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THE EFFECTIVENESS USING INQUIRY BASED NATURAL SCIENCE MODULE WITH AUTHENTIC ASSESSMENT TO IMPROVE THE CRITICAL THINKING AND INQUIRY SKILLS OF JUNIOR HIGH SCHOOL STUDENTS

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ABSTRACT

The aim of this research is to investigate the effectiveness of inquiry-based science modul with 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 7th grade of one of Junior High School in Pontianak, by using 2 classes as a sample. The data was collected by using inquiry skills observation sheets, critical thinking test, and interview. The result shows that the mean of inquiry skills and critical thinking 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. Score of N-gain shows that the mean of experiment group's inqury skills and critical thinking score after the treatment, is higher than control group. It concludes that science learning by using inquiry-based modul with authentic assessment is effective to develop students' inquiry skills and critical thinking.

Keywords: authentic assessment, critical thinking, inquiry, inquiry skills, science modul

INTRODUCTION

Students' involvement in the activities under investigation (inquiry) in order to find a concept is considered primary in science learning. This is important as, in science, learning prioritizes skills development and process.

Science learning and inquiry cannot be separated referring to the 2013 curriculum that emphasizes on direct experience in order to develop students' competencies. Thus, students are able to understand the nature around them scientifically and to have the skills of inquiry and critical thinking. There are several findings as the result of the preliminary study of the learning process in Pontianak Junior High School: 1) teaching and learning process is centered on the teacher, so that students would potentially not develop; 2) most of the time, students only listen and record what is described by the teacher. The learning activities tend to be dominated by rote and verbal submission to master knowledge, therefore, it does not develop students' critical thinking skills and scientific work; 3) the assessment of teachers is still limited to paper and pencil test, while the students' aspects of skills and attitudes tend to be neglected; and 4) the science practicum is still rarely performed.

One of the learning strategies that develop curiosity and scientific thinking of students is inquiry learning. Inquiry learning is a method that refers to the students' activities that develop knowledge (Oguz-Unver & Arabacioglu, 2011).

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This learning method can help students develop critical thinking skills and construct knowledge as if they are real scientists (Corlu & Corlu, 2012).

Kuhlthau & Todd (2007) stated that in the inquiry strategy, knowledge can be built by the students, so that they are able to carry out independent learning in science-related issues. Guided inquiry learning model is ideal for science subjects, and some studies have shown that this method is effective to improve student learning outcomes (Abdi, 2014).

Experts' opinions above reflect that the inquiry learning objective is to develop the thinking skills of students logically, critically and systematically through inquiry regarding science facts, concepts, and principles. Through inquiry, the critical thinking of students can be developed. Bassham, et al. (2011) suggests that critical thinking skills are the cognitive skills required to effectively identify, analyze, evaluate arguments or claims what is true, locate and resolve allegations that are subjective, formulate and present the right reason and support the logical conclusion, as well as make decisions about what is to believe and what will be done. Critical thinking skills are also influential for students' academic and professional success in the future (Quitadamo, et al., 2008)

In the inquiry-based science learning, students' performance in every inquiry activity is being assessed. For example, during practicum, teachers can assess the process as well as the product when students conduct group discussions, collect data, answer questions or problems in the handout, conclude solutions, make hypotheses, design experiments, take measurements, etc. Thus, the achievement of students in cognitive, affective, and psychomotor can be known quickly and continuously with various types of assessment, making it easier for teachers to provide feedback. Assessment that involves all three aspects are authentic assessment.

The reality in the science learning in Pontianak Junior High School shows that many teachers use the teaching and learning method that is centered on the teacher (traditional). This is because the teachers consider the inquiry strategy difficult to attempt (Wilke & Strait, 2002). According to Rustaman (2005), one of the constraints of the implementation of inquiry learning is the limited teaching materials or learning resources. The observations in Pontianak Junior High School show that the inquiry model is rarely practiced because of the lacked supports especially the facilitation for the inquiry activities. Also, teachers are less skilled in applying inquiry learning strategy. During the science teaching, teachers often dominate. It is thus necessary to use a new student teaching method, such as inquiry-based science modules. Using inquiry-based modules can help the students to determine the steps of science investigation individually, so that they can develop inquiry skills. Accordingly, this research is to answer the question about the effectiveness of the implementation of inquiry-based science modules with authentic assessment for junior high school students in improving the skills of inquiry and critical thinking of students.

METHOD

This study aims to determine the effectiveness of the use of inquiry-based science modules with authentic assessment. The study used a quasi-experimental research method and the object was the students of Pontianak Junior High School with the material of food additives. The research design was pretest-posttest control group design (Gall, et al., 2003), with its design as follows:

	Pretest	*Treatment*	*Posttest*
Experimental Class	O_1	X	O_2
Control Class	O_1		O_2

Information:
O_1: *Pretest* Implementation
O_2: *Posttest* Implementation
X: *Treatment*

In this study, the pretest was given to the experimental and control class. Then, the posttest was practiced to the experimental students after they learn about food additives using inquiry-based module with authentic assessment, meanwhile the control class was given the conventional learning method.

