

Research-Oriented Collaborative Inquiry Learning Model to Improve Students' Science Process Skills in Reaction Rate Topic

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ABSTRACT

This research aimed to improve students' science process skills and to describe the profile of students' science process skills in the Research-Oriented Collaborative Inquiry Learning (REORCILEA) in reaction rate learning. A quasi-experimental design had been employed in this research. The sample in this research was the 11th-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 observation sheet consisted of 15 indicators developed from 9 aspects of science process skills namely designing an experiment, identifying variables, formulating hypotheses, measuring, experimenting, observing, interpreting data, inferring, and communicating were used to obtain the data on students' science process skills. 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 science process skills of high school students. Profile of students' science process skills in REORCILEA in each indicator showed good and very good categories. REORCILEA model could be considered an effective strategy in improving students' science process skills.

Keywords: Reaction rate, Research-Oriented Collaborative Inquiry Learning, Science process skills

1. INTRODUCTION

Teaching and learning activities in chemistry are inseparable from the laboratory. Activities in the laboratory are related to scientific performance that requires skills. One of the most relevant skills in learning chemistry to facilitate teamwork is the science process skills [1]. Science process skills in the context of 21st-century learning can't be separated from chemistry learning. According to [2], science process skills are procedural skills for conducting experiments to increase scientific thinking abilities. Science process skills not only to explore their conceptions of scientific concepts but also construct scientific concepts in their cognition structures [3].

Science process skills are generally grouped into basic and integrated process skills. Basic science process skills are skills that students generally performed when doing science [4]. Indicators of basic science process skills include skills in observing, measuring, inferring, and communicating. Integrated

science process skills are terminal skills for solving problems or conducting science experiments [5]. If students have mastered basic science process skills, it will be easier to apply Integrated science process skills. Integrated science process skills indicators include skills in formulating hypotheses, identifying variables, designing experiments, experimenting, and interpreting data [6].

Besides directing students to apply basic and integrated skills, science process skills need to be applied to students because it will indirectly involve them in various inquiry activities [7]. Science process skills provide a more meaningful learning experience for students. Therefore, science process skills have a great impact on learning chemistry because they can help students to expand higher thinking skills, such as critical thinking, conclusion making, and problem solving [8]. Science process skills require scientific thinking and creativity to evolve new methods and solutions to solve problems [9], so that is very appropriate when applied in the chemistry learning

process that involves the process of thinking and reasoning.

However, there are many indicators of science process skills that have never been trained in the laboratory activity so that learning in the laboratory does not run optimally. The previous research showed that science process skills in students were still unsatisfactory [10]. The low science process skills of students can be caused by practicum activities in the laboratory have been limited to only practicing the practical guide book so that students are less involved in scientific practice and the laboratory activities provide fewer opportunities to develop science process skills. This is in line with previous findings that stated that students only carry out laboratory procedures that have prepared by the teacher [11]. Laboratories have an important role in learning chemistry. Besides, laboratory activities provide a chance for students to develop inquiry skills [12].

Students perceive chemistry as a difficult subject because the chemical concepts are abstract and teaching styles applied in the classroom are the causes of difficulties in learning chemistry [13]. One of the chemical materials considered difficult by students is the reaction rate [14]. Reaction rate material includes several sub-topics, namely the concept of reaction rate, reaction order, and factors that affect the reaction rate. Many students have difficulty understanding the concept of collision theory and the factors that affect the reaction rate because students were used to memorizing concepts only. The reaction rate is a chemical material that has many concepts that must be proven and associated with laboratory experiments. Students must be trained to find and build their own concepts. Building concepts in students is a process of solving a problem that can be done through experiments.

The research-oriented collaborative inquiry learning model is one of the learning models that is expected to overcome this problem. Research-oriented collaborative inquiry learning is a systematic, methodological, and consistent investigation to test truth to produce new knowledge by utilizing laboratories, from designing, implementing, to communicating practicum results [15]. When students involve in experiments in the laboratory, they will improve their process skills and obtain scientific skills that have a positive impact on learning achievement [16]. REORCILEA learning model is a learning model that is able to connect learning activities in theory and learning activities in practice.

