



## Reducing Senior High School Students' Misconceptions through Inquiry Learning Model on Thermochemistry Material

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**Abstract:** Misconception is a serious problem faced by high school students. Through the application of inquiry learning model, this study tries to reduce students' misconceptions, especially on thermochemical material. The experimental method with the pretest-posttest randomized control group design was used in this study. The samples of the research were 72 eleventh-grade high school students. The inquiry model was applied to the experimental class and the scientific approach was applied to the control class. The three-tier multiple choice with the Certainty of Response Index (CRI) was used to look at misconceptions experienced by the students. The results of the statistical calculation found that the  $t_{\text{observed}}$  was greater than  $t_{\text{critical}}$ . The reduction of misconception categories and the percentage of reduction of misconceptions in the experimental class was 47.53 % in the medium category. Based on the results, it can be concluded that the inquiry learning model helped the students to overcome the misconceptions in thermochemical material. The researcher recommends that the inquiry learning model can be applied to other chemistry materials because their learning can help students find the correct concepts and reduce misconceptions.

## INTRODUCTION

The world of education is required to improve the quality of education by creating effective and enjoyable learning (Irwandani & Juariyah, 2016; Puspitasari et al., 2018; Sugiawati, 2013). Education is the most important part of human life because education is a source of strength and truth to achieve the desired goals (Adam et al., 2017; F. K. Sari et al., 2016; Setiowati et al., 2015).

The Indonesian government, through the Ministry of Education and Culture, has implemented the 2013 curriculum in the 2014/2015 school year. It focuses on 3 aspects, namely knowledge, attitude, and skills (Anitasari et al., 2019; O. Kurniawan & Noviana, 2017; Puspitasari et al., 2018). The

knowledge understanding and character education aspects are the basis for optimizing students' skills (Khoiriyah & Erman, 2017).

Learning is said to be successful if someone is doing the processes to be able to lead something in a better direction (Suwanto, 2013). Learning occurs when there is an interaction between teachers and students to realize the learning objectives (Rusman, 2012). According to Sanjaya (2010), teaching is a form of living conditions or environments that enable the learning process to take place.

Learning is said to be good if there is a reciprocal relationship between teachers and students (Budiningsih, 2012). Chemistry is one branch of natural science that covers the conceptual

understanding and algorithmic understanding (Andrianie et al., 2018; Lintong et al., 2018; M. W. Sari & Nasrudin, 2015; Zidny, 2013). Based on literature studies, it is known that in chemistry lessons, thermochemical material is among the hardest ones to be studied (Aswita et al., 2015; Dewi et al., 2018; Piawi et al., 2018; Sugiharti & Habeahan, 2018).

Thermochemistry is a combination of theory and calculation (Sugawati, 2013) where a good conceptual and algorithmic understanding is needed. If students do not understand it, then they will face difficulties in solving problems that will lead them toward misconceptions. The misconception is concept interception through a statement that cannot be accepted in theory (Bayuni et al., 2018; Safrida et al., 2017; Shofiyah, 2017; Siswaningsih et al., 2014; Soeharto et al., 2019; Wijaya et al., 2016). Misconceptions harm students' learning outcomes in every subject (Khomaria & Nasrudin, 2016; Lintong et al., 2018; Wijaya et al., 2016).

One of the causes of the low learning outcomes is the teachers who pay less attention to the difficulties and misconceptions experienced by students (Milenkovic et al., 2016; Suparno, 2013; Wijaya et al., 2016). The low learning outcomes are caused by the misconception of essential concepts (Astuti et al., 2016). Therefore, misconceptions must be addressed immediately because they are harmful to students (Bayuni et al., 2018; Soeharto et al., 2019; Wahyuningsih et al., 2013).

Misconceptions that often occur in thermochemical material are exothermic and endothermic reactions, the changes in decomposition enthalpy standards, the changes in enthalpy of combustion standards, Hess's law, and energy bond (Astuti et al., 2016; Aswita et al., 2015). Sugawati (2013) also states that the misconception on thermochemical

material is contained in the concept of combustion enthalpy changes.

