Implementation of ECIRR model based on virtual simulation media to reduce students’ misconception on kinetic theory of gases

A C Prastiwi¹, A Kholiq¹### and W Setyarsih¹

¹Department of Physics, Faculty of Mathematics and Natural Sciences
State University of Surabaya, Indonesia
Jl. Ketintang, Surabaya 60231, Indonesia

Email: #kholiq@unesa.ac.id

Abstract. The purpose of this study are to analyse reduction of students’ misconceptions after getting ECIRR with virtual simulation. The design of research is the pre-experimental design with One Group Pretest-Posttest Design. Subjects of this research were 36 students of class XI MIA-5 SMAN 1 Driyorejo Gresik 2015/2016 school year. Students misconceptions was determined by Three-tier Diagnostic Test. The result shows that the average percentage of misconceptions reduced on topics of ideal gas law, equation of ideal gases and kinetic theory of gases respectively are 38%, 34% and 38%.

1. Introduction

Learning activities is designed by teacher in which actual learning occurs and learners actively involved. Teacher acts as a facilitator for learners by encouraging students, explaining concept, fixing misconception and practicing problem solving in learning activities. The main role of the teacher is in explanation of the concept and improvement of the students' misconceptions. Previous research revealed that one of difficulties in teaching physics is a result of students' misconceptions [1]. Students' misconceptions commonly due to simple phenomena in daily life that they experienced. Students have been already experience various physical phenomena such as free-falling objects, electricity, energy, collisions, gas properties and others.

Most of the students have had its own understanding about physical phenomena or concepts that they have been experienced which is inconsistence with scientific concepts. When the concept of understanding is incorrectly formed, it will usually be very difficult to repair, because unintentionally the incorrect concept of physics becomes the handle of his life. The existence of this misconception will obviously hamper the process of acceptance and assimilation of new knowledge in the students, so that will hinder the success of students in the process of learning more. This is a major problem in the teaching of physics that can’t be tolerated. Along with the growing awareness of this, efforts to tackle the problem of misconception continue to be developed, although the results have not been significant.

The misconception diagnostic instrument is an assessment instrument that can be used to identify misconceptions experienced by students. To find misconceptions in students, there is an instrument known as the three-tier diagnostic test. The result of misconception analysis using the instrument can be
identified misconception to know misconception that happened in student. So, it will be easier to help students change their misconception [2].

In conventional learning, misconception can be reduced by a learning model which stages include elicit, confront, and resolve [3]. However, this learning is less effective because it fails to identify student misconceptions, so the teacher cannot know the cause of student misconception. In addition, in this model, the teacher does not provide reinforcement of the correct concept in the student, so students cannot change the wrong initial concept and keep repeating it after the learning is over. Therefore, Wenning in 2006 [8] developed the learning model by adding two stages of identify and reinforce which then called ECIRR learning model. The ECIRR model stands for elicit-confront-identify-resolve-reinforce. The ECIRR model emphasizes the use of cognitive conflicts and constructivist theories that invite students to build their concepts. One of the tips to reduce misconceptions is by the way students are exposed to the correctness of existing concepts, according to the stage of the ECIRR model in the confront stage. At this stage students are exposed to two different phenomena, namely the phenomenon of conception that they already have with a phenomenon that describes the scientific concept. Having been exposed to two different phenomena students will experience cognitive conflicts. Furthermore, at the stage of identifying students will know the error of the concept that they experienced and at the resolve stage students are given activities that will solve student cognitive conflict. In this phase, the role of teacher is needed to direct the students to concept improvement. After the students have improved the initial concept, the teacher reinforces the new concept students receive during the reinforcement phase.

Learning model that will be used for teaching needs to be supported by learning media that can be accepted either by the students, so that the given material can be processed correctly. A virtual simulation that is a means to conduct demonstration activities, and laboratory activities that can be done to meet the needs of the conceptual thinking on students about materials whose concepts are abstract to understand. One of the most commonly used software as a virtual lab is the PhET software. PhET simulation is one of the discovery-based simulation media and is used to clarify physical concepts, thus minimizing misconceptions of students.

