Research-oriented collaborative inquiry learning (REORCILEA): improving analytical thinking ability of high school students in reaction rate learning

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Abstract. This research aimed to improve students’ analytical thinking ability and to describe the profile of students’ analytical thinking ability in the Research-Oriented Collaborative Inquiry Learning (REORCILEA) in reaction rate learning. A quasi-experimental post-test only control group design had been employed in this research. The sample in this research was the eleventh-grade students of a senior high school in Kroya, Indonesia. The experimental group and control group were chosen by using a random sampling technique. The essay questions of reaction rate consisting of three indicators of analytical thinking ability namely differentiating, attributing, and organizing were used to obtain data on students’ analytical thinking ability. Independent t-test analysis techniques and descriptive quantitative were used in this research. The result showed that the implementation of REORCILEA has a significant influence on the analytical thinking ability of high school students in reaction rate. Profile of students’ analytical thinking ability in REORCILEA for each indicator showed good and very good categories. The implication of this result is that REORCILEA could be used in reaction rate learning to improve students’ analytical thinking ability.

1. Introduction

Chemistry generally presents concepts in multiple representations covering macroscopic, microscopic, symbolic, and mathematical aspects [1]. Chemistry had been considered a difficult subject for students because the concepts of chemistry are abstract and the teaching styles applied in class make students difficult in learning chemistry [2]. Students who are not fully and precisely in understanding the basic concepts of chemistry will have difficulty understanding further chemical concepts. This caused many students to misunderstand basic chemical concepts and it does not change until they enter the university level [3] [4]. One of the topics of chemistry that considered difficult is the reaction rate which is a part of chemical kinetics [5]. Moreover, the reaction rate topic is a fundamental part of chemistry and explains many important chemical concepts.

Fostering higher-order thinking among students was considered an important educational goal [6]. One part of higher-order thinking is analytical thinking ability. According to Anderson and Krathwohl [7], the analytical thinking ability is ability of students to describe concepts into more detailed parts and explain the relationship between these parts and the overall structure. Previous studies showed that analytical thinking can help developing key components in the learning process that are beneficial for
all students [8]. Indicators of analytical thinking abilities are differentiating, organizing, and attributing. Differentiating is the ability to isolate, sort, choose, and focus; organizing is the ability to find, coherence, integrate, describe roles, and structure; and attributing is the ability to determine the point of view or value that underlies the material presented [9].

Based on the 2011 TIMSS (Trends International Mathematics and Science Study) study results, only 2% of students in Indonesia can work on reasoning problems with some missing information [10]. While the results of the 2012 PISA (Program for International Student Assessment) report indicated that less than 1% of Indonesian students can answer questions in complex situations that require mathematical modeling, reflection, conceptualization, generalization, and reasoning, which means that most students in Indonesia cannot work on problems related to high order thinking skills [11]. This shows that it is very important to improve the quality of learning in Indonesia especially in analytical ability.

The use of one learning model sometimes cannot include several learning objectives. Therefore, innovation is needed that integrates several learning models or approaches to improve effectiveness and efficiency in achieving learning objectives. The REORCILEA model is one of the learning models that is expected to overcome this problem. It is an active learning model that integrates the principles of guided inquiry into a collaborative environment that is supported by research-oriented teaching elements that can improve thinking abilities and skills [12]. The syntax of the REORCILEA model includes 5 phases, namely: (a) Initiating, (b) Hypothesizing, (c) Experimenting, (d) Writing, and (e) Evaluating and Reflecting the Learning Process [13]. The objectives of the research is REORCILEA model can improve students’ analytical thinking ability in reaction rate learning.

2. Method
This research employed a quasi-experimental post-test only control group design. The sample was selected using a random sampling technique from eleventh-grade students of a senior high school in Kroya, Indonesia. The experimental group consisting of 34 students were taught by using REORCILEA and the control group consisting of 32 students were taught by using a scientific approach. This course included 2 courses and 4 laboratory sessions for each group in the reaction rate topic.