To overcome the misconceptions experienced by the students, the teachers must choose a learning model that can emphasize the process of critical and analytical thinking to help them see and find their own answers to a problem (Irwandani & Rofiah, 2015; Khomaria & Nasrudin, 2016). One learning model that emphasizes critical and analytical thinking processes is the inquiry learning model (Chong et al., 2017; Eppes et al., 2020; Hastuti et al., 2018; Pedaste et al., 2015; Puspitasari et al., 2018; Shofiyah, 2017).

In this study, the inquiry learning model was applied to assist students in elaborating their thinking skills and building their knowledge independently (Eppes et al., 2020; Hastuti et al., 2018; Mulyana et al., 2018; Puspitasari et al., 2018). The effect of developing knowledge independently can make the information obtained by students during the learning process more meaningful and stored in their long-term memory (Aini & Dwiningsih, 2014).

Based on the results of chemical representation research, to reduce students' misconceptions on redox material through the application of student worksheet-assisted guided inquiry learning model, it is known that the guided inquiry learning model can reduce students' misconceptions by 39 % and can improve their cognitive learning outcomes (Andrianie et al., 2018). Based on the results of research on the application of guided inquiry learning model equipped with student worksheets to improve students' learning activities and achievement on the solubility material for the eleventh-grade students of SMA Negeri 1 Banyudono, it is known that the guided inquiry learning model can increase learning activities and achievement solubility with percentages of 80 % and 84 % (Setiowati et al., 2015).

Efforts to reduce students' misconceptions on thermochemical material in this research were done by applying the inquiry learning model where the students find their own answers to problems so they are logically, systematically, critically, and confidently developed (Hastuti et al., 2018; Puspitasari et al., 2018).

The method used to identify students' misconceptions in this research was the three-tier multiple-choice diagnostic test (Bayuni et al., 2018; Monita & Suharto, 2016; Soeharto et al., 2019; Wijaya et al., 2016; Zafitri et al., 2018). This diagnostic test was chosen because it can identify misconceptions experienced by students more deeply, can determine the parts of the material that require more emphasis when learning, and design better learning to help reduce students' misconceptions (Hasyim et al., 2018; Istiyani et al., 2018; Mubarak et al., 2016; Wijaya et al., 2016).

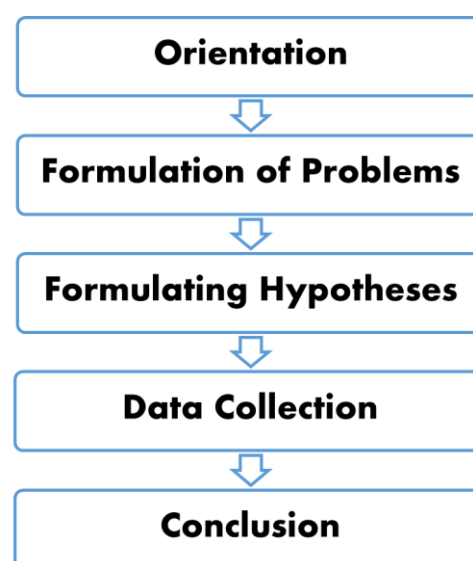
Based on the research results by Ratnaningdyah & Sugiarti (2018), it was found that the inquiry learning model can reduce students' misconceptions by 20 % and can increase their understanding of concepts with an N-gain value of 0.43. The results of Shofiyah (2017) showed that students' understanding of concepts increased from an average score of 21.3 to 68.3. Based on the data analysis using the N-gain score, it can be concluded that the application of the modified free inquiry model has a moderate effect on decreasing students' misconceptions on fluid material. Furthermore, the results of the research by Fatmawati et al. (2018) show that the Inquiry-Based Learning Design model assisted by Semi-Soft Scaffolding affects the reduction of students' misconceptions on animal kingdom material by 14 %.