Associated with the misconception, has been checked to the students of senior high school at SMAN 1 Driyorejo by using three-tier diagnostic test instrument, obtained the result that the students have misconception on sub material equation gas state equal to 64.58%, gas law 54.89% , and the kinetic theory of gas is 65.74%. Therefore, the researcher tries to do research using ECIRR learning model with virtual simulation media so that the misconception owned by the students can be reduced and the students also get deep understanding about the concept they are learning.

2. Theory

On learning conventional, misconception can be reduce to a learning’s model with elicit, confront, and resolve These approaches tend to have in common the requirement that students encounter phenomena that run counter to their existing beliefs. Doing so, they are put in a state of intellectual disequilibrium or cognitive conflict. Becoming aware of the conflict between what they believe to be correct based on prior experiences and know to be correct based on more recent experience helps them to confront and resolve their conflicting perspectives in favor of a proper understanding. Such pedagogical approaches that emphasise conflict and resolution appear to derive from a Piagetian perspective on learning [4].

These and other approaches dealing with alternative concepts typically include three fundamental steps—those identified by the University of Washington Physics Education Group: elicit/confront/resolve [5]. Firstly, in this model a teacher elicits a response (prediction about what will happen or an indication of agreement or disagreement with a given statement) from students, forcing them to commit to an answer in relation to a specific situation. Secondly, the students confront a situation that challenges their beliefs and answers, typically in an experiment that the students perform. During this second phase, if the students were incorrect in their prediction, they experience cognitive dissonance when confronting the conflict between prediction and experience. Students quickly come to realize the
need for a new understanding about the concept under consideration, and are motivated to resolve the conflict with teacher assistance in phase three.

The traditional approach of overcoming misconception consists of eliciting, confronting, and resolving has not always been an effective way for teaching and learning physics as can be inferred from the results certain physics education research. ELICIT-CONFRONT-RESOLVE approach fails to make a substantial lasting difference in the area of misconception because it fails to clearly IDENTIFY the existence of the misconception to students and fails to REINFORCE student learning in the area of the misconception. A better approach to dealing with misconception suggests a more clearly elucidated five-step approach that will be herein referred to as the ECIRR (Elicit-Confront-Identify-Resolve-Reinforce) model.

2.1 How the ECIRR Model Works

ELICIT, the teacher probes for students’ misconception through activities that make students’ thinking evident such as asking questions, and conducting Socratic dialogues with white boarding [6]. During such practices teachers ask students to predict, explain, and make clarify statements. Of course, this step assumes that the teacher is cognizant that misconception exist and what they are. Previous research has shown that in order for a teacher to effectively address student’s misconception, they must be aware of the presence of such ideas [7].

CONFRONT, the teacher uses discrepant events to provide contradictions to students’ statements or predictions and place them in a state of cognitive conflict. They confront misconceptions through demonstration, implications, and questions, and encourage discussion [6, 8].

IDENTIFY, After misconception are elicited and confronted, the teacher must clearly and unambiguously identify them as such. Teachers must be careful, however, not to denigrate the value of intuition that often can lead to correct predictions. They must explain the power of misconception to mislead, and state emphatically that students must not be misled and they should divorce themselves from it because the old conception will compete with the new conception [6, 8].

RESOLVE, The teacher should foster the replacement of an alternative conception using any of the following approaches: questions, thought experiments, interactive demonstrations, hypothetical situations, and experiments designed to test hypotheses. They should help reevaluate students’ understanding by posing conceptual questions, and eliciting student sources of misconception. To overcome misconception, teachers should place as much attention on students’ prior knowledge as possible, but allow students to actively resolve discrepancies by themselves because teaching by telling simply does not work [6, 8].

REINFORCE, When teachers help students develop a new understanding of a phenomenon rooted in an misconception, this does not necessarily extinguish prior learning. As experience shows, there are frequently two competing concepts in students’ minds. To address misconception effectively, teachers must reinforce the pathway that leads to the new understanding and extinguish or at least suppress the pathway that leads to the old understanding, or help students to decide in the case of preconceptions. Failure to do so can result in students recalling the misconception preferentially over the desired understanding [6, 8].

This reinforcement should be done repeatedly, over time, and under varying conditions. This is due in part because retrieval pathways are not well established, and effort must be expended on firmly establishing the retrieval mechanism associated with the new understanding. Several important approaches from cognitive psychology can be used to do so.