The population in the study were all of the VII-grade students of 11 Pontianak Junior High School that amounted to 7 classes. The sampling technique was cluster random sampling, as the homogeneity test results the average score of students' science daily test is homogeneous. The VIIA class was selected as the experimental group and VIID class as the control group.

The primary variable of this study is the independent and dependent variable. The independent variable is the learning science using inquiry-based module with authentic assessment in the experimental group, and the learning science conventionally uses discussions in the control group. The dependent variable in this study are

the skills of inquiry and critical thinking.

The data collection technique used is data collection tool measurement with the critical thinking & skills tests and observation sheet. Observation sheet is used to measure the skills of inquiry during the learning inquiry-based. The inquiry skills include making observations, asking questions, drawing up hypotheses, and communicating. The complete aspects and indicators of inquiry skills can be seen in Table 1.

The test of critical thinking skill was arranged referring to the indicators of critical thinking skill, which is by formulating answers about cases relating to food additives, assessing arguments relating to food additives, identifying the relevance and non-relevanan on food additives, finding similarities and differences, and making decisions about the negative effects and misuse of food additives. Aspects of critical thinking skill can be seen in Table 2.

Interview implementation refered to the data analysis results of observation, with the aim to support the test result data of critical thinking skills and inquiry skills observation results. Data analysis was performed by grouping the research data based on the indicators on each aspect inquiry skill and critical thinking. The average score of students in every aspect was determined by the sum of the scores for each skill aspect, then by the division of number of students. Furthermore, an assessment with hypothesis test using SPSS at the 5% significance level was applied to determine whether there was a difference of critical thinking skills and inquiry among students who applied inquiry-based science module and conventional learning.

The effectiveness in this study can be seen in the students' improved skills of inquiry and critical thinking before and after the learning module with inquiry-based food additives with authentic assessment, calculated using the equation normalized gain (Meltzer, 2002), namely:

Normalized gain griteria (g)

$g < 0,3$: low

$0,3 \leq g \leq 0,7$: middle

$0,7 \leq g$: high

The data obtained from the test of critical thinking skills and inquiry skills of observation sheet would be applied with normality test of data distribution using the Shapiro-Wilk statistic, as the sample was <50. If the test results indicate the the data distribution was normal, then the homogeneity test would be attempted to see diversed data using Levene's Test of Equality of Error Variance. To answer a hypothetical problem, AsympSig paired t test (two-tailed) was used.

RESULTS AND DISCUSSION

Based on the research data collection, the data of inquiry in the experimental and control class is shown in Figure 1.

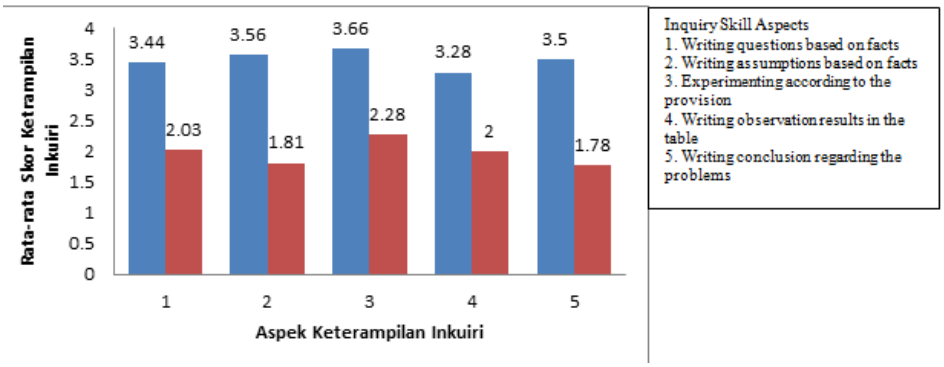
Figure 1 above shows that the average skills of inquiry in the experimental class is higher than the control class for all inquiry aspects (writing down the observations results in detail, the questions based on the data, the provisional assumptions based on facts, the observations results in the table, and the conclusion according to the problems). Thus, it can be seen that the inquiry-based science learning on food additives improves the

