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ENHANCEMENT OF STUDENT'S CRITICAL THINKING SKILL THROUGH SCIENCE CONTEXT-BASED INQUIRY LEARNING

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ABSTRACT

This study aims to enhance critical thinking skill through science context-based inquiry learning (SCOIL). This study is a quasi-experimental research with pretest and posttest control group design. The SCOIL was carried out in seventh-grade junior high school in Bogor with 56 students consisted of 24 boys and 36 girls. Data were collected by giving out critical thinking skill tests, observing the teaching and learning process, and students' activities. Those data were analyzed descriptively and inferentially. Syntax of SCOIL was namely observation, investigation, representation, conclusions, and communication. The result of the SCOIL model implementation showed increased activity with high category and N-gain critical thinking skill was categorized at the medium level. The significance test showed the critical thinking skills of students with the SCOIL model are greater than the guided inquiry learning model. It can be concluded that the SCOIL model can enhance the critical thinking skills of junior high school students.

Keywords: context science; critical thinking; inquiry learning

INTRODUCTION

The 21st century requires students to have "four Cs" that is: critical thinking and problem-solving, creativity and innovation, communication, and collaboration to compete in a global society (Erdogan, 2019). Moreover, science learning in junior high school needs to be implemented in an integrated manner by providing students with direct experience to build up their knowledge. The constructivist learning environment provides the students a chance to seek for various of information, proceed them in a different point of views, create links between the learning process with students' culture and experience, reinforce various kinds of learning styles, and also encourage reflection activity on the learning process (Sasson et al., 2018).

In reality, the results of the observations several junior high schools in Bogor showed that the implementation of science learning is still conceptual and does not provide opportunities for students to carry out investigations in the laboratory and the surrounding environment. Science learning is also fragmented. The results of Group Discussion Forum of science teachers in Bogor city concluded that the problem of science learning in Bogor city is that the teachers have

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difficulties in teaching science in a holistic and contextual manner (Rubini et al., 2016). Science learning does not only concern the nature of science to improve the achievement of science literacy, but also to facilitate students to develop their competencies to become qualified human resources. The development of competency in knowledge and skills in the national curriculum aims to build the ability of students to understand and apply science correctly and to have higher-order thinking skills. One of the higher-order thinking skills that can be built through science learning is critical thinking.

The results of the preliminary study showed that students' critical thinking skills in Bogor were still low with an average of 46.3. The low level of students' critical thinking skills is due to the learning process which has not facilitated them to develop their critical thinking skills. Moreover, it tends to be teacher-centered. The students have not been trained to ask and answer questions, and they also rarely do experiments. Even if they conducted experiments, the experiments were in the form of a cookbook. Expressing ideas and opinions also are not accustomed to most of the students. As stated by Ramos (2014a) that students who are passive and only listen to the teacher's explanation will become individuals who do not dare to express opinions and tend to only carry out instructions. Therefore, the passive learning environment does not provide opportunities for students to develop critical thinking.

Critical thinking is reasonable and reflective thinking that is focused on making decisions about what is done or believed (Ennis, 2011). Thinking critically is an intellectual process to actively and skillfully conceive, apply, analyze, synthesize, and/or evaluate the information that is collected by observation, experience, reflection, and reasoning (DeWaelsche, 2015; Duran & Sendag, 2012; Paul, 2002). The skill to think critically does not occur by chance; but it happens by the structured explanation, intentionally and repeatedly done by the students to develop their in-depth thinking (Changwong et al., 2018). Lai (2011) states that the ability to think critically includes: (1) analyzing arguments, claims and evidence, (2) drawing conclusions deductively and inductively, (3) deciding or evaluating, and (4) making decisions or solving problems. Therefore, critical thinking is a combination of abilities, knowledge, attitudes, skills, and processes. People who think critically have the ability to ask questions correctly, combine and reduce relevant information, think logically for the information they obtained, and make reliable conclusions.

Critical thinking skill is one of the skills that require us to be able to face and solve the problems in the 21st century. According to Quitadamo et al. (2008) and Khasanah (2018), the skill to think critically is necessary for daily activities and affects the success of students academically and professionally in the future. The research stated that the skill to think critically is affected by the early critical thinking skill, instructor, and ethnicity. Others stated that critical thinking involves activities in analyzing more specific ideas, differentiating, choosing, identifying, assessing, and developing them in a more perfect direction (Usmeldi et al., 2017). Those activities are similar to the high level of thinking skill in Bloom Taxonomy from C4-C6 namely analysis, synthesis, and evaluation (Moore & Stanley, 2010). Someone who has good critical thinking skill is considerably able to solve problems through a process of making a rational decision reinforced by valid evidence.

