



THE EFFECTIVENESS OF INQUIRY-BASED SCIENCE LEARNING BY FUTURE TEACHER OF ELEMENTARY SCHOOL

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Abstract

This research aims to investigate the effectiveness of science inquiry-based module with the authentic assessment to develop students' inquiry skills and critical thinking. This research employed a quasi-experiment method with pretest-posttest control group design. This research is conducted on the 5th grade of one of Junior Elementary School in Pontianak, by using two classes as a sample. The data was collected by using inquiry skills observation sheets, and interview. The result shows that the mean of inquiry skills scores of experiment group is higher than the control group, and the significance score from using t-test is $(0.00) < 0.05$, which means there is a difference of inquiry skills in the experiment and control group. A score of N-gain shows that the mean of experiment group's inquiry skills scores after the treatment is higher than the control group. It concludes that science learning by using inquiry-based is effective to develop students' inquiry skills.

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INTRODUCTION

Students' involvement in the investigation during learning process is mainly needed for science learning. It is in line to science learning of finding information of nature systematically. Learning science is the not only mastering group of facts, concepts, or principles, but also a process of discoveries (Depdiknas, 2006). Thus, in learning science, teachers are not only explaining facts, concepts, or principles verbally, science process also needs to be trained instead.

Science and inquiry process are inseparable, since current curriculum, Curriculum 2013, emphasize on direct experience in developing students' competence. Therefore, students can understand their surrounding scientifically or possessing inquiry ability. Buck *et al.* (2007) find that inquiry-based science learning gives positive impact or resulting complete and meaningful understanding, whether in the content or skills. It is emphasized that the characteristic of inquiry-based learning should cope authentic learning, importance of data, collaboration between students and teachers, relation between students and local community, demonstration of scientific behavior, development of students' skills, digging students' questions, freedom of scientific working, building explanation and concept based on data, and implementing science knowledge (Aulls and Shore, 2009; Hwang *et al.*, 2013; Setiawan *et al.*, 2016).

It is strengthened by research of Rosnita *et al.* (2011) that inquiry skills of future teachers can be developed through science learning by giving more chance to them to be active in doing real learning experience; students are trained how to observe, ask, answer question from investigation, making decision, and be responsible for their job.

The investigation is critical in science learning (Fraser, 2015). Nonetheless, facts from initial observation showed that in some elementary school in Pontianak were found that: 1) the learning process was centered to the teacher; thus, it limited students' potentials; 2) students' activities are mostly listening and noting what their teachers explained. The activities are dominated by memorizing and oral explanation to master the material; thereby, students cannot develop their ability in thinking and working scientifically; 3) the

scoring done by teachers was limited to content, paper, and pencil test, while scoring in skills and behavior were not done optimally; and 4) experiments were rarely done.

One of the morel in developing curiosity and students' scientific thinking is inquiry learning. This learning is a learning model referred to students' activity and developing their knowledge (Nugent *et al.*, 2008). Previously, Windschitl (2003) explains that inquiry model can improve future teachers' perspective to inquiry activity, concept mastery, and communication. Moreover, in inquiry model, knowledge can be built by students; thus, they can learn independently in facing related science problems Artigue and Blomhøj (2013). National Research Council (1996) states that inquiry learning is a learning model involving activities that students can observe, asking questions, reviewing books and other literature, planning the investigation, previewing experiment result, analyzing, interpreting data, proposing answers to data, giving an explanation to prediction, and communicating results. Inquiry learning model is ideal for elementary school students and is proven able to improve students' learning result and skills (Pyle, 2008).

Some opinions and research results from experts are showing that inquiry learning is purposed to develop students' thinking through logical, critical, and systematic investigation of certain facts, concepts, and principles, that inquiry skills and thinking of students can be developed. Mao and Chang (2011) state that inquiry and thinking skills are the cognitive ability which is needed effectively to identify, analyze, and evaluate true arguments or claims, find and handle subjective presumption, formulating and delivering right reasons to support the conclusion; that it will be logical, and making the trusted decision. Inquiry and thinking skills are also influential to the academic and professional success of students in the future (Keys and Bryan, 2000). In inquiry-based science learning, every activity can be scored; for example, in the experiment, teachers can score the process or the product while students are doing group discussion, collecting data, answer problems/questions, concluding, creating the hypothesis, planning experiments, and doing the measurement. Therefore, students' achievement in

cognitive, affective, and psychomotor aspect can be known quickly and continuously in different type of assessment; thus, teachers are eased in giving the feedback. The scoring involves three aspects is authentic scoring in test or non-test.