This study was aimed to determine the magnitude of the reduction of students' misconceptions and the category of students' misconceptions on

thermochemical material after the inquiry learning model had been applied. It is hoped that this research can prove that the inquiry learning model can reduce students' misconceptions, especially on thermochemical material. In contrast to previous studies, this study employed the three-tier multiple-choice diagnostic test to detect the students' misconceptions about thermochemical material.

## METHOD

This research was conducted at SMA 4 Pekanbaru in the 2019/2020 academic year. The data were collected on April-September 2019. The population of the research was all students of the eleventh-grade of the XI MIPA class. The samples were randomly selected after they were declared homogeneous, namely class XI MIPA 4 as the experimental class with 36 students and class XI MIPA 2 as the control class with 36 students. The samples' average age range was 15-16 years. The design of the experimental research was the pretest-posttest randomized control group design (Sugiyono, 2016). The steps of inquiry learning in thermochemical material can be seen in Figure 1.



**Figure 1.** Steps of Inquiry Learning Model

a. Data Collection

The steps of data collection were as follows: (1) during the pre-research, the researchers collected test scores of previous material i.e hydrocarbons material, (2) the pre-tests were administered to the students before the treatments on the thermochemical material were given, (3) after the treatments, the post-tests were administered to both classes. The data obtained were tested for normality and homogeneity.

b. Hypothesis Testing

1) Assessment

The criteria of multiple-choice questions scoring are as follows: point given to the correct answers of the level 1 and 2 was 1 and 0 for incorrect answers (Arikunto, 2013).

2) Grouping the data

The results of the misconception test were further grouped into four criteria as can be seen in Table 1. Then, the percentages of misconceptions for each student based on test data were calculated.

**Table 1.** Students' Conception Grouping Criteria

| Level 1 | Level 2 | Level 3 | Criterion |
|---------|---------|---------|-----------|
| T       | T       | C       | KC        |
| T       | T       | NC      | G         |
| T       | F       | C       | MC        |
| T       | F       | NC      | G         |
| T       | F       | C       | MC        |
| F       | F       | NC      | DKC       |
| F       | T       | C       | MC        |
| F       | T       | NC      | G         |

(Y. Kurniawan & Suhandi, 2015; Monita & Suharto, 2016; Waluyo et al., 2019)

Note:

- T = True
- F = False
- C = Confident
- NC = Not Sure

- KC = Group of students who know the concept
- DKC = Groups of students who do not know the concept
- MC = groups of students showing misconceptions
- G = groups of students who guess the answers

3) Using t-test

The t-test proved the research hypothesis that the inquiry learning model can reduce students' misconceptions on thermochemical material by using the following formula (Sugiyono, 2015).

$$t = \frac{\bar{x}_1 - \bar{x}_2}{S_{\bar{x}} \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

with

$$S_{\bar{x}}^2 = \frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}$$

4) Determining the level of misconceptions categories

After calculating the percentage of misconceptions, then the extent of misconceptions category was determined as shown in Table 2.

**Table 2.** Misconceptions Category

| Percentage               | Category |
|--------------------------|----------|
| 0 < misconception ≤ 30   | Low      |
| 30 < misconception ≤ 70  | Moderate |
| 70 < misconception ≤ 100 | High     |

(Y. Kurniawan & Suhandi, 2015)

**RESULT AND DISCUSSION**

Students' diagnostic test results before treatment (pretest) and after treatment (posttest) can be seen in Figure 2.