The ability to think critically can be trained to students. Kim et al. (2013) have implemented an active learning module to build students' critical thinking in science learning. The results showed that the mastery of concepts and critical thinking skills of students increased. Combining students' problem solving and reflection skills can also improve critical thinking and problem-solving skills, complex topics can be well integrated, and students' understanding of learning actually is also better (Houde, 2011). Critical thinking skills have also been trained to students of Class VII Junior High Schools in Palu through innovative thematic-based science learning (Pursitasari et al., 2015). The results showed that thematic based integrated science learning can build students' critical thinking skills in the medium category. This model can also be used in science learning in public and private junior high schools (Pursitasari et al. 2018). Usmeldi et al (2017) and Hairida (2016) have developed a research-based learning model and inquiry-based science module equipped by the authentic assessment to increase the critical thinking skill of the students. The improvement of critical thinking skill can also be possibly achieved by contextual learning (Bustami et al., 2018), cultural-based integrated science learning (Dewi et al., 2017), guided-inquiry learning (Putra et al., 2018), project-based learning (Anazifa & Djukri, 2017), and socio-biological case-based learning (Suwono et al., 2017).

Based on the problems and the result of the studies have been stated previously, the science learning process in Bogor Junior High School tends to be teacher-centered so that it does not develop critical thinking skills. Meanwhile, critical thinking needs to be developed so that students are accustomed to expressing opinions and solving problems by predicting, analyzing, and evaluating. These activities require students' interaction and collaboration in the learning process and also in and practicum class. Laal & Ghodsi (2012) concluded that collaborative learning has several advantages such as higher achievement, more caring, supportive, and greater social competence, and self-esteem.

Based on the result of previous studies, inquiry learning is one of the models/methods that are possibly used to train critical thinking skill in learning science in junior high school. Wenning (2011) suggests that a hierarchy of inquiry learning (level of inquiry) is ranging from simple levels of discovery learning, interactive demonstration, inquiry lesson, inquiry lab, real-world applications, and hypothetical inquiry. Some of the learning stages that have been done by some of the researchers are (1) observation, manipulation, generalization, verification, and application. (Wenning, 2005); (2) problem orientation, formulating problems, formulating hypotheses, gathering evidence, testing hypotheses, and making a conclusion (Şimşek & Kabapınar (2010).); and (3) identify problems, ask questions, present research steps, give explanations, make predictions, and arrange argumentations that support their experience (Ambarsari, 2012).

According to the explanation above, inquiry learning done by the researchers does not have the science context that helped at the beginning of the lesson yet. The presentation of the scientific context is crucial as it is a platform to develop critical thinking skill and comprehension of the nature of science. Another thing that is needed by the students when they have to report the observation result of the experiments they have done is making the proper presentation. Inquiry learning also needs teaching materials. This can be used as media to achieve more meaningful science learning (Glynn & Muth, 1994). Students learn not only to rely on the transformation of knowledge from the teacher but also the independence to find knowledge. Students, who read the subject lesson from textbooks and other teaching materials, will store the knowledge of science obtained in their long-term memory. The science context presented in this research is about Ciliwung river pollution and acid rain. Due to the problems stated, the purpose of this study was to analyze the possibility of inquiry learning with science context in science learning in the seventh-grade junior high school in Bogor and to enhance students' critical thinking skills through inquiry-learning models with science contexts. The critical thinking skill is expected to be a provision for the students to face problems in science learning or daily lives.

METHODS

Course overview

This research was conducted in a Junior High School in Bogor with 56 seventh-grade students divided into 2 classes; controlled and experiment classes. There were 28 students in a control class consisted of 11 male students and 17 female students, while there were 28 students in the experiment class consisted of 13 male students and 15 female students. The method used in this research is quasi-experiment with only pretest-posttest control group design. The design of this study is in Figure 1 (Fraenkel et al., 2011).

Treatment group	O_1	X	O_2
Control group	O_1	C	O_2

Figure 1. Only Pretest-Posttest Control Group Design

Only pretest-posttest control group design uses two groups namely treatment group used SCOIL learning (X) and controlled group used guided inquiry learning (C) whose abilities are determined before and after studying environmental pollution (O_1) and (O_2). The learning process in the experiment class used science context-based inquiry learningF following the stages of observation, investigation, explanation, conclusion, and communication (Table 1). To support the implementation of SCOIL, teaching materials have been developed by involving teachers. Characteristics of Environmental Pollution teaching materials are following pedagogic aspects that can be used to measure critical thinking skills, and the books are equipped with science contexts in the form of environmental pollution images and problems to explore students' curiosity and get the students used to think critically when solving the problems. Those teaching materials have been assessed professionally with the average result of the assessment is 85%, and readability test on environmental pollution and the impact of environmental pollution are 63.7% and 62.5%. (Pursitasari et al., 2019). This means that teaching material with science context have been validated and can be understood by students, but still requires teacher guidance through the learning process.