Table 1. Aspects and Indicators of Inquiry Skills

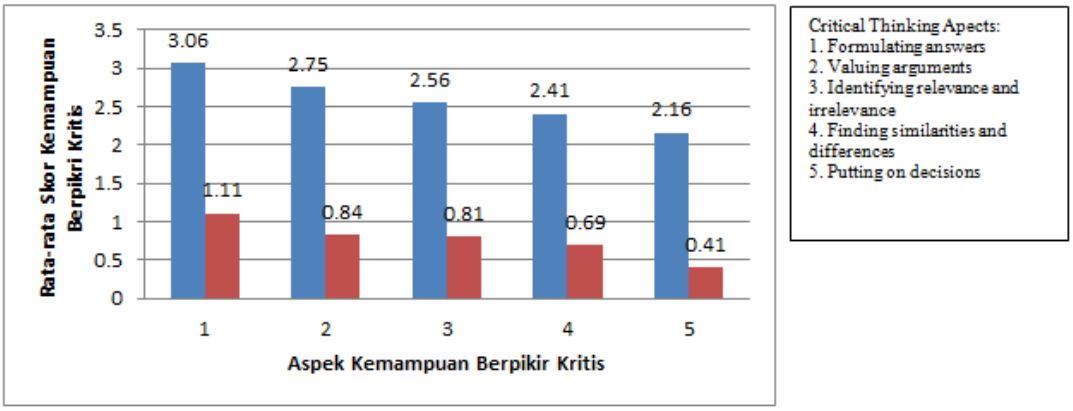
Inquiry Skills Aspects	Indicators
Asking questions	Writing questions based on data
Compiling hypothesis	Writing temporary assumptions based on the fact
Experimenting	Experimenting according to the provision
Communicating	Writing experiment results on the table
	Writing conclusion regarding the problems

Tabel 2. Critical Thinking Skill

Aspect	Critical Thinking Indicator
Giving simple explanation	Formulating answers regarding food additives cases
	Valuing arguments regarding food additives
Building Basic Skills	Identifying the relevance and the irrelevance of food additives
	Finding the similarities and differences of food additives
Making Decision	Deciding the negative impacts of the misapplication of food additives



Information: Blue = Experimental, Red = Control
Figure 1. Inquiry skills of the experimental and control class



Information: Blue = Experimental, Red = Control
Figure 2. Critical thinking skills of the experimental and control class

skills of inquiry. Analysis of the test data of students' critical thinking skills in experimental and control class obtained on Figure 2:

Figure 2 shows that the average critical thinking skills of students in the experimental class was higher than the control class for all aspects of critical thinking. Thus, the use of inquiry-based science modules with authentic assessment was considered effective to improve students' critical thinking skills.

Research hyphothesis test was conducted after the test requirements, which is the normality test on all inquiry and critical thinking skills data. The test results of normality with the Shapiro-Wilk test was obtained as follows:

Price Sig. > 0.05, meaning that data is otherwise normal. As all the data is normally distributed, then the homogeneity test was conducted, which results as follows:

	Critical Thinking	Inquiry
Levene Statistic	Sig.	
Based on Mean	.420	.065

Sig price obtained. > 0.05 for all data, meaning the data is expressed homogeneous. All meets the requirements, followed by a test of the hypothesis. Hypothesis test results used paired t-test sig price. (0.00) is less than 0.05, then Ho is rejected, which means that there is a difference between students' inquiry skills that used inquiry-based science modules with authentic assessment and conventional learning. Thus, the use of inquiry-based additives module with authentic assessment affects the students' inquiry skills. Similarly, the results of hypothesis testing on the data of critical thinking skills, the sig. (0.00) price

Class	Inquiry Skill			Critical Thinking Skill		
	Shapiro-Wilk					
	Statistic	Df	Sig.	Statistic	Df	Sig.
Control	.940	32	0.076	.943	32	.089
Experiment	.945	32	0.107	.939	32	.069

obtained is less than 0.05, meaning that there are differences in critical thinking skills among students who applied inquiry-based science modules with authentic assessment and conventional learning.

Based on the calculation of N-gain score, an average N-Score of inquiry skills is obtained for inquiry skills in the control class with 0,25 in the low category, and in the experimental class with 0,70 in the middle category. Meanwhile, the N-gain score of critical thinking skills in the control class is 0,14 in the low category and in the experimental class with 0,57 in the middle category. It can be concluded that the inquiry-based learning science module with authentic assessment is effective (the middle category) in order to improve the students' skills of inquiry and critical thinking. It shows that learning to use inquiry-based science modules with authentic assessment is effectively used in learning activities.

Based on the results of the research hypothesis test, it is concluded that there are differences in the skills of inquiry and critical thinking among students who applied inquiry-based science modules and conventional learning. Therefore, inquiry-based science modules with authentic assessment affect the inquiry and critical thinking skills of junior high school students.

The experimental group has average skills of inquiry and critical thinking which is better than the control class, therefore, it can be said that the learning module using science-based inquiry learning with authentic assessment is effective to increase inquiry and critical thinking skills of students. This is in line with the results of the research by Neuby (2010) on inquiry that the initial knowledge and student involvement in learning is increased. Furthermore, the results of the research by Remziye (2011) concluded that the science process skills and scientific attitudes of students increased in inquiry-based learning. This is also in line with Wenning (2011) who concluded, the inquiry can improve scientific literacy of students and has a better learning value. Further Sochibin, et al., (2009) found that the understanding of the concepts and critical thinking skills increase.