2.2 Three Tier Diagnostic Test (TTDT)

Therefore, identification of the students’ misconceptions is crucial for the planning of effective instruction and remediation of students’ difficulties in understanding science concepts. Therefore, identification of the students’ misconceptions is crucial for the planning of effective instruction and remediation of students’ difficulties in understanding science concepts.
However, multiple-choice tests do not provide reasons for students’ holding a particular conception. A student can give a correct answer with a wrong reason or a wrong answer with a correct reason. Because of the above limitations of the aforementioned tools, two-tier multiple-choice instruments have been developed by researchers [5, 9]. The first part of each item includes a conventional multiple choice question and the second part of each item contains a set of possible reasons for the given answer in the first part [10].

Three-tier Diagnostic Test (TTDT) enable researchers to address this limitation by adding an extra tier that require students to state whether or not they are sure about their answers to the first two tiers [11,12]. TTDT are valid tests that can be used efficiently with large samples of students, and help researchers to understand students’ reasoning behind their answers without conducting interviews to distinguish misconceptions from lack of knowledge, and to estimate percentages of false positives and negatives [12]. Students could provide correct answers with wrong reasoning as “false positive” and wrong answers with correct reasoning as “false negative”.

TTDT instrument have three step to analyze students’ misconception:

One-tier scores: The first part of each item includes a conventional multiple choice question. This score was created by using students’ answers for only the first tiers of items. Correct answers were coded as 1 and others were coded as 0.

Two-tier scores: The second part of each item contains a set of possible reasons for the given answer in the first part. This variable was based on the first two tiers of items. When a student’s answer to both the first and second tiers was correct, it was coded as 1; otherwise, 0.

Three-tier scores: In the form of an affirmation question from a previously selected answer. This score was produced by taking all three tiers into account. When a student’s answer to all tiers was correct, it was coded as 1; otherwise, 0. This means that it was coded as 1 if the student answers the first two tiers correctly and she/he selects “I am sure” in the third tier [13].

3. Method

3.1 Sample
In the research, the ECIRR was administered to 36 students of 11th grade at Driyorejo senior high school aged 16-17 years after they were taught about the kinetic theory of gases. Just one class to include of the research this is XI IPA grade.

3.2 Design of research
The research used pre-experimental-design of one group pretest-posttest design without control class. Design of research:

\[
O_1 \quad X \quad O_2
\]

\(O_1\) = pretest score (first observation before treatment)

\(X\) = treatment by implementing ECIRR model with virtual simulation media

\(O_2\) = value of the second observation (posttest)

3.3 Procedure
Identification of student’s conception can be analyzed with TTDT instrument with combination answer were reported (see Table 1).

| Type Diagnostic | Combine of result | Category               | Code |
|-----------------|-------------------|------------------------|------|
| Three-tier      | True + True + Sure| Understand the concept | SU   |
| Type Diagnostic | Combine of result | Category       | Code |
|-----------------|-------------------|----------------|------|
| False + False + Not Sure | Lack of knowledge | LK             |
| False + True + Not Sure | Guessing         | G              |
| True + False + Not Sure |               |                |
| True + False + Sure | Misconception    | M              |
| False + T + Sure |               |                |
| False + False + Sure |               |                |

Adaptation [13].

To calculate percentage of student’s misconception can use this formula:

\[
\text{(%student’s misconception)} = \frac{\text{N}_M}{\text{N}} \times 100\% \tag{1}
\]

\(\text{N}_M\) = quantity of question that resulted student’s misconception

\(\text{N}\) = total of question

The difference between student’s misconception during pretest and posttest after the implementation of ECIRR’s model with virtual simulation media can be done using t-test[14].

\[
t = \frac{\text{M}_d}{\sqrt{\frac{\Sigma x^2_d}{N(N-1)}}} \tag{2}
\]

\(\text{Md}\) = mean from difference between student’s misconception during pretest and posttest

\(\text{Xd}\) = deviation each subject (d-Md)

\(\Sigma x^2_d\) = total of chi square

\(\text{N}\) = total of subject

\(\text{d.b}\) = \(\text{N}-1\)

Hypothesis of research:

\(\text{H}_0\) : Implementation of ECIRR model with virtual simulation media in theory kinetic of gas not reduce student’s misconception on 11th grade Driyorejo Senior high school

\(\text{H}_i\) : Implementation of ECIRR model with virtual simulation media in theory kinetic of gas reduce student’s misconception on 11th grade Driyorejo Senior high school