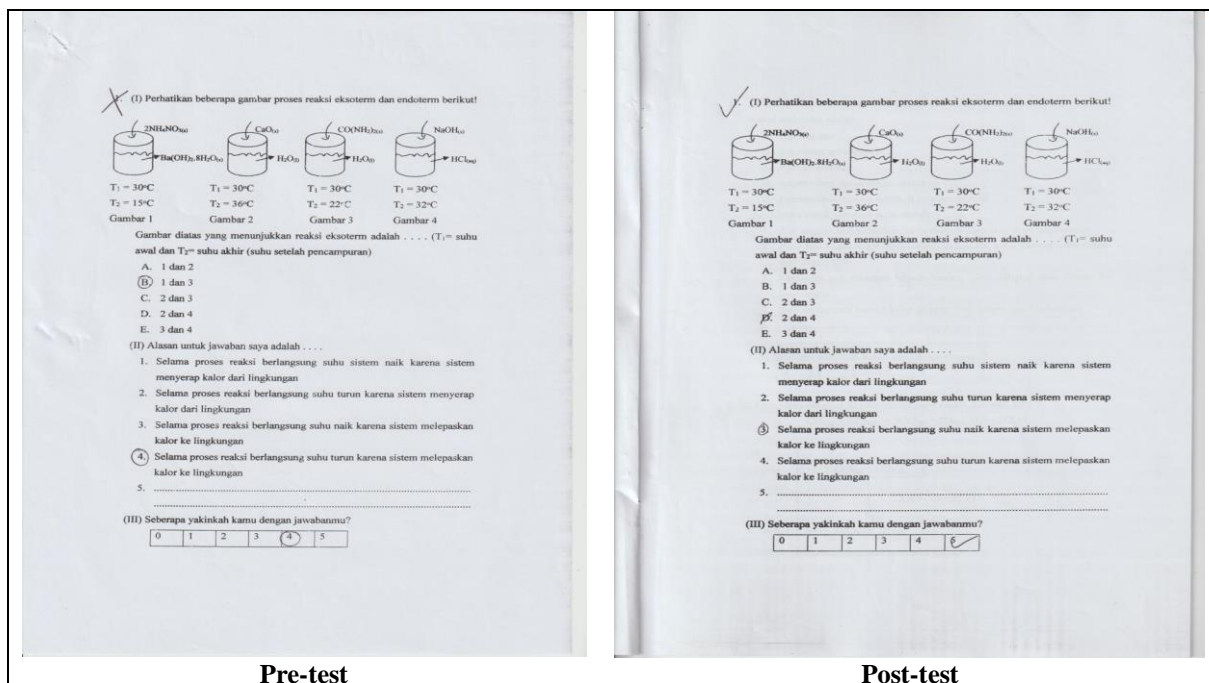


Figure 2. Students' Diagnostic Test Results

Based on Figure 2, there was a change in students' misconceptions, from the misconception into know the concepts, after the inquiry learning model had been applied. After administering the pre-test and post-test, the hypothetical test was conducted.

The hypothetical test was used to investigate the difference in misconception before and after the treatments. The results of the analysis of the hypothetical test can be seen in Table 3.

Table 3. The Results Hypothetical Test

| Classes    | n  | ΣX      | $\bar{x}$ | S    | t <sub>observed</sub> | t <sub>critical</sub> | Description            |
|------------|----|---------|-----------|------|-----------------------|-----------------------|------------------------|
| Experiment | 36 | 1694,42 | 47,07     | 4,10 | 8,81                  | 1,67                  | Hypothesis is accepted |
| Control    | 36 | 1361,11 | 37,81     |      |                       |                       |                        |

Description:

