR learning model with the pictorial riddle method for the misconceptions of grade VIII students in one of the junior high schools in Central Lampung District. The research method used is a quasi-experiment with nonequivalent control group design. The independent sample t-test showed that the decrease of the misconceptions in the experimental class was greater than that in the control class. Furthermore, the effect size value of 0.63 is obtained. It means, the ECIRR learning model with pictorial riddle method is effective in reducing misconceptions with medium categories.

Keywords: concept understanding, ECIRR learning model, flash card media, misconception, pictorial riddle method.

1. Introduction

Physics is the most fundamental science for the development of information technology, transportation and energy production [1]. Physics contains scientific concepts, laws, equations and events that often occur in the surrounding environment [2-4]. The purpose of learning physics is to deliver students to be able to understand physics' concept and be able to apply it in their everyday life [5-7].

Learning physics emphasizes more on understanding concepts than memorizing [8, 9]. Understanding concept is a basic and a very important stage in learning [10]. If there is an error in understanding the concept of physics, it will affect the continuation of the learning process of the students [11]. One of the causes of students' poor concept understanding is misconception [12, 13]. Many students find it difficult to understand the concepts of physics [14]. The main cause of difficulties is due to misconceptions [15].

The results of the pre-research at a junior high school in Central Lampung district showed that besides the low of students'concept mastery ability, many students are wrong in understanding the concept, for

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example about the concept of work. Most students assume that work depends only on force. The bigger the force given, the work will also be bigger. However, it is not the right concept, because work could be zero ifthe distance is zero (there is no displacement).

Misconception is a phenomenon where the concepts understood by students are not appropriate or different from the scientific concepts by physicists [16, 17]. Misconceptions are difficult to correct, students tend to maintain the initial concepts they understand [18, 19]. Therefore, misconception is still a frightening problem and is always present in learning, especially in basic physics concepts in science learning [20]. Factors that cause misconceptions include students themselves, the teachers, the textbook used, context, internet and also due to the way of teaching [5, 21]. Misconceptions are also due to ideas based on irrelevant experiences [22]. Misconceptions must be immediately recognized and overcome, because it can cause negative effects on student learning outcomes and interfere with the learning process further [23].

Misconceptions cannot be reduced by classical learning methods [16]. One of the lessons that can be applied to reduce misconceptions is learning with the ECIRR model. ECIRR learning model (elicit, confront, identify, resolve, reinforce) is a learning model that can reduce misconceptions properly [2]. ECIRR learning model follows understanding constructivism which will cause cognitive conflict in students in the learning process. Cognitive conflict learning can reduce misconceptions well and has a significant influence on learning outcomes [24].

One learning method that can be used and optimize the implementation of learning with ECIRR model is pictorial riddle method. The pictorial riddle method can improve students' understanding of concepts [25]. The pictorial riddle method can help in developing student activities and improving student learning outcomes [26]. The pictorial riddle method makes learning more interesting and motivates students to discuss [27].

Research on the application of the ECIRR learning model in learning has been conducted several times. ECIRR learning models used to improve students' concept understanding in kinetic gas theory are proven with significant results [28]. The application of the ECIRR learning model has also been proven to reduce misconception on redox reaction material [29]. Furthermore, the ECIRR learning model can reduce misconceptions well on chemical equilibrium material [30]. From several studies above, it is known that there has been no research on the application of ECIRR learning models to misconceptions in physics learning and there are no studies that apply the ECIRR model with the pictorial riddle method simultaneously. Thus it is necessary to conduct research on the application of the ECIRR learning model with the pictorial riddle method of the junior students' misconception in learning physics, especially on work and simple machine material. Furthermore, as a complement,in this study we used flash cards as a learning media. Flash card media can help motivate students in learning and improve learning outcomes [31]. Moreover, flash card media can also help students in understanding concepts so as to improve students' concepts understanding [32]. With these learning tools, can make the learning process run well and make the learning process not rigid and boring.

2. Research Methods

The research method used is quasi-experimental research with noneequivalent control group design, becausethis research using a pretest-posttest control group design. The population in this study were students of class VIII in one of the junior high school in Central Lampung in the academic year 2018/2019, with the sample consisting of 2 classes: the first class as the experimental class and the second class as the control class. The sampling technique used is purposive sampling which is a sampling technique with special consideration [33]. In this study, the sample is chosen based on the average value of learning outcomes that can represent each class with standard knowledge, besides the class that will be the sample must have a variety of class member. Students in the experimental class amounted to 29, and the control class has 28 students. The experimental class applied the ECIRR learning model with the pictorial riddle method, meanwhile the control class applied the discovery learning model, the learning model commobly used by the teacher.