Students in the control group worked the experiments using cook-book procedures provided by the teacher in the laboratory. While students in the experimental group designed their experiment in groups. The REORCILEA model was adopted from Rohaeti, Prodjosantoso, and Irwanto [12] allowed students to follow a series of learning activities as shown in Table 1.

| Phase         | Activities                                                                 |
|---------------|----------------------------------------------------------------------------|
| Initiating    | Students were faced with unstructured problems and stimulated to solve daily life problems. |
| Hypothesizing | Students asked various questions, claims, and possible solutions based on the empirical evidence that they found. |
| Experimenting | Students worked in small groups to test their hypotheses in the laboratory like true scientists. |
| Writing       | Students collected, organized and presented the data they had obtained in the form of tables, graphs, and charts presented in a written report. |
| Evaluating    | Students were involved to evaluate and reflect on their performance during the learning activities, and to set further learning goals. |
| Reflecting    |                                                                            |

The instrument was tested for validity and reliability before it was used to collect the data. Theoretical validity was obtained from the opinion of expert judgment and the empirical validity was obtained from 116 students who had studied the reaction rate. The data from empirical validity were analyzed using the Rasch model and showed that there were 15 valid items and obtained reliability of 0.84. Therefore, the data collection of students’ analytical thinking ability was carried out using 15 items of essay question of reaction rate consisting of three indicators of analytical thinking ability. The grid of the post-test of analytical thinking ability in reaction rate topic could be seen in Table 2.
Table 2. The grid of post-test of analytical thinking ability in reaction rate topic

| Indicators | Sub indicators                                                                 | No |
|------------|---------------------------------------------------------------------------------|----|
| Differentiating | Differentiating effective and ineffective collisions in chemical reactions.       | 1  |
|             | Differentiating graphs to define the concept of reaction rate.                   | 3  |
| Organizing | Organizing reaction rates by reviewing the factors that affect reaction rates through images. | 6a |
|             | Organizing the factors that affect the reaction rate based on the collision theory. | 6b |
|             | Organizing the experimental data to determine the reaction order.                | 7a |
|             | Organizing a reaction order graph to determine the conclusion of the reaction rate in the experiment. | 7c |
| Attributing | Attributing the results of experiments to the graph of reaction products.         | 5  |
|             | Attributing experimental data to determine the magnitude of a reactant’s reaction order. | 2a |
|             | Attributing experimental data to determine the magnitude of a reactant’s reaction order. | 2b |
|             | Attributing the experimental data to determine the magnitude of the reaction rate. | 2c |
|             | Attributing experimental data to determine the magnitude of the reaction rate at a certain temperature. | 4a |
|             | Attributing experimental data to determine the reaction time at a certain temperature. | 4b |
|             | Attributing an example of the use of catalysts with catalyst works.              | 8a |
|             | Attributing an example of catalyst use with catalyst characteristics.            | 8b |
|             | Attributing an example of the use of catalysts with catalyst types.              | 8c |

An independent t-test was used to test the difference between students’ analytical thinking ability in the experimental group and the control group. Descriptive quantitative analysis was used to analyze the profile of students’ analytical thinking ability in the experimental group. Scores obtained were categorized based on the ideal rating category suggestion by Stiggins [14] into 5 categories, namely very good, good, quite good, less good, and bad. The score of the ideal rating category could be seen in Table 3.

Table 3. Ideal rating category

| Percentage (%) | Category       |
|----------------|----------------|
| 80 ≤ x ≤100    | Very Good      |
| 60 ≤ x ≤ 80    | Good           |
| 40 ≤ x ≤ 60    | Quite Good     |
| 20 ≤ x ≤40     | Less Good      |
| 0 ≤ x < 20     | Bad            |

3. Result and Discussion

The data obtained then performed the Shapiro-Wilk and Levene test to examine the assumption of normality and homogeneity. Shapiro-Wilk test was carried out to test the normality. Based on the result, the data of the analytical thinking ability of students in both groups were normally distributed (sig. > .05) as presented in Table 4.

Table 4. The result of tests of normality

| Group      | Shapiro-Wilk Statistic | df | Sig.     |
|------------|-------------------------|----|---------|
| Experimental | 0.952                   | 34 | 0.142   |
| Control    | 0.972                   | 32 | 0.567   |
The homogeneity test was carried out using the Levene test. The result showed that the data of the analytical thinking ability of students in both groups were homogeneous (sig. > .05) as presented in Table 5.

Table 5. The result of test of homogeneity of variance

|                | Levene statistic | df1 | df2 | Sig. |
|----------------|------------------|-----|-----|------|
| Based on Mean  | 0.355            | 1   | 64  | 0.553|
| Based on Median| 0.315            | 1   | 64  | 0.577|

Furthermore, the analysis was carried out to compare the two groups of students is the parametric comparison analysis of the independent t-test. The results of the t-test analysis of students’ analytical thinking ability were presented in Table 6.