n = Number of students

ΣX = Total misconceptions difference values before and after the treatments

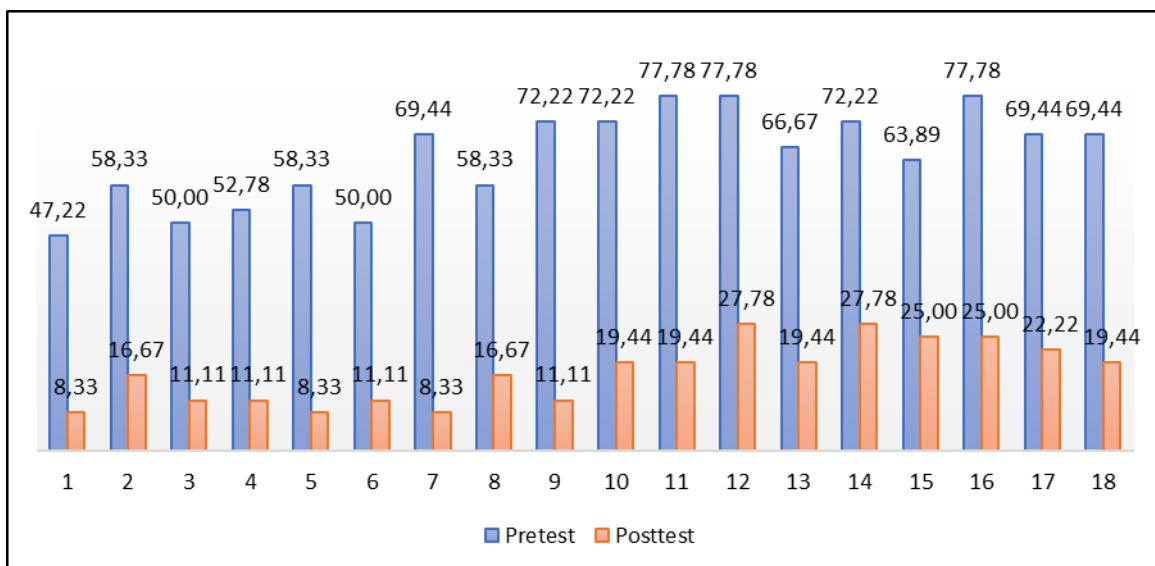
$\bar{x}$  = The average difference values before and after the treatments

S = Combined Standard deviation before and after treatment

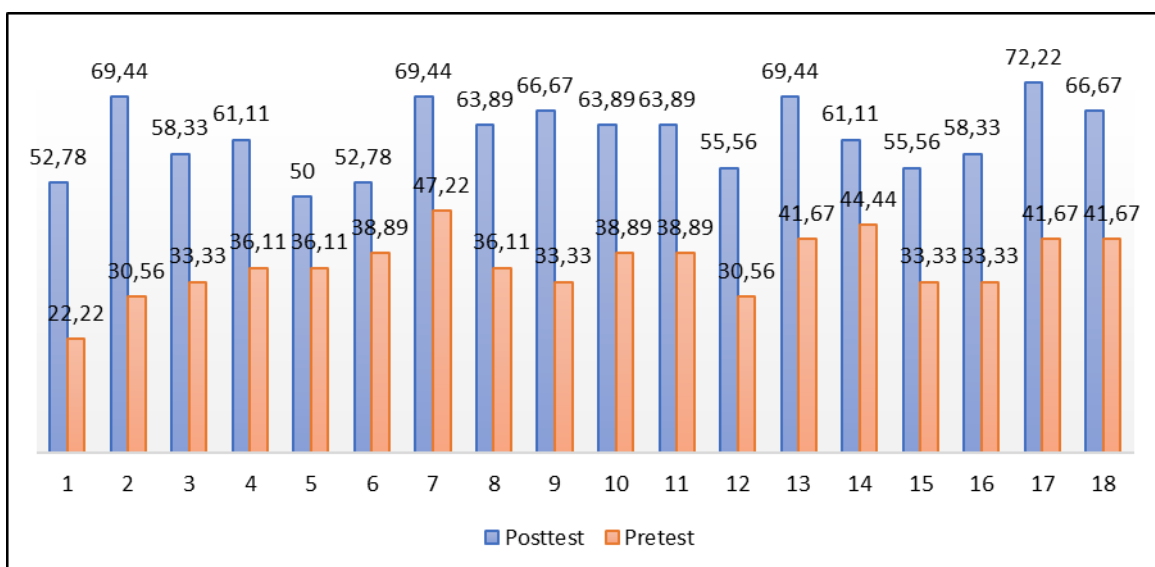
Table 3 shows that the research hypothesis was accepted because it met the criteria of  $t > t_{critical}$  with  $df = n_1 + n_2 - 2$ , criteria probability  $1 - \alpha$  is 1.67. The calculation obtained that  $t_{observed} > t_{critical}$  ( $8.81 > 1.67$ ) which means that the hypothesis was accepted.