The instrument used was a four-tier diagnostic test that was equipped with a CRI (certainty of response index) certainty scale. Four-tier diagnostic test is a four-level test, an upgradeofthree tier testwith semi-closed typein the reasons section [34]. One four-tier diagnostic test consists of questions, level of confidence in choosing answers, reasons, and level of confidence in choosing reasons [35]. Diagnostic tests are believed to help teachers recognize students' misconceptions [36]. The use of the CRI certainty scale can help in analyzing data accurately and more effectively in diagnosing students' misconceptions [37]. Interpretations of the combination of answers from the four-tier and CRI (Certainty of Response Index) certainty scale are presented in Table 1, and the details of the CRI certainty level scale category are presented in Table 2.

Table 1 The Answer Combination of *Four Tier Diagnostic Test* [11]

Answer Combination	Answer Combination			
	The Answer	**Certainty Level of the answer**	**Reason**	**Certainty Level of the reason**
Understand the concept	Right	Sure	Right	Sure
	Right	Not Sure	Right	Not Sure
	Right	Sure	Right	Not Sure
	Right	Not Sure	Right	Sure
Not understand the concept	Right	Not Sure	Wrong	Not Sure
	Wrong	Not Sure	Right	Not Sure
	Wrong	Not Sure	Wrong	Not Sure
	Right	Sure	Wrong	Not Sure
	Wrong	Not Sure	Right	Sure
	Right	Not Sure	Wrong	Sure
	Right	Sure	Wrong	Sure
Miisconception	Wrong	Sure	Right	Not Sure
	Wrong	Sure	Right	Sure
	Wrong	Sure	Wrong	Not Sure
	Wrong	Not Sure	Wrong	Sure
	Wrong	Sure	Wrong	Sure

Table 2 CRI Certainty Level Scale Category[38]

Category	Scale	Certainty Level
Guessing	0	Low/ Not Sure
Very Unsure	1	
Not Sure	2	
Sure	3	High/ Sure
Very Sure	4	
Strongly Sure	5	

The instrument to be used is tested on students (not sample students) who have studied work and simple machines material. The data obtained were then analyzed to find out the validity, reliability, level of difficulty, difference of power and the functioning of the deception. Furthermore, we got an appropriate instrument to be used in measuring students' misconceptions. Of the 20 questions developed, 15 were obtained that were feasible to be used with a high level of reliability, it is 0.76.

The data analysis technique used is the N-gain test which is used to see the difference in the results of misconceptions that occur between the control class and the experimental class [39]. The formula used is:

$$\text{N-gain} = \frac{posttest\ score - prete\ \ score}{Maximum\ score - pretest\ score} \quad (1)$$

Normalized N-gain scores are categorized according to Table 3:

Table 3 N-Gain Category [10]

Gain Category	Criteria
g > 0,70	High
0,30 ≤ g ≤ 0,70	Medium
g < 0,30	Low

The percentage of misconceptions that occur in students are analyzed using [40-42]:

$$P = \frac{F}{N} \text{ x } 100\% \quad (2)$$

With:
P = the percentage of students who experience misconception.
F = students who experience misconception.
N = the number of participants.

The results of the misconception calculation are categorized based on Table 4.

Table 4 Level of Misconception Criteria [43, 44]

Besar P	Kriteria
61% - 100%	Tinggi
31% - 60%	Sedang
0% - 30%	Rendah

Before testing the hypothesis and effect size the data prerequisites are tested. The first data prerequisite test is the normality test using the Lilliefors [45]. After the data is declared normal, the data is tested for homogeneity which aims to see whether the results of the data in the experimental class and the control class have the same variance [46]. After the data is declared normal and has a homogeneous variance, then the data analysis can proceed with the hypothesis test with the independent sample t-test [47]. Statistical tests were done with a significance level of 5%. Provisions for hypothesis testing are seen in table 5.