Table 6. The results of t-test analysis of students’ analytical thinking ability

|                | t     | df  | Sig. (2-tailed) | Mean Difference | Std. Error Difference |
|----------------|-------|-----|-----------------|----------------|-----------------------|
| Equal variance assumed | 3.628 | 64  | 0.001           | 11.091          | 3.057                 |

Based on Table 6, students’ analytical thinking ability between the two groups was significantly different with a significance level at 0.001 (Sig. < 0.05). The mean score of students’ analytical thinking ability on reaction rate has a significant difference between REORCILEA in the experimental group and the scientific approach in the control group. The experimental group’s mean score of students’ analytical thinking ability (74.65) higher than the control group’s mean score of students’ analytical thinking ability (63.56).

REORCILEA is a learning model that integrates the principles of several learning models namely guided inquiry, collaborative, and research-oriented learning. Each of these learning models has the advantage of optimizing the learning process and making students more active and independent in the learning process to enhance higher-order thinking skills. Research-Oriented Collaborative Learning (REORCILEA) is a systematic, methodological, and consistent investigation effort to test the truth to produce new knowledge by utilizing laboratories, including designing, implementing, and communicating research results in an integrative way [13]. Educational programs and pedagogical practices need to improve students’ performance through laboratory work. Students need to be given challenging tasks and actively involved in discoveries supported by research-oriented collaborative inquiry learning [15].

Analytical thinking is closely related to academic achievement, self-efficacy, scientific reasoning, problem-solving skills, and creative thinking. This indicates that the development of analytical thinking skills through inquiry learning can have a positive impact on cognitive skills, so the development of analytical thinking skills can greatly support students’ academic achievement. This is in line with research conducted by Zaini [16] which showed that guided inquiry-based learning has a significant influence on students’ cognitive learning outcomes. Mistry, Fitzpatrick, and Groman [17] also stated that the application of guided inquiry learning models can improve problem-solving skills and understanding students’ chemical concepts.

In addition, previous research about the effect of collaborative learning showed that collaborative learning improves student learning achievement [18]. This is because interactive learning processes such as discussion, commenting, and reflection involve more intense interaction between the teacher and students so they can provide a better academic focus. Research-oriented learning integrated into the REORCILEA model aimed to connect the learning process in theory and practice. In line with this, previous research showed that research-teaching relationships were interrelated and dynamic which has a positive impact on students in learning [19].

The REORCILEA model succeeded in increasing students’ analytical thinking skills because the REORCILEA model placed students at the center to actively build knowledge and interpret the experiences they had gained. Students were given the opportunity to discuss and collaborate in the
construction of new knowledge so that students can evaluate existing knowledge with new knowledge. The learning process using the REORCILEA model also encourages students to solve problems independently by asking questions, gathering information related to the problem, proposing answers, and communicating the results.

The results of the percentages and categories of each indicator of analytical thinking ability in REORCILEA were presented in Table 7.

| Indicators  | Percentage (%) | Category  |
|-------------|----------------|-----------|
| Differentiating | 75.4           | Good      |
| Attributing   | 72.2           | Good      |
| Organizing    | 83.1           | Very Good |

The results in Table 7 showed that the profile of students’ analytical thinking ability that followed the learning by using the REORCILEA model on the organizing indicator had the highest percentage of 83.1% with a very good category, the differentiating indicator had a percentage of 75.4% with a good category, and the lowest percentage is the connecting indicator of 72.2% with a good category. Organizing information was a process needed to analyze so that larger information will be obtained and will produce a good understanding [20]. Students trained to understand the information fully, in detail, and able to connect between components so it could improve the ability to differentiating. Students who actively participate in learning activities by practicing individually or in small groups will have significant analytical ability including finding relationships and reasons [21]. The ability to differentiate in analytical thinking is the ability to differentiate relevant and irrelevant parts of an object presented.

REORCILEA model could improve the ability of students to connect experimental data into a reaction rate concept. The learning process using the REORCILEA model makes students actively involved in problem-solving so that students could improve their problem-solving abilities such as the ability to connecting between problems, elaborating information, interpreting data to solve problems, and formulate hypotheses.

4. Conclusion

Based on the research, it was concluded that the implementation of REORCILEA has a significant influence on the analytical thinking ability of high school students in reaction rate learning. The mean score of students was taught with REORCILEA is higher than students were taught with scientific approach. The profile of students’ analytical thinking ability in REORCILEA for differentiating indicators had good category, attributing indicator had good category, and organizing indicator had very good category. The implementation of the REORCILEA model was a form of innovation and alternative learning models that can be applied to improve students’ analytical thinking ability. The REORCILEA model also could be used to connecting learning theory and practice, especially in science learning.

5. References

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Acknowledgments
Special thank to the Ministry of Education and Culture Indonesia by supporting fund via Hibah Pasca year 2020.