4. Result

The result of implementation ECIRR’s models were reported (see Table 2):
Table 2. Classification of student’s misconception.

| Number of students | (%) Student’s misconception of Pretest | (%) Student’s misconception of Posttest | (%) Reduce of Student’s Misconception | Category           |
|--------------------|----------------------------------------|----------------------------------------|---------------------------------------|--------------------|
| 3                  | 79                                     | 14                                     | -64                                   | High Reduce of     |
|                    |                                        |                                        |                                       | Student’s          |
|                    |                                        |                                        |                                       | Misconception      |
| 1                  | 93                                     | 36                                     | -57                                   | Middle Reduce of   |
|                    |                                        |                                        |                                       | Student’s          |
|                    |                                        |                                        |                                       | Misconception      |
| 6                  | 71                                     | 14                                     | -57                                   | Low Reduce of      |
|                    |                                        |                                        |                                       | Student’s Misconception |
| 11                 | 93                                     | 36                                     | -57                                   |                     |
| 15                 | 86                                     | 29                                     | -57                                   |                     |
| 12                 | 93                                     | 43                                     | -50                                   |                     |
| 14                 | 64                                     | 14                                     | -50                                   |                     |
| 10                 | 57                                     | 7                                      | -50                                   |                     |
| 33                 | 57                                     | 7                                      | -50                                   |                     |
| 18                 | 86                                     | 36                                     | -50                                   |                     |
| 4                  | 50                                     | 7                                      | -43                                   |                     |
| 20                 | 71                                     | 29                                     | -43                                   |                     |
| 21                 | 64                                     | 21                                     | -43                                   |                     |
| 25                 | 64                                     | 21                                     | -43                                   |                     |
| 27                 | 64                                     | 21                                     | -43                                   |                     |
| 28                 | 64                                     | 21                                     | -43                                   |                     |
| 23                 | 79                                     | 36                                     | -43                                   |                     |
| 29                 | 86                                     | 43                                     | -43                                   |                     |
| 36                 | 64                                     | 29                                     | -36                                   |                     |
| 2                  | 36                                     | 0                                      | -36                                   |                     |
| 5                  | 50                                     | 14                                     | -36                                   |                     |
| 24                 | 79                                     | 43                                     | -36                                   |                     |
| 26                 | 50                                     | 14                                     | -36                                   |                     |
| 8                  | 57                                     | 21                                     | -36                                   |                     |
| 16                 | 43                                     | 7                                      | -36                                   |                     |
| 17                 | 57                                     | 21                                     | -36                                   |                     |
| 19                 | 50                                     | 21                                     | -29                                   |                     |
| 31                 | 79                                     | 50                                     | -29                                   |                     |
| 35                 | 50                                     | 29                                     | -21                                   |                     |
| 7                  | 29                                     | 7                                      | -21                                   |                     |
| 13                 | 29                                     | 7                                      | -21                                   |                     |
| 34                 | 21                                     | 0                                      | -21                                   |                     |
| 9                  | 21                                     | 7                                      | -14                                   |                     |
| 22                 | 57                                     | 43                                     | -14                                   |                     |
| 30                 | 57                                     | 43                                     | -14                                   |                     |
| 32                 | 43                                     | 36                                     | -7                                    |                     |

Table 2 describes that the category of middle student’s misconception more with the other categories. It’s show that this sample of research matches with the normality graph, the data that used obtained comes from a normally distributed sample. If the Table 2 change to graph (see figure 1).
There are reduce student’s misconception because the student get a treatment ECIRR’s models with virtual simulation. Phase of ECIRR’s model that can be used to change students conception is confront. On the confront phase, the teacher uses discrepant events to provide contradictions to student’s statements or predictions and place them in a state of cognitive conflict. They confront misconceptions through demonstration, questions, and encourage discussion. There are cognitive conflict on confront phase, it make a students know that his conception wrong. Cognitive conflict suggest that when a new concept is learned it weakens or destroys an existing memory. So, cognitive conflict have an important phase to change incorrect conception to correct conception.