The reality in some elementary school in Pontianak, some teachers were still using conventional learning method; which is dominated by them. It is in line to Keys and Kennedy (1999) that learning model which is centered to teachers are still used in the learning process; as they think that inquiry learning model is challenging to apply. According to Rustaman (2005), one of the problems in applying inquiry learning is related to teachers' preparation. A limited number of the lecturer who facilitated students to teach with inquiry-based learning is one of the problems. The observation in the higher educational institution which produces future elementary school teachers in Pontianak showed that inquiry model was rarely taught since teachers were not habituated and trained to inquiry activities. Teachers were not skillful in applying inquiry model in the learning process. In science, teachers tend to dominate the class making students absorbed more than enough. Therefore, inquiry-based learning in science can help students individually or collectively to implement inquiry steps in the investigation; later, students' inquiry skills can be developed. In accordance to that, this research is made to answer the problems of the effectiveness of inquiry-based learning in science to future teachers in developing students' inquiry skills.

METHODS

This research was purposed to unveil the effectiveness of inquiry-based learning in science to future teachers in developing students' inquiry skills. This research was designed as quasi-experimental research in SD Negeri (State Elementary School) in Pontianak in the material of substance and its transformation. The design of this research was done in pretest-posttest control group design (Gall *et al.*, 2003). The design of this research can be seen in the following figure.

	Pretest	Treatment	Posttest
Experiment Class	O ₁	X	O ₂
Control Class	O ₁		O ₂

Note:

O₁ : pretest
O₂ : posttest
X : Treatment

In this research, the pretest was given to students in experiment class (inquiry-based learning) and control class (traditional learning) before the materials were given. After that, the posttest was given to the class after the treatment was given to the experiment and control class.

The population in this research was all students of V grade in SD Negeri 03 Pontianak in 3 classes. The sampling method in this research used random cluster sampling because the homogeneity test showed that the average score of the daily test of science was homogenous. The chosen sample was VA class of the experiment class (inquiry-based learning) and VB class as the control class (conventional learning/ lecturing and experiment guided by students' worksheet).

The primary variables in this research were dependent and independent variables. The independent variable was inquiry-based science learning to experiment class, and conventional science learning to control class. The dependent variable of this research was inquiry skills. The methods of collecting data in this research were the measurement of tools in collecting inquiry skills test and observation sheets. The observation sheet was used to measure experiment class students' inquiry skills while they are learning "substance and its transformation". The aspects of inquiry skills observed included observation, formulating problems, hypothesis, using tools, interpreting data, concluding, and communicating. Completely, inquiry skills aspect and its indicators can be seen in Table 1 as follows.

Table 1. Inquiry Skills and Indicators

No	Inquiry Aspects	Indicators
1	Observation	<ul style="list-style-type: none"> • Using many sense organs • Obtaining many data
2	Formulating Problems	<ul style="list-style-type: none"> • Formulating brief questions • Delivering problems related to variables, dependent and independent
3	Formulating Hypothesis	<ul style="list-style-type: none"> • Delivering questions to find topic and planning research • Choosing questions through inquiry • Creating hypothesis • Making prediction supporting the hypothesis
4	Using Tools	<ul style="list-style-type: none"> • Identifying research variables (dependent and independent), and explain how to measure and observe • Determining qualitative or quantitative data • Planning research steps to answer questions about the problems
5	Analyzing Data	<ul style="list-style-type: none"> • Making logical interpretation or inference based on the data • Identifying tendency between variables
6	Communicating Result of the Investigation	<ul style="list-style-type: none"> • Using oral, table, graphic presentation to deliver the result of the research • Preparing written report from the research, including problems, hypothesis, tools/materials, working procedures, discussion, and conclusion

The interview referred to the analysis of observation data to support the data of inquiry skills test and observation results. The analysis of data was collecting the result of the research in every inquiry skills. The average score of students' inquiry skills was determined by adding the score for every aspect of the skills added to the total of students' score divided by the total of the students. Then, the identification of inquiry skills among students in both class used the hypothesis test using SPSS at a significance level of 5%.

