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Effectiveness of free inquiry approach module-based case study in the environmental impact analysis material to practice critical thinking skill of undergraduate biology education student

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Abstract. Critical thinking skill is characteristic of global era society. By free inquiry approach combained with case study method, we engaged students in the case situations to practice their criticall thinking skills. This research is aimed to determine the effectiveness of free inquiry approach module-based case study to practice critical thinking skills of undergraduate biology education student in enviromental science course especially in environmental impact analysis material. This research was conducted in Sunan Kalijaga State Islamic University in Yogyakarta. The samples were 51 biology education students. The research method used quasi-experimental with pre test and post test control group design. The data of students critical thinking skill obtained by test and be analyzed by mann whitney test. The result showed that (Sig.) < 0.05. This result indicates that free inquiry approach module-based case study effective to practice student critical thinking skill in environmental impact analysis material.

1. Introduction

According to the United Nations (UN), today critical thinking skill is characteristic of global era society, namely knowledge-based society [1]. The critical thinking skills require students to be able to ask critically, reveal their opinions and thoughts, and be able to solve problems faced independently. The ability to think critically in a systematic, logical and critical manner is part of a mental process to analyze information obtained, through observation, experience, communication, or reading [2]. Through observation and discussion with several students and lecturers on the campus of Sunan Kalijaga State University in Yogyakarta, students' critical thinking skills in environmental science subjects are quite low. A total of 57.5% of students responded less successfully to practice their critical thinking.

Through inquiry methods the ability to think critically in a systematic, logical and critical manner is very possible to train. Inquiry originates from inquiry word which is an English word which means inquiry or asking for information; free translation of this concept is that someone is asked to find and find out for themselves [5]. Inquiry learning methods have several components like questioning, student engaging, cooperative interacting, performance evaluating, and variety of resourcing [6].

The general purpose of inquiry learning is to help students develop the skills needed to generate questions that arise from their curiosity and efforts to find answers. Inquiry learning is generally always associated with problem based learning [7]. The development of these skills can be started by

initiating students with problems. A learning that can involve students' thinking activities is problem-based learning, which uses real-world problems as a context for students or students to learn about critical thinking and problem solving skills, and to obtain essential knowledge and concepts from a subject matter [8]. Inquiry learning is divided into four levels namely controlled inquiry, guided inquiry, planned inquiry, and free inquiry [5]. Compared with controlled, guided and planned inquiry, the selection of free inquiry in this development research is because free inquiry really gives students the freedom to determine the problem with all their efforts to solve problems independently. At the level of free inquiry, students no longer rely on instructions from lecturers, lecturers only act as facilitators. On the other hand students in this case are undergraduate students, the cognitive level should be very mature to be able to take part in free inquiry learning. Controlled inquiry, guided inquiry, and planned inquiry tend to be more suitable for student at the elementary and secondary levels.

Regarding to the inquiry approach, the inquiry approach is an initial strategy used by the teacher or lecturer to guide students, in this case students can find out a problem to collect and analyze data to make their own decisions [9]. The inquiry process is associated with the definition of problem based learning in which the inquiry process will provoke questions, curiosity, doubts, and uncertainties about the complex phenomena obtained by students [10]. One of the learning approaches that are closely related to critical thinking skills is the inquiry approach. Through an inquiry approach the ability to think critically in a systematic, logical and critical manner is very possible to be trained. This is in line with the opinion of Anam that one of the principles of inquiry is learning to think, which is not only remembering a number of facts but developing the potential of the entire brain for thought processes [5]. The thinking process is the maximum use of the left and right helisphere so that they can think logically and rationally.

Based on Susanti's research of learners' critical thinking skills through the application of modified free inquiry model, it can train students' critical thinking skills in photosynthetic and cellular respiration material, the students' critical thinking abilities are seen from the N-Gain value having a range of values with middle and high categories with scores between 0.25-0.95. Overall, changes in the value of N-Gain for each student and each indicator of critical thinking ability increased with the medium category. Increasing the value of N-Gain results from the fact that students are directly involved in managing their learning process [3]. The results of the research are expected to be applied nationally to familiarize students with andragogical learning styles that place students as subjects of learning. The selection of free inquiry approach based on case studies will be developed and formulated in module form so that students can freely carry out a case study based investigation of an environmental area.