The magnitude of the reduction in students' misconceptions on each item in the experimental and control classes can be seen in Figures 3 and 4. It can be seen

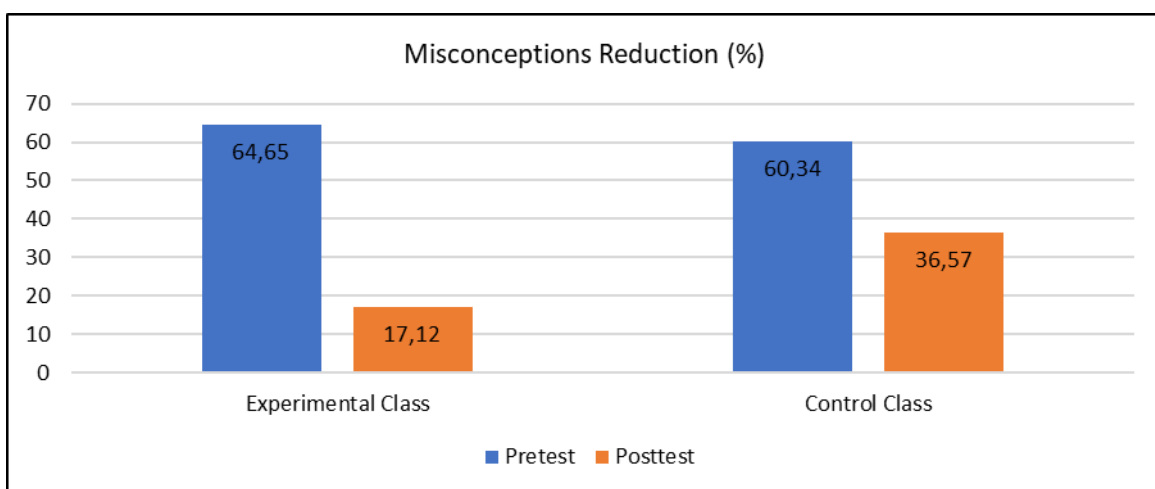
the trends of misconceptions decrease after treatments were administered i.e the misconceptions in post-tests have decreased although the decline in control classes was not as high as the experimental class. The percentage of students' misconception reduction in the experimental and control classes can be seen in Figure 5.



**Figure 3.** The Percentage of Misconceptions Reduction for Each Item in the Experimental Class



**Figure 4.** The Percentage of Misconceptions Reduction for Each Item in the Control Class



**Figure 5.** The Average Percentage of Students' Misconceptions

The moderate reduction of misconceptions with a value of 47.53 % by applying the inquiry model was done to the eleventh-grade students on thermochemical material at SMA N 4 Pekanbaru. Overall, there was a reduction in misconceptions about each item and concept as can be seen in Figures 3 and 4. However, in calculating the enthalpy change based on Hess's law, there was a high misconceptions reduction, precisely in item number 14. Some students understood the concept that Hess's law determines the change of enthalpy in a reaction depends on the initial state and the final state of the reaction. Problem number 14 was mostly answered by choosing option B. After applying the inquiry model, students built appropriate concepts relevant to the question. Students can build their own understanding through activities where they are the center while the teacher acts as a facilitator so that the student learning process can be active (Andrianie et al., 2018).