The effectiveness of this research can be seen from the improvement of students' inquiry skills before and after inquiry-based learning using normalized gain equation as follows (Meltzer, 2002).

$$\text{N-Gain} = \frac{\text{Posttest score} - \text{Pretest score}}{\text{Ideal score} - \text{Pretest score}}$$

Normalized gain criteria (g)

$$\begin{aligned} g < 0.3 & : \text{low} \\ 0.3 \leq g \leq 0.7 & : \text{medium} \\ 0.7 \leq g & : \text{high} \end{aligned}$$

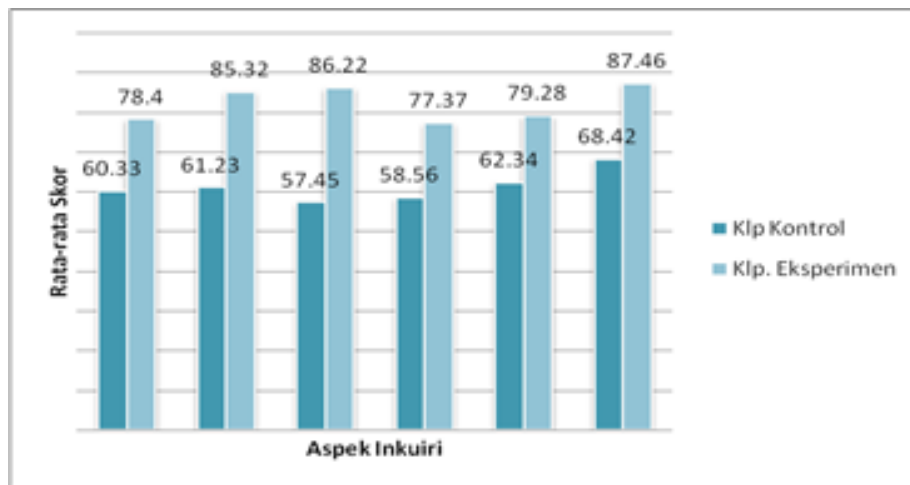
The obtained data from skills test and observation sheets was measured again in normality test with data distribution using Shapiro-Wilk, since the samples < 50. If normality test showed normal distribution, it was continued with homogeneity test to know data distribution using Levene's Test of Equality of Error Variance. To answer this hypothesis, the researcher used paired t-test asymp. Sig (2-tailed).

RESULTS AND DISCUSSION

Results

Based on the data collection of the research, the inquiry skills in experiment and control class are obtained in Figure 1. Figure 1 showed that the average skills of inquiry in experiment class were higher than control class in all aspects (writing observation result, formulating questions based on

data, writing hypothesis based on facts, writing observation result based on table observation, writing conclusion based on the problems, and delivering the results of the experiment to other groups in class discussion). Therefore, inquiry-based learning can improve students' inquiry skills. The testing of the hypothesis was done after the required test, normality test in all data of inquiry skills.



Inquiry Skills Aspects

1. Observing
2. Asking
3. Hypothesis
4. Using Tools
5. Analysis
6. Concluding

Figure 1. Average Score of Students' Inquiry Skills

The result of normality test with Shapiro-Wilk obtained data as follows:

Group	Inquiry Skills		
	Statistic	Df	Sig.
Control	0.840	30	0.066
Experiment	0.845	30	0.104

The significance > 0.05 . It meant the data was normal. It is because all data were normally distributed; therefore, homogeneity test was done subsequently. The result of homogeneity test can be seen as the significance > 0.05 for all data, meaning that the data was homogenous. Since all required test was fulfilling the requirement, it was continued with a hypothesis test.

The result of hypothesis test using paired t-test obtained significance of 0.00 less than 0.05; thus, H_0 is rejected. It meant there was a difference between students with inquiry-based treatment to conventional one. Therefore, science learning based on inquiry learning was proven influential to students.

Based on N-gain score measurement, the average score of inquiry skills in control class was 0.25 (low), and in the experiment, the class was 0.70 (medium). It can be concluded that inquiry-based learning on science was sufficient to improve students' inquiry skills to medium level. The thing showed that students' inquiry skills were improved after the inquiry-based treatment.

Discussion

Based on the hypothesis of the research, it can be concluded that there was a difference in inquiry skills to experiment and control class. Therefore, inquiry-based learning on science was proven effective to improve students' scientific skills. Experiment group got inquiry-based learning with average skills better than control class. This idea is in line with the research conducted by Buck *et al.* (2007) to the inquiry that it improves the absorption of first knowledge and students' involvement in the learning process. Then, Aulls and Shore (2009) conclude that science processing skills and students' scientific skills can be improved in inquiry-based learning. Rosnita *et al.* (2011) find that future teachers' inquiry skills can be developed through science learning with more chance to them to be active in doing real learning experience; students are trained how to observe, ask, answer the question from the investigation, making the decision, and be responsible for their job.