Table 5 Hypothesis Testing Provisions [46]

Sig	Statement	Description
Sig > 0,05	H_0Accepted H_1Rejected	There is no difference in the reduction of misconception between the experimental class and the control class
Sig ≤ 0.05	H_0Rejected H_1Accepted	There is a difference in the reduction of misconception between the experimental class and the control class

Hypothesis test [48]:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{(n1-1)s_1^2+(n2-n1)s_2^2}{(n1+n2-2)}\left(\frac{1}{n1}\right)+\left(\frac{1}{n2}\right)}} \quad (3)$$

With:
$\bar{x}_1$ =the average results of the experimental class.
$\bar{x}_2$ =the average results of the control class.
n_1 =the number of the students in experimental class.
n_2 =the number of the students in control class.
s_1^2 =experimental class data variance.
s_2^2 =control class data variance.

Effect size can be interpreted as a treatment in the learning process that shows how effective a variable is towards other variables [46]. Effect sizes can be calculated with the Cohen formula, and are described in more detail by Hake [46, 49].

$$d = \frac{m_A - m_B}{\left[\frac{(sd^2A + SD^2B}{2}\right]^{\frac{1}{2}}} \quad (4)$$

with :

d = Effect size
m_A = Average gain of experimental class.
m_B = Average gain of control class.
sd_A = standard deviation of the experimental class.
sd_B = standard deviation of the control class.

The effect size criteria are presented in Table 6.

Table 6 Criteria of Effect Size [50]

Effect Size	Criteria
d< 0,2	Low
0,2 < d > 0,8	Medium
d > 0.8	High

To describe the implementation of the ECIRR learning model with the pictorial riddle method in the classroom, observations were done using an observation sheet. Observation results were analyzed using formulas:

$$\text{Percentage} = \frac{Total\ Score}{Maximum\ number\ of\ questions} \text{x } 100 \quad (5)$$

The results obtained are categorized according to Table 7.

Table 7 Learning Implementation Criteria [51]

Sig	Criteria
0% - 20%	Very Not Good
21% - 40%	Not Good
41% - 60%	Good Enough
61% - 80%	Good
81% - 100%	Very Good

3. Results and Discussion

The N-Gain results of the experimental class and the control class are presented in Table 8.

Table 8 N-Gain Test Results

Research Results	Pretest	Posttest	N-Gain	Criteria
Kelas Eksperimen	12,44%	18,17%	0,39%	Medium
Kelas Kontrol	11,32%	13,71%	0,11%	Low

Based on Table 8 it is known that the percentage of N-gain in experimental class is greater than that in the control class. It means the concept understanding of the experimental class is higher than the concept understanding of the control class. The N-gain results in the experimental class are in the medium category, while in the control class are in the low category.

The percentage of misconceptions in the experimental class and the control class is presented in Figure 1.

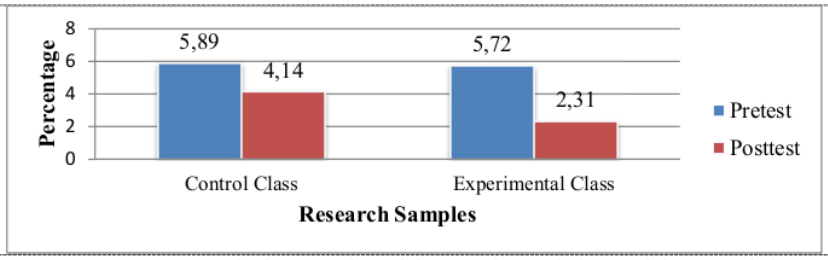

Figure 1 Percentage of misconception of the experimental class and the control class

Based on Figure 1 it is known that there was a decrease in misconceptions in both classes. However, students in the experimental class have a greater decrease in misconceptions than in the control class. Thus, it can be concluded that the application of the ECIRR learning model with the pictorial riddle method can reduce misconceptions.

The next statistical test is to test the data prerequisites namely normality test and homogeneity test. The results of the normality test are presented in Table 9, and the results of the homogeneity test are presented in Table 10.

Table 9 Normality Test Result

Statistic	Experimental Class		Control Class	
	Pretest	Posttest	Pretest	Posttest
L_{count}	0,155	0,163	0,166	0,083
L_{table}	0,164	0,164	0,167	0,167
Sig	0,05	0,05	0,05	0,05
Lilieffors test	Lc< Lt	Lc< Lt	Lc< Lt	Lc< Lt
Conclusion	Normal	Normal	Normal	Normal

Table 10 Homogeneity Test Result

Statistic	*Pretest*		*Posttest*	
	Experimental Class	Control Class	Experimental Class	Control Class
SD^2	55,39	58,30	83,14	56,87
Sig	0,05		0,05	
F_{count}	0,95		1,46	
F_{table}	1,87		1,87	
Conclusion	Homogen		Homogen	

Tables 9 and 10 show that data on misconceptions both pretest and posttest in the experimental class and control class are normally distributed and have homogeneous variance, meaning that the samples used in this study are at the same level.