Inquiry-based learning encourages students to seek and find new knowledge independently, therefore learning activities tend to be student-centered, democratic, and interactive. Students build knowledge based on new information and data obtained from an exploratory learning environment. Collaborative learning encourages collaboration between students to work actively and together in groups to optimize their own learning and those of other students. Each student of the group has equal responsibility and they contribute to each other so that the interaction allows them to develop cognitive skills and social skills. Research-oriented learning requires students to take an active role in a series of scientific activities. Students were design, conduct, and analyze experiments in the laboratory independently so that it helps students to connect several different concepts and construct new knowledge better. The syntax of the REORCILEA model includes 5 phases, namely: (a) Initiating, (b) Hypothesizing, (c) Experimentating, (d) Writing, and (e) Evaluating and Reflecting the Learning Process [17]. Regarding the explanation, the objectives of this study are improved students' science process skills and described the profile of students' science process skills in the Research-Oriented Collaborative Inquiry Learning (REORCILEA) in reaction rate learning.

2. RESEARCH METHOD

2.1. Research Design and Procedure

This research was a quasi-experimental design. The sample consisted of the experimental and control groups from eleventh-grade students in the second semester of the 2019/2020 academic year in a senior high school in Kroya, Indonesia that selected using a random sampling technique. The experimental group students were taught using REORCILEA, while the ones in the control group were taught using a scientific approach. A total of 34 students in the experimental group and 32 students in the control group. This course included a total of six 100 min courses with four 100 min laboratory sessions in reaction rate topic. Students conducted experiments in the laboratory on the topic of factors that influence the reaction rate (concentration, surface area, temperature, and catalyst). Students in the control group were taught using a scientific approach and using a practical guidebook in laboratory sessions provided by the teacher. Meanwhile, students in the experimental group were taught using the REORCILEA model which was adopted from [17] as presented in Table 1.

Table 1. The syntax of REORCILEA in experimental group

Phase	Activities	Teaching Intervention
Initiating	Students were faced with unstructured problems and stimulated to solve daily life problems.	Students were given problems regarding the factors that affect the reaction rate.
Hypothesizing	Students asked various questions, claims, and possible solutions based on the empirical evidence that they found.	Students were directed to make questions about these problems and make hypotheses from the questions chosen by the teacher.
Experimenting	Students worked in small groups to test their hypotheses in the laboratory like true scientists.	Students were directed to formulate experimental objectives, determine variables, design experiments, conduct experiments, and observe experiments regarding concentration factors that affect reaction rate.
Writing	Students collected, organized and presented the data they had obtained in the form of tables, graphs, and charts presented in a written report.	Students were directed to write the experimental data into tables and graphs, then students write reports of experimental results and conclusions.
Evaluating and Reflecting	Students were involved to evaluate and reflect on their performance during the learning activities, and to set further learning goals.	Students answered questions that have been provided by the teacher and present the results of the experiment.

2.2. Data Analysis

The collected data were analyzed using independent t-test and descriptive quantitative. Observations were made four times during the meeting in the laboratory. An independent t-test was used to analyze the difference between students' science process skills in the experimental group and students' science process skills in the control group, while the descriptive quantitative was used to analyze the profile of students' science process skills in the experimental group. The scores obtained were converted to percentages and then categorized. Percentage of science process skills calculated by the equation:

$$\bar{X} = \frac{\Sigma X}{n} \times 100\% \tag{1}$$

\bar{X} = percentage value, ΣX = raw value obtained, and n = maximum score. The percentage of students' science process skills was categorized based on Stiggins' suggestion of the ideal rating category [18]. There were 5 categories, namely very good, good, quite good, less good, and bad. The maximum ideal

score and minimum ideal score in this calculation assessment category were 100 and 0. The ideal rating category scores are presented in Table 2.