Table 1. Syntax and Student's Activity in SCOIL

No.	Syntax	Student's Activity
1.	Observation	Students observe the presentation of phenomena related to the context of science Students ask questions based on observations Students identify problems based on the existing phenomenon
2.	Investigation	Students conduct investigations based on the results of the problem identified in groups Students collect, process and analyze the results of the investigation
3.	Representation	Students present the results of the investigation using the appropriate form of presentation Students interpret and explain the results of the investigation in a written explanation
4.	Conclusion	Students make conclusions about the content of the material based on the results of the investigation
5.	Communication	Students explain the results of investigation classically Students from other groups ask questions or give responses

The five learning stages of SCOIL accommodate inquiry learning with a scientific approach to facilitate the development of critical thinking skills. The interrelationship between the stages of learning with critical thinking skills is shown in Table 2.

Table 2. Relationship of SCOIL Model with Critical Thinking Skill

No.	Syntax of SCOIL	Critical Thinking Skills
1.	Observation	Do basic clarification of the problem
2.	Investigation	Collect basic information
3.	Representation	Do strategies and tactics to make the best conclusions
4.	Conclusion	Do strategies and tactics to make the best conclusions
5.	Communication	Provide further clarification

The data collecting technique used in this research is by giving a test, observing the learning process and students' activities. The test instrument used was a test of critical thinking skills consisting of five indicators adopted from Ennis (1994) as follows: analyzing arguments; conclude; observing and considering the results of observations; decide on an action, and focus questions. The results of the validity test showed there were 15 valid questions from 20 questions developed. The reliability test results using the Kuder Richardson 20 formula (KR-20) show the reliability coefficient of 0.84. This test was given before and after the learning process. The learning process was done for 3 meetings in total. During the learning process, two observers observed the process of learning with SCOIL and group activity. The collected data then were analyzed descriptively and inferentially. The qualitative data were then preceded in the quantitative descriptive way by counting the percentage of every aspect measured, while the quantitative data proceeded in inferential statistics way after its normality and homogeneity had been tested.

RESULTS AND DISCUSSION

Inquiry learning with science context is a learning that is developed by using the context of science as a media to build and improve the critical thinking skills of students. Students conduct inquiry stages guided by the teacher because students are still in the seventh grade of junior high school. The learning consists of observation, investigation, explanation, conclusion, and communication (Table 1). These stages of SCOIL give a chance to the students to do investigation activities under teacher supervision (Table 2). According to Wenning (2011), guided inquiry learning provides opportunities for students to carry out controlled activities with the help of instructors or teachers. Students ask questions and look for references to find answers or solve a problem in groups or individuals with a scientific approach. Also, inquiry-based learning will develop high order thinking skills, communication skills, investigation, and understanding of science facts (Cahyarini et al., 2016).

SCOIL stage is done by presenting phenomena, which is wrapped in a science context in personal, social, or global contexts. Furthermore, students are allowed to ask questions and solve problems through the stages of inquiry as follows: identification of problems, conducting scientific experiments, collecting, processing, and analyzing data, representing data, concluding, and explaining unexpected results.

The Implementation of the Science Context-based Inquiry Learning (SCOIL)

The implementation of SCOIL in the pollution material was carried out at one of Junior High School in Bogor. The main activity was started by showing a video about environmental pollution. During the video shows, the students indicated serious expressions in watching and asking questions. Some students asked questions directly and some wrote them in a piece of paper provided by the teacher. Thirty different questions were coming from 28 students. Ten of them are: (1) What will happen to live things if the water pollution keeps on happening? (2) How to reduce plastic waste in our environment? (3) Why does the environmental pollution affect living things? (4) How to solve the pollution in the Ciliwung River? (5) How do people react to environmental pollution? (6) How to reduce plastic waste in the world? (7) What will the effect be if the plastic waste is buried in the soil? (8) What is the effect of environmental pollution on human beings? (9) What is the effect of plastic existence under the sea? (10) Why is the smoke of the vehicle 's color black?

Based on those questions, it indicates that the seventh-grade students have considerably thought critically when they faced a particular phenomenon. According to DeWaelsche (2015), asking questions can initiate the process of students thinking skill. The students' ability to ask critical questions is also one of the skills that are expected to be acquired in the 21^{st} century.