After the data is normal and homogen, the hypothesis test is continued. The results of the hypothesis test analysis are presented in Table 11.

Table 11 Hypothesis Test Result

Class	$\dot{x}$	Sp	t_{tabel}	t_{hitung}	Conclusion
Experiment	18,1	8,382	2,004	2,008	There is influence
Control	13,7				

Table 11 shows the results that $t_{count} > t_{table}$, it can be concluded that there is an influence of the ECIRR model with pictorial puzzle method towards misconceptions which is showed by the difference in the results of misconceptions between the experimental class and the control class.

The effectiveness of the ECIRR learning model with the pictorial riddle method towards misconceptions was measured using the effect size test. The resultis presented in Table 12.

Table 12 Effect Size Result

Statistic	Experiment	Control
Mean of Gain (Average of Gain)	5,72	2,39
SD	5,9	4,54
Effect Size	0,63	
Criteria	Medium	

Table 12 shows that the ECIRR learning model with the pictorial riddle method is effective in reducing students' misconceptions in work and simple machines material, with medium categories. that means, there are still misconceptions but not as big as before. Next, Figure 2 presents the decrease in the number of students who experience misconceptions on each item.

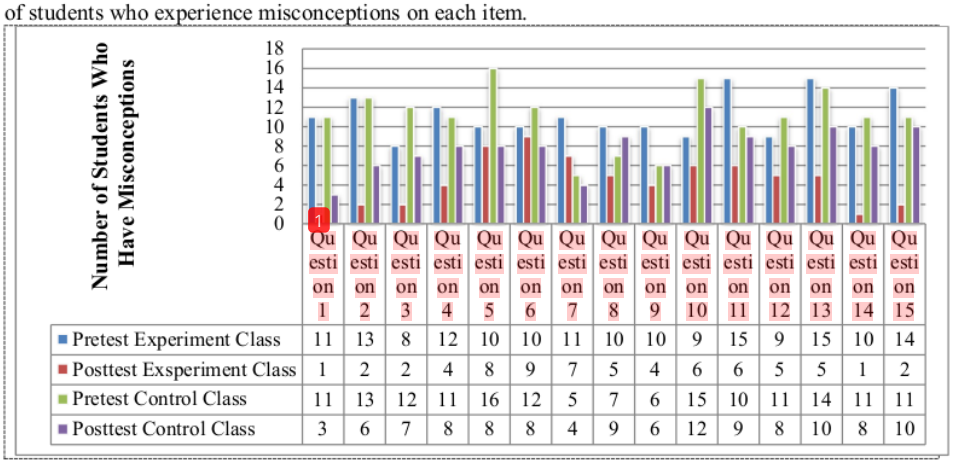

Figure 2 Adecrease in the number of students that are experiencing misconceptions on each item

Figure 2 shows that misconceptions still occur in both classes. But the decrease number in the experimental class is greater than in the control class. It was concluded that the ECIRR learning model with the pictorial riddle method had an effect on reducing misconceptions. Figure 2 also shows that misconceptions occur in all sub-concepts of work and simple machines material. The percentage of misconceptions that occur in sub-concepts of work and simple machines material are presented in Table 13.

Table 13 Percentage of Students Misconceptions Per Sub-Concept onwork and simple machines material

Sub-Concept	Number of Question	Percentage
Work	1,2,3,7,10	37,24%
Simple machine pulley type	5,8,15	39,08%
Simple machine lever type	9,12,14	32,75%
Simple machine inclined plane type	4, 6, 11, 13	42,66%

The results of the implementation of the ECIRR learning model with pictorial riddle method are shown in Figure 3.

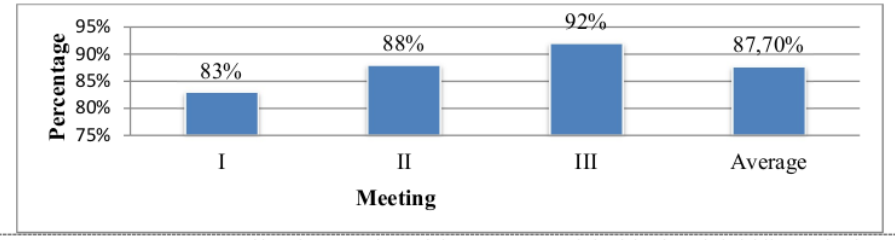

Figure 3 Percentage of implementation of the ECIRR model with pictorial riddle method

Based on Figure 3, the percentage of implementation of the ECIRR learning model with pictorial riddle method is in very good category. That means, the application of the ECIRR learning model with pictorial riddle method is well implemented so it is effective in reducing students' misconceptions.