4.1 Discussion
The following will be discussed about the misconceptions experienced by some students.

Student 1

Based on the Figure 2 can be discussed as follows:
1) Student 1 has misconception 93% for pretest. The misconceptions occurred in several sub-materials, among others, the sub-material on ideal gas law about the numbers 1, 4, 5, 9, 10 and 13, because the number of questions for ideal gas law is 7 so students 1 get misconceptions of 86% in this sub
material. For sub-material equation of ideal gases, student 1 get misconceptions of the numbers 6, 7, 8 and 11, in this sub material total number is 4, so students 1 get misconceptions 100% in this sub material. On sub-material kinetic theory of gases about numbers 2,3, and 12, because the number of questions for kinetic theory of gases is 3 so students 1 get misconceptions of 100% in this sub material.

2) The result of identification misconception during posttest shows the change of misconception level experienced by Student 1. The misconception experienced by Student 1 when posttest becomes 36%, that is in sub-material ideal gas law in question number 13, so students 1 get misconceptions of 14%. For sub-material equation of ideal gases in question number 6, 7, and 11, so she/he get misconception 75%. As well as sub- material kinetic theory of gases get problem or number 12, so students 1 get reduce misconception become 33%.

3) The existence of students misconception reduction on some number, because students have been given treatment of ECIRR learning model with virtual simulation media. In the ECIRR learning with virtual simulation media, the teacher tries to create a learning that raises the cognitive conflict in the students through the confront phase by confronting the students with a reality different from the students' initial thinking. When students experience it, students feel uncomfortable and will be more open to new concept changes [15].

**Student 32**

![Figure 3](image)

Based on the Figure 3 can be discussed as follows:

1) Misconception of students number 32 during pretest can viewed from picture 2 is 43%. The misconception in all sub-materials, on the sub-material ideal gas law of misconceptions identified in number 9, 10, and 13, for the sub-matter equation of ideal gases in question 11, whereas in the sub-material of kinetic theory of gas at question number 3 and 12. If this data change into percent form to each submitter is 43% for ideal gas law, 25% for equation of ideal gases, and 67% for kinetic theory of gases.

2) Based on the posttest result shows the reduction of misconception to become 36%. The still-identified misconception lies in the matter of ideal gas law in questions 9 and 10, on the sub-matter of kinetic theory of gas still in questions 3 and 12, as well as on the sub-matter of the equation of ideal gases still in question number 11. So, student 32 just get reduce misconception on the matter of ideal gas law about 29%.

3) The percentage reduction of student misconception 32 is quite low at only 7%. This is probably because the percentage of misconceptions of students based on pretest and posttest is not much different, so the difference between the two results in a low percentage value. In the 32 students, there is not much change of misconception, only one number is reduced number 13. This can happen
because the learning treatment given to the students is interpreted slowly, so there is only a small change from the concept that students have [12]. It can also be from affection, social, and context factors. Elements of affection such as motivation, values, student interests can influence concept changes. Students who do not have the motivation and interest in physics learning usually do not quickly experience a change of concept [15].

5. Conclusion
Based on the results of research and discussion, the conclusion of this study are:
1) ECIRR learning model with virtual simulation media can significantly reduce misconception of students of class XI MIA-5 in SMAN 1 Driyorejo on the material of kinetic theory of gas. This is evidenced by the t test calculation, which shows that the t count is greater than the t table with $< t \text{ count} > = 15.60$ and $< t \text{ table} > = 2.04$. The result showed that the percentage of misconception of each student decreased after learning using ECIRR model with virtual simulation media. The mean percentage reduction in misconceptions for gas law submissions is 38%, for submission the gas state equation is 34%, and for sub chapter the kinetic theory of gas is 38%.

2) Effectively addressing misconception requires more than just eliciting, confronting, and resolving a false notion. Forming memories that are easily and accurately retrieved requires more than a desire to remember. Efforts must also include identifying the presence of misconception and reinforcing new learning. Forgetting takes work, and it is important to include activities that weaken memories and enhance recall of preferred understandings.

3) Explanations and reminders reinforce learning and are important to the habit-breaking process. Study and practice are required if students are to develop a long-lasting change in understanding and the ability to recall that knowledge accurately under a variety of new conditions. While the EICRR model for dealing more effectively with misconception is conjectural, findings from both craft wisdom and cognitive psychology would seem to suggest that it is also important to identify misconception and reinforce student learning in this area. This ECIRR conjecture could well be a fruitful area of work by physics education researchers.

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