Table 2. Assessment category

Percentage (%)	Category
$80 \leq x \leq 100$	Very Good
$60 \leq x \leq 80$	Good
$40 \leq x \leq 60$	Quite Good
$20 \leq x \leq 40$	Less Good
$0 \leq x < 20$	Bad

2.3. Data Collection Instrument

Data collection of students' science process skills was carried out using an observation sheet which consisted of 15 indicators developed from 9 aspects of science process skills according to [6] as in Table 3.

Table 3. The grid of science process skills’ observation

Aspects of Science Process Skills	Indicators of Science Process Skills
Designing experiment	Formulate the experimental objectives
	Designing an experiment
	Preparing tools and materials to be used
Identifying variables	Determining the dependent, independent, and control variables
Formulating hypotheses	Formulating hypotheses
Measuring	Read the volume of liquid in a graduated cylinder correctly
Experimenting	Using a dropper
	Using an analytical balance
	Using a stopwatch
	Cleaning the equipment after use
Observing	Observing experiments
Interpreting data	Drawing and explain an experiment graph
	Writing down the equation of the reaction involved in the experiment
Inferring	Formulating the conclusion of an experiment
Communicating	Preparing and communicating the reports

3. RESULT AND DISCUSSION

3.1. The Differences Students’ Science Process Skills Between the Two Groups

Shapiro-Wilk test and Levene’s test were performed to examine the assumption of normality and homogeneity before an analysis using an independent t-test. Based on the results, the data in both groups are homogeneous and normally distributed ($sig. > .05$) as shown in Table 4.

Table 4. The normality and homogeneity test for the data of observation

Groups	Normality	Homogeneity
Experimental	.181	.906
Control	.138	

There is a difference in the mean score of science process skills in students who taught using REORCILEA in the experimental group and students who taught using a scientific approach in the control group. The experimental group’s mean score of students’ science process skills (81.09) higher than the control group’s mean score of students’ science process skills (56.46). Therefore, further analysis to compare the two groups of students is the parametric

comparison analysis of the independent t-test. The results showed that students’ science process skills between the two groups are significantly different with a significance level at .000 ($Sig. < .05$). The results of the independent t-test analysis are presented in Table 5.

Table 5. Results of t-test analysis on the students’ science process skills

t-test for Equality of Means					
	t	df	Sig.	Mean Diff.	Std. Error Diff.
Equal variance assumed	23.603	64	.000	24.632	1.043

Science process skills are behaviors that encourage the formation of learners’ skills to gain knowledge and increase the use of mental and psychomotor skills [19]. 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 advantages in optimizing the learning process and making students more active

and independent in the classroom and laboratory learning process so that this learning model can improve the thinking ability at a higher level and students' science process skills. Practical activities in the laboratory may motivate the students in the reaction rate learning. The REORCILEA model directed students to design their own experiments. The students in the experimental group more actively involved in the experiments than students in the control group who only follow the cookbook provided by the teacher. The students who taught using the REORCILEA model are directed by the teacher to formulating the experiment objectives, identifying variables, and formulating hypotheses before designing the experiment so that the learning process in the experimental group will be more meaningful than the control group and students' scientific process skills can be improved. This is in line with previous research which reported that research-based learning can improve the skills of students during the research process [20]. Other research stated that the application of guided inquiry can improve students' abilities in designing experiments and can encourage students to learn actively and independently [21].

3.2. Profile of Students' Science Process Skills in REORCILEA

The result of the students' science process skills in the experimental group which taught using REORCILEA can be seen in Figure 1.

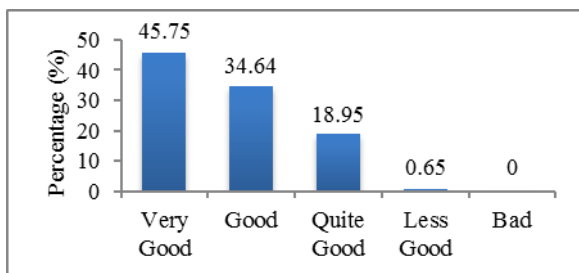


Figure 1. The category of students' science process skills

As presented on Figure 1, students' science process skills in a very good category were highest (45.75%). Moreover, students' science process skills in the good category (34.64%) also had a high percentage. While for quite good category (18.95%) and less good category (0.65%) had a low percentage. The students with the science process skills category were bad is 0%. This showed that many students who were taught using the REORCILEA model have good science process skills.