Learning with inquiry-based allowed students to discover knowledge and critical attributes stimulated by the investigation, centered on students, independent learning, and active approach. It is strengthened to Pyle (2008) saying that inquiry can improve students' scientific literacy and well learning process. Then, in the research conducted by Mao and Chang (2011), the inquiry process and understanding can be improved from such learning model.

The high average score of inquiry skills in experiment class than in control class is caused by experiment class used inquiry-based learning with the investigation. Investigation helped students in finding the concepts independently. Besides, students were motivated in learning because there were many activities should be done by them. Students' involvement in learning became higher than before. Windschitl (2003) states that inquiry is an activity in which many activities should be done by students, like observation, making questions, reading resources book and literature, planning investigation, reviewing back to obtain evidence, analysis, and data interpretation, finding answers, explanation and prediction. These activities should be done to improve students' positive behavior in learning science Keys and Kennedy (1999).

Inquiry-based learning in science makes students enthusiastic in following every step of inquiry activity. This curiosity can be seen more evident when the students experimented. Students became more curious and enthusiast to see the result of the investigation. These activities can train students to

consider the decision in facing problems in their life asking them to make the critical decision. The students have got the capitals of how to make a correct decision.

The existence of clear direction to every inquiry activities through guided questions can help students in finding answers to questions in their worksheets. In the experiment class, the use of tools and materials for the experiment was by working procedures. The result of the observation showed that the experiment should be done correctly, conscientiously, and thoughtfully. In the trials, the obtained data by the students in experiment class was reported entirely and organized in an excellent handwritten report. Meanwhile, the data in the control class was not complete and inorganized with minor mistakes. The result of data analysis showed that students in experiment class were more skillful than in the control class. This result is the same to Pujani and Liliasari (2011), saying that students who know how to use experiment tools will be impactful to their psychomotor. Thus, students in experiment class had an excellent psychomotor and practicum result better than the control class.

Therefore, inquiry skills can be developed by students in the learning process. The investigation done by students were the same to the scientists, the steps included: a) proposing questions regarding natural phenomena; b) formulating problems related to natural phenomena; c) formulating hypothesis; d) planning investigative approach; e) conducting investigation; f) making synthesis from the knowledge; and g) possessing scientific behavior (Nugent *et al.*, 2008).

From all inquiry aspects, the highest score in experiment class and control class was observing (indicator: writing observation in details). In observation, students did the observation in details to find information. The interview with science teacher obtained information that these times, students were adapted experiment and made an individual report to it. Thereby, students had been adapted to report the experiment based on fact in the practicum.

The result of observation of both classes showed that students had followed the procedures for the experiment; somehow, many students in control class did not do the tasks in their worksheet completely and correctly. Furthermore, the interview data were not

obtained completely, since the students did not have enough time to think, and they considered it was not worth a good score for them. The interview to science teachers showed information that students' worksheet was only submitted without any proper feedback. It was different to experiment, class, where every student was given an inquiry-based students' worksheet with explanation and time allocation. The non-test scoring can be given to monitoring the activity or development of students during the learning process. Thus, teachers' scoring should include the feedback; thereby, students will know how far their understanding is.

Inquiry skills of writing problem were obtained the lowest score in control class and experiment class. The observation sheet and interview can conclude that the data in students' worksheet was not complete because students were not interested in writing there. Thus, when students were asked to make questions based on data, they could not write it. It made the students wrote wrong statements for the hypothesis. The inquiry was suggested to train students to think analytically (Keys and Bryan, 2000).

The existence of clear inquiry steps through guided questions can guide students to analyze wrong answers in the handout to reach the goals of the learning process. In experiment class, the use of tools in practicum were according to working procedures. The observation showed that students in experiment class were smarter, more conscientious, and serious. In the experiment, the data obtained by students in experiment class were reported correctly, organized, and conscientiously. In control class, the data was not complete, unorganized, and had the minor mistake. The data analysis showed that students in experiment class were more skillful in controlling class. This result is the same to Pujani and Liliasari (2011), saying that students who know how to use experiment tools will be impactful to their psychomotor. Thus, students in experiment class had an excellent psychomotor and practicum result better than the control class.

CONCLUSION

The data of the N-gain score showed that students' inquiry skills in experiment class were higher than in control class. Therefore, inquiry-based science learning was effective to improve students' inquiry skills.

In the learning process, inquiry-based students' worksheet was effective to improve students' inquiry

skills. It is suggested that teachers should understand the syntax of guided inquiry and its purpose that the learning process will be executed as its plan and vision.

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