The high average score of inquiry skills in the experimental class compared to the control class is due to the inquiry-based science modules with authentic assessment. This module greatly assisted students in finding concepts independently. In addition, students also felt motivated in learning because of the activities students had to do. The involvement of students in learning can be very high, too. Hmelo, et al., (2006) stated, inquiry as an activity which also includes many activities that students have to do, such as making observations, making questions, reading the source books and other sources of information, planning investigation, reviewing what is already known for obtaining evidence in experiments, analyzing and interpreting data, finding answers, explaining and predicting. The activities of inquiry students have to do can create better understanding and positive attitude in learning (Kubicek, 2005)

During the teaching and learning that used inquiry-based science modules with authentic assessment, students enthusiastically participated in learning activities at every stage of the proceedings. The curiosity of students was clearly visible at the time of the practicum. Students got curious and excited to see the results of the investigation of food ingredients that they consume daily. The results of these activities can train students in considering the option of daily food intake. This is important, because when students face problems in life, which requires them to take important decisions, the students already have a stock of how to take the right decisions (Patricia & Ganaden, 2008).

The module assist students in achieving the learning objectives at every stage of the inquiry through questions in order to guide students in finding answers to problems. In the experimental class students, the use of tools and materials was in accordance with the student practicum work procedures. The observations also show that the experimental class students perform accurately, carefully and seriously. In practical activities, the experiment results that students obtained was written meticulously organized and tidy in the report book. Meanwhile, in the control class, the experimental results were less complete and less organized. Results of the analysis of observational data showed, students in the experimental class are more skilled in the classroom than the

control class. Thus, the experimental class students have a better psychomotor abilities.

Modules can be studied by students independently (Prastowo, 2011). Pummawan research results (2007) regarding the effectiveness of the module development concluded that the module can develop students' cognitive abilities. Therefore, the inquiry-based module is considered a teaching material that is systematically arranged by following the steps of inquiry and equipped with authentic assessment, which is to help students achieve learning goals. The use of inquiry-based learning modules in the experimental class greatly assist students in inquiry activities. Module-based inquiry can guide students in conducting investigations based on the stage in the inquiry learning.

Inquiry strategiy provides an opportunity for students to be active in the working groups (Rigeway & Padilla, 1998). This is in accordance with the opinion of Harlen (2014) that the during inquiry learning, students play an active role to develop understanding in finding ways to resolve the problem. Thus, the critical thinking skills, the communication, and the ability to work independently can be developed in a collaborative inquiry-based learning.

According to the aspect of the inquiry skill, observing is the highest acquisition of the score both in the experimental class and the control class (indicator: writing down observation results in detail). On the indicator to make observations, students' direct observation is to find information. Interview with chemistry teachers obtained information that during this time in chemistry learning, students are used to the lab and creating an individual report after practical completion. Thus, students are used to createing and reporting the results of the practicum.

Observational data on both class show that actually most students had followed the procedure when they are experimenting in the lab, however many students in the control class had not yet done their Student Worksheet rightly and completely. More in-depth interviews obtained information that the students did not complete filling because the time was already over. They also thought that the teachers would not grade their work on the Student Worksheet. Interview with the science teachers obtained information that the student worksheets so far were only being collected, without being given any feedback. This is different with what of in the experimental class. Each student was given inquiry-based modules. In addition, authentic assessments were also provided in the modules, so that students could gauge their own understanding and skills as accompanied guide / assessment rubric was already available. Azim and Khan (2012) concluded that authentic assessment can develop high-level skills, such as: developing questions, interviews, collect data or information, analyze information, presentation, and communication.

Inquiry skills on conclusion writing in accordance with the problems of the control class obtained the smallest average score compared to other aspects, both in the control class itself and the experimental class. According to observation and interviews, it can be concluded that the data written in student worksheet was incomplete. This might be the reason of why students were less interested in filling the questions in the worksheet. Consequently, when asked to make inquiries based on existing data, the students could not do it. When they were asked to make a hypothesis, they did many erroneous, too. Therefore, inquiry was highly recommended to practice analytical thinking skills and student learning satisfaction (Nuangchalerm & Thammasena, 2008).

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CONCLUSION

The results of the calculation of the N-gain score indicates that inquiry and critical thinking skills of the students in experimental class is higher than the control class. Therefore, inquiry-based science modules with authentic assessment on food additives is effective to improve the skills of inquiry and critical thinking of students. The results of this study can be used by teachers to improve the skills of inquiry and critical thinking of the junior high school students in learning science.

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