In another side the selection of case study method as the basis of the free inquiry approach will also be expected to be able to train students' critical thinking skills. This is in line with the opinion of Clyde Freeman Herreid, PhD, professor at the State University of New York who published about 100 articles in the fields of psychology, ecology, and education. He argues that case studies have gained a strong foothold in science education. Moreover, in his article published, through workshops and conferences the results of a study from the National Center for Case Study Teaching in Science revealed that 97% of students taught with case studies could find new ways to think about a problem, 95% students take a more active part in the learning process, 92% of students are more involved in the classroom, 59% of students are more likely to do independent research outside the classroom to increase their understanding of the material, and 68% think they can get more lessons through case studies [4].

Based on Nadeem role-based case study also helped lecturer to bring to life and explaine abstract concepts and complex situations, and guide students to make effective decision keeping in mind complex human [20]. The lecturer of the course acted as a facilitator during the whole exercise [21] [22] [23]. Case study learning presents students with problems and challenges based on real life situations and encourages them to make difficult decisions based on the evidence provided. They are designed to ask questions and present enough data to stimulate and/ or involve themselves in finding

their own answers [11]. Characteristics of learning using the case study method have the following characteristics questioning, open-ended, decision forcing, and engaging. Selection of case study methods in learning is expected to provide student learning activities based on cases or problems caused. Case study orientation is based on place, not variables. The social comparison of science that has been made illustrates the outline of an answer to the question. But this is terminated to a place and time [12].

As for the material studied in this module is environmental impact analysis. In bahasa we called Amdal or Analisis mengenai dampak lingkungan, it consists of four documents, in bahasa namely Kerangka Acuan or KA (Reference Framework), Analisis dampak lingkungan or Andal (Analysis of environmental impacts), Rencana Pengelolaan dan Pemantauan Lingkungan or RKL-RPL (Environmental management plan and Environmental monitoring plan). If the performance of environmental management is good, it means that the planning stated in the RKL-RPL and its implementation is also good [13]. Based on observations at the Faculty of Science and Technology, Sunan Kalijaga State Islamic University in Yogyakarta, 40 students who have taken environmental science courses obtained data that 67.5% considered Amdal material in environmental science subjects to be difficult material. This is because the Amdal material tends to be ignored by students. As much as 57.5% of students respond to feeling less trained in critical thinking skills when studying Amdal material in environmental science courses. According to that background above, the aim of this research was to determine the effectiveness of free inquiry approach module-based case study to practice critical thinking skills of undergraduate biology education student in enviromental science course especially in environmental impact analysis material.

2. Research Method

The research method used quasi-experimental with pretest-posttest control group design shown in table 3. The samples were 51 biology education undergraduate students who selected by saturated sampling divided into two classes, involving 26 for experimental class and 25 for control class. The critical thinking skills in this study was assessed using essay test. The pretest is given at the beginning of experimental and control classroom. After the initial test, the experimental class students were given free inquiry approach module-based case study while the control class students were given conventional learning only. At the end of the lesson, students are given a post-test with the equivalent of the pretest. The data of students critical thinking skill obtained would be analyzed by Mann Whitney Test because the data is not normally distributed [14].

Table 1. Experimental design

Class	Pretest	Treatment	Post-test
Experiment	O1	X	O2
Control	O1	Y	O2

Description; X: using free inquiry approach-module based case study, Y: using conventional learning.

3. Results

After 3 weeks of treatment, the students were given a post-test to determine the improvement of critical thinking skills in the experimental class and control class, which was then compared with the pretest results. The results of pre-test and post-test can be seen in table 2.

Table 2. Description analysis of pre-test and post-test data

	Experiment Class		Control Class	
	Pre Test	Post Test	Pre Test	Post Test
Maximum Score	40	90	40	75
Minimum Score	15	55	15	25
Standart Deviation	7.21	8.82	7.86	11,79
Score Average	25.00	69.62	26.60	43.40

Based on table 2, the pretest results of both classes are not much different ie 25.00 and 26.60, this shows the initial ability of learners are at the same level. After a different treatment, the experimental class used free inquiry approach module-based case study, and control class using conventional learning only, and posttest result showed that the experiment class students were much higher than the control class. Knowing the difference between of critical thinking skills improvement on the students is using Man Whitney test, because firstly tested normality not fulfilled. Normality test to determine whether the ability of learners have normal distribution, and homogeneity test to determine whether the ability of learners have the same variance. Normality test results can be seen in table 3.

Table 3. Normality test

Critical thinking skill in		Shapiro-wilk	
		Df	(Sig.)
Experiment	Pre-Test	26	0.024
	Post-Test	26	0.360
Control	Pre-Test	25	0.069
	Post-Test	25	0.102

For the pre-test results of students' critical thinking skills in the control class as well as the post-test results of students' critical thinking skills in the experiment and control classes were normally distributed, while the pre-test results of students' critical thinking skills in the experimental class were not normally distributed. Furthermore, the homogeneity