Based on the students' questions above, the students then were asked to do investigations about the effects of water, land, as well as air pollution in the laboratory. The characteristic of the experiments done by the students in SCOIL class is semi open-ended experiment. The teacher and laboratory assistant provided the tools and the materials only. Following the tools and materials provided, the students, in a group, planned the procedure, did the experiments enthusiastically and got involved actively. They also wrote down the result of their observation, present it in the table and then concluded it. After that, they presented the result of their experiments to the other groups by giving explanations done by two students and asking questions given to the other groups that are done by another two students in the group. Through this method, they are trained to be brave to ask questions and give an explanation based on their reasoning and understanding so that they have the skill of communication that is also needed in this era.

The lessons of environmental pollution consist of 3 different meetings with the topics as follows: the discussion about the environment, the environmental pollution types, and the countermeasure of environmental pollution. The results of the observation on the implementation of SCOIL are shown in Table 3.

Table 3. The Observation Result of SCOIL Implementation

Stages of Activity	Description of Activity	Average of Assessment in the Learning Process (%)		
		First	Second	Third
Introduction	The teacher gives greetings, performs apperception, presents the learning objectives	90	90	100
Core activities	Observation	75	100	100
	Investigation	100	100	100
	Representation	100	100	100
	Conclusion	100	100	100
	Communication	100	100	100
Final Activity	Summarize and evaluate	83.5	100	100
Mean		92.6	98.6	100

The stages of the investigation, representation, conclusions, and communication carried out very well (100%) from the first lesson to the third lesson. This happens because, since the first lesson, the teacher has guided students to carry out investigations in solving problems, represent the results obtained in the form of appropriate presentations, draw conclusions from the results of the investigation, and communicate them to other groups. In the second and third lesson, the teacher reduces guidance but still monitors student activities in solving problems to develop critical thinking skills. Gradual reduction of teacher guidance aims to make students more responsible in solving problems known as scaffolding. According to Hasnunidah et al. (2015), scaffolding is a form of assistance to the potential abilities of students who are in the Zone of Proximal Development (ZPD) to achieve higher abilities. Scaffolding can also improve the ability to think critically through search, solve, create, and share learning models (Saregar et al., 2018) and encouraging students critical thinking disposition (Weinstein, 2017). SCOIL takes place well because teachers and students are active and have good observation, communication, and cooperation. The observation and communication stage in the learning process can facilitate the students to think critically in order to gain knowledge (DeWaelsche, 2015).

The activities of students appear with an increase from the first, second, and third meetings (Figure 2) with an average increase in lesson 1, lesson 2, and lesson 3 at 3.78; 3.90; and 3.97. The average overall learning activity is 3.90 with a very good category. Students look fun and enthusiastic in participating in each stage of learning, exploring, group activities, and they also show courage and politeness in expressing opinions. This is in line with the conclusion promoted by Ramos (2014b) which stated that the active involvement of students in learning can activate their critical thinking. Students' activities in collaborative group work also provide opportunities for them to work together in planning, implementing, negotiating, and evaluating when completing assignments or problems given by the teacher (Fung, 2017).

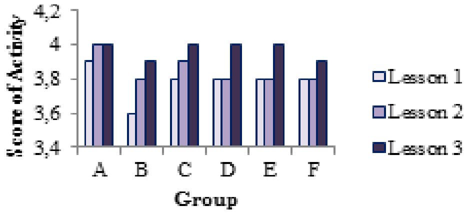

Figure 2. The Average of Students' Learning Activity

Figure 2 shows that group A indicates a very high activity since the first meeting. This is because one of the members of the group has ever joined scientific groups in the school so that they got used to doing with the investigation activity and problem-solving. This investigation activity is able to make the students become independent learner and encourages them to be responsible to their own learning, learning effectiveness, and critical thinking (Smallhorn et al., 2015; Kopzhassarova et al., 2016; Geng et al., 2019).

Students' Critical Thinking Skills through Science Context-based Inquiry Learning.

Apart from being able to improve the achievement of science literacy, the implementation of science context-based inquiry learning (SCOIL) can improve students' critical thinking skill (Table 4). The average of students' critical thinking skills before participating in SCOIL is higher than guided inquiry learning (GIL). Table 4 shows an increase in the average of students' critical thinking skills through both SCOIL and GIL with an average N-gain of 59.6 and 32.2 respectively.

To determine the significance of improvement in critical thinking skills, statistical tests were conducted on the two average improvements in students' critical thinking skills with SCOIL and GIL. Before testing inferentially, a prerequisite test had been carried out, which were testing for normality and homogeneity then proceeded with t-test.