The inquiry learning model was chosen to reduce misconceptions because its steps can build activeness and responsibility during the learning process and lead students to understand concepts. The guidance given can be in the form of questions and discussions. The steps in inquiry learning in thermochemical material are explained below (Shofiyah, 2017). The first step is an orientation where students are directed to be ready to learn. The teacher sets the classroom atmosphere so that learning can run conducive, explains the rules in the learning process, and explains the learning objectives. The second step is the formulation of the problem where the students are allowed to raise problems regarding thermochemical material. The ability that students must achieve in this step is that they can grasp the phenomena that occur regarding thermochemical

material so that they can determine the priority of the problem and utilize their knowledge to study and analyze the problems.

This ability includes the change of words into other words (for example paraphrasing), images into words, words into images, numbers into words, and so on. Inquiry learning is one of the strategies that can help students formulate problems. Student activities include experimental activities in groups and discuss the observations in the form of data which is then interpreted in graphical form. Then, the students are guided to change the words into equations.

The third step is to formulate a hypothesis. The teacher encourages students to formulate a hypothesis based on the problem in the second step. In the process of formulating problems and formulating hypotheses, the students are required to provide many variations of answers and to generate ideas (Zanzibar et al., 2015). In this activity, students are given directions to provide hypotheses about thermochemical concepts. Next, the students are guided to be able to identify the main characteristics of a concept.

The fourth step is to collect data or information by reading books or literature and conducting experiments to test the truth of the hypotheses. In this step, the first and second meetings are focused on collecting the data by doing a practicum.

The fifth step is evaluating the hypothesis based on the data that has been collected in the fourth step. The students are asked to evaluate through the student worksheets whether the hypotheses are accepted or rejected. The work result of the student worksheet is then discussed. In this step, the students are expected to be able to express one sentence that represents information or the abstract of the theme. This evaluation can be done when the students discuss the data that have been found.



The sixth step is to make conclusions. The students are guided by the teacher to draw conclusions based on hypotheses and use these conclusions to build concepts or theories. The conclusions should include a series of examples or events. Conclusions are formed when students can summarize the concept or principle that consists of a series of examples or events by drawing connections between the characteristics. Next, students work on the evaluation questions.

According to Suardana (2007), the inquiry learning process is oriented towards classroom activity. Students, as a learning center, explore their own knowledge. Activating students optimally in the process of assimilation and accommodation of knowledge and experience according to Piaget (Budinarsih, 2012). Through this inquiry learning model, the students can manage cognitive conflict through stages of inquiry so that scientific concepts are developed that can ultimately reduce and improve students' misconceptions (Ratnaningdyah & Sugiarti, 2018).

The inquiry model activities require students to be active, discover for themselves a concept, and be involved in each step of the learning so that the understanding obtained becomes more meaningful as suggested by Sularso et al. (2017) and Trianto (2009) states that the inquiry learning model means a series of learning activities that maximally involve all students' abilities to critically, logically, analytically, and systematically search and investigate so that they can formulate their own findings with confidence. In the inquiry model, students learn to work hard to bring out their full potential so that they could be more active (Yeritia et al., 2018).

The inquiry learning model encourages students to think and work on their own initiative. It can have a good influence on the learning process and can reduce misconceptions. In the inquiry

learning, the students are demanded to find answers to a problem to increase their activity in learning. Through the application of the inquiry learning model, teachers are expected to be able to carry out learning activities that emphasize the students' activeness in finding their own answers to a problem. If students can achieve the goals set by the teacher, the learning process is considered successful (Oemar, 2003; Putra et al., 2018).

## CONCLUSION

Based on the results and discussion, it can be concluded that there was a moderate reduction in students' misconceptions on thermochemical material by 47.53 % after the inquiry learning model had been applied. The reduction of misconceptions occurred because the inquiry learning model facilitated the students to be accustomed to freely exploring their own learning resources to find the correct concepts of science. Based on the results of this study, an effective learning model was obtained to reduce misconceptions and it is hoped that the inquiry learning model can be applied to other chemistry materials.

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