The aspects of designing an experiment, identifying variables, formulating hypotheses, experimenting, observing, and inferring have very good categories. While aspects of measuring, interpreting data, and communicating have good categories. The highest percentage is in the aspect of observing (88.97%) and the lowest percentage is in the aspect of measuring (63.79%). Profile of the students' science process skills was taught using REORCILEA model based on percentages and ideal rating category in each aspect can be seen in Table 6.

Table 6. Percentage and category of students' science process skills in REORCILEA

Aspects of Science Process Skills	Percentage (%)	Category
Designing experiment	80.76%	Very good
Identifying variables	88.24%	Very good
Formulating hypotheses	86.95%	Very good
Measuring	63.79%	Good
Experimenting	85.52%	Very good
Observing	88.97%	Very good
Interpreting data	72.61%	Good
Inferring	84.01%	Very good
Communicating	77.34%	Good

Students look more confident when observing the experiments because they are directed to design experiments independently so that students more understand the steps of the experiments being carried out. Students who were taught using the REORCILEA model are more motivated and more engaged in experimenting. The measuring aspect is in a good category but has the lowest percentage compared to other categories. In the measuring aspect, students must read the volume on the graduated cylinder correctly. But, in fact, many students do it in such a hurry and they are ignoring how to read the graduated cylinder volume properly. They are not placing the graduated cylinder on a flat surface when reading the volume. Moreover, some students did not place their eyes parallel to the meniscus when reading the scale volume.

Students in the phase of hypothesizing performed indicators of formulating hypotheses from questions they make before. In the hypothesizing phase, students formulating hypotheses from questions they make before. In the experimenting phase, students performed some science process skills indicators, including formulating experimental objectives,

identifying variables, designing experiments, preparing tools and materials to be used. Aside from that, students conducting experiments such as using a dropping pipette, using an analytical balance, using a stopwatch, reading the volume of liquid in a graduated cylinder, observing experiments, and cleaning experimental equipment after use. Besides writing reports on the experiment results in the writing phase, students also drawing and explaining experimental graphs, writing reaction equations, and formulating experimental conclusions.

Through collaborative inquiry learning in a research-oriented learning environment, students interact with tools, materials, and objects to find solutions to the problems. Collaborative learning that supports teamwork, exchange of ideas, and giving responsibilities is a major factor in developing students' science process skills. The REORCILEA model is an effort to achieve learning objectives more effectively by using science processes skills systematically and intensively. The development of science process skills is one of the goals of science learning to increase independence, curiosity, and problem-solving skills [22]. Previous research showed that inquiry-based learning can improve students' science process skills [23]. This is because, in inquiry-based learning, students were trained to be actively involved in problem-solving. Also, the discussion activities can improve students' skills in designing experiments because they can exchange ideas with others so that students' creativity can be increased.

The time of learning process was different between the experimental group and the control group may affect the performance of students. The learning process implementation time was different between the experimental group and the control group may affect the performance of students in each group. In addition, students were not familiar with changing the learning model, so they found it difficult to follow the learning stages. The application of the REORCILEA model can be used as a form of innovation and an alternative learning model that can be applied in the classroom. REORCILEA model can be used to connect between theoretical and practical learning, especially in science learning.

4. CONCLUSION

Based on the research, it was concluded that the implementation of REORCILEA has a significant influence on the students' science process skills in reaction rate learning. The profile of the science process skills of students was taught using the REORCILEA model for aspects of designing an experiment, identifying variables, formulating

hypotheses, conducting experiments, observing, and inferring have very good categories. While aspects of measuring, interpreting, and communicating have good categories. Research-oriented collaborative inquiry learning model must often be applied in schools to improve students' science process skills.

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