Factors that influence the differences in the results of students' misconceptions in the experimental class and the control class are the different models, methods and learning media that were used in learning. The ECIRR learning model has proven to be more effective in reducing misconceptions on of work and simple machines material. This is supported by the results of previous studies which was showing that the ECIRR learning model with a combination of real laboratory and virtual laboratory can reduce student misconceptions [52], and the previous research that showed that ECIRR learning can influence student learning outcomes [53],and also previous research which said that the ECIRR learning model is an effective learning model to reduce misconceptions on chemistry, because the ECIRR learning model emphasizes the conceptual change of students by confronting the wrong understanding of students [54].

Learning with the ECIRR model in reducing misconceptions is more optimal with the pictorial riddle method. The pictorial riddle learning method can help to improve students' activities [55] and can improve student learning outcomes [56]. In addition, the use of the pictorial riddle method can improve students' concepts understanding [57]. Learning becomes more interesting with the use of flash card media. Flash cards can help students to improve the understanding of the concepts [32], attract learning interest [31] and increase the activeness of students in learning. Besides, it can also improve student learning outcomes [58].

ECIRR learning model with pictorial riddle method using flash card can help students recognize misconceptions, reduce misconceptions, motivate students to be active in discussions, solve problems given by teachers, and all students can be actively involved and able to work together in the learning process. With the increase of students' learning activities, the learning outcomes of students will increase [59]. In the elicit stage, the teacher gives a question to students to find out the student's initial concept. At this stage teacher explore alternative concepts that exist in students to recognize the misconceptions [60]. In the confront stage, teacher demonstrate physical phenomena to create contradictions and ask students to compare them. In this phase there will be a conflict in students' mind so there will be a cognitive imbalance in students [2]. The physics phenomenon on the flash card is presented in Figure 4.

(a) (b)

Figure 4 Flash card (a)someone who is pushing a car and (b) a speeding car

At the identify stage students were asked to explain the concepts and reasons based on hypotheses in the elicit and confront stages. At this stage students could clarify and revised their initial concept (previous concept) [52].In the resolve stage, the teacher tried to provide an understanding of the actual concept by conducting demonstrations and giving examples that were often happen in daily life. For example, the activity of pushing a table causes the table moving, this is an example of a work that has a positive value, because the movement is in the same direction as the given force. Another example was the activity of lifting a book and putting it back in its original place. This is the example of a zero-value work, because the book is not moving, even though the force is given. In this phase students are guided by teacher to reduce their misconceptions [61]. At the reinforce stage which was the final stage, teacher reviewed the learning process. Teacher tried to give questions back that lead to the actual concepts that have been learned. Through this stage, the teacher can clearly see whether students really understand or not. Teacher also invited students to ask questions about concepts or things that were not yet understood. This stage is the most important stage, techer repeatedly reinforce the concept in various ways, including giving questions. But make sure the questions given are conceptual questions [30].

Figure 2 and Table 13 show that the misconceptions on students have not been completely reduced. This is because misconceptions are resistant and difficult to fix. Students tend to maintain the original concept [18, 62]. Students tend to maintain their misconceptions so that misconceptions are not easily overcome [63]. Besides, the deficiencies in the implementation of the ECIRR model can also affect, for example at the reinforce stage, activities provide reinforcement of concepts to students. If the implementation of this stage is enhanced it will be more effective in reducing misconceptions. Although the results of observations of the implementation of learning that is presented in Figure 3 shows that the ECIRR model with the pictorial riddle method is implemented very well, it still have to be improved so the results obtained are more optimal.

4. Conclusion

Based on the results of the study, it can be concluded that the ECIRR learning model with the pictorial riddle method is effective in reducing students' misconceptions on work and simple machine. The independent sample t-test showed that the decrease in the misconception of the experimental class was greater than that of the control class. That means the ECIRR learning model with the pictorial riddle method has an effect in reducing students' misconceptions. Furthermore, the effect size value is 0.63. It means the ECIRR learning model with the pictorial riddle method is effective in reducing misconceptions with medium categories.

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