Table 4. Descriptive Data of Students' Critical Thinking Skills

Description	SCOIL		GIL	
	Pre-test	Post-test	Pre-test	Post-test
Mean	42.4	77.4	43.8	62.6
Standard of Deviation	6.6	9.1	9.5	7.3
Variance	43.6	82.8	90.2	53.29
Maximum	53.3	93.3	66.7	73.3
Minimum	33.3	53.3	33.3	46.7
Range	20.0	26.7	33.4	20.0
Mean of N-gain	59.6 (medium)		32.2 (medium)	

The test results are in Table 5. The results of the normality and homogeneity test show the acquisition of p> 0.05 so it can be concluded that the two data are normally distributed and homogeneous. The results of the t-test show the value of $t_{count} > t_{table}$ and $p < 0.05$. This means that there are significant differences between the average improvement in students' critical thinking skills with SCOIL and GIL. This increase is because the students seem to seriously pay attention to the learning process to observe the phenomena containing the science context while writing down the things that will be asked. Besides, the students seemed enthusiastic and collaborative during the investigation. Students appeared confident when asking and explaining to other students. Activities and discussions conducted by students foster student criticality which ultimately can improve their critical thinking skills. According to Duran & Dökme (2016), the activity of answering and asking questions contributes positively to the development of a level of critical thinking. Discussions can also increase the level of critical thinking of students and help students improve their ability to connect between claims and evidence. The observation also shows that almost all students are actively involved in solving contextual problems through investigative activities. Students criticize the problems they faced, develop plans and carry out problem-solving. This supports the research results of Rusilowati & Khanafiyah (2012) that open investigation can improve students' critical thinking skills.

Table 5. Result of Normality, Homogeneity, and t-Test of Critical Thinking Skills

Group	Normality Test	Homogeneity Test	t-Test
SCOIL	p = 0.092	p = 0.629	t_{count}= 7.026; t_{table}=2,01 p = 0.000
GIL	p = 0.200		

The aspect of critical thinking skills in this research includes conducting basic clarifications of the problems, gathering basic information, making inferences, providing further clarifications, carrying out strategies and tactics to produce the best conclusions. The achievement of the students' skills in each aspect of critical thinking skill is shown in Figure 3.

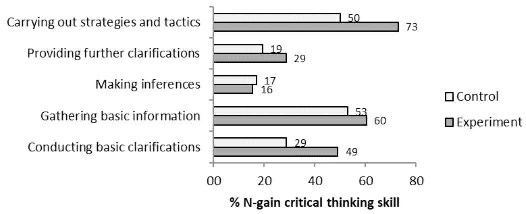

Figure 3. The Increase in the Students' Skills in Each Aspect

Figure 3 shows the achievement of students' critical thinking skills on each aspect in the experiment class is bigger than the achievement in the control class, except, on making reference aspect whose result is relatively the same. This happens since the students in the experiment and control class concluded their last stage of inquiry activity. The most significant difference in the increase of the critical thinking skill is on the carrying out strategies aspect and on tactics to produce the best conclusions.

This happens because the SCOIL learning gives a chance to students to make the plans before the experiment such as deciding experiment purposes, preparing the tools and materials, literature searching, deciding the stages, as well as collecting and analyzing the data. This activity needs strategies and techniques to solve the problems properly. Laboratory open-ended activity facilitates the learning process in creating the formation of a more authentic learning environment, why and how we investigate the nature phenomenon (Wilcox & Lewandowski, 2016). Giving the students open-ended problems is also able to improve students' students' creativity (Lahra et al., 2017). On the other side, in the GIL class, the students experimented by following the laboratory guidance arranged by the teacher. This guidance does not require the students to get involved in the experiment itself.

Based on the results obtained, the implementation of SCOIL can improve critical thinking skills (Table 4 and Table 5). According to Vieira & Tenreiro-Vieira (2016), critical thinking is a key component of science education aimed at preparing students to think and be responsible as citizens. Therefore science learning must be able to facilitate students to build critical thinking skills of students.

CONCLUSION

Science context-based inquiry learning provides daily contexts related to science. The syntax in science context-based inquiry learning includes observation, investigation, representation, conclusion, and communication. Those syntaxes make students get involved actively in learning so that they can develop their knowledge and improve critical thinking skill in the medium category. The students' habit of developing their knowledge and critical thinking needs to be done continuously in various levels of education. Critical thinking skills encourage the students to solve the problems that they face. Thinking critically is the skill that needed to be obtained by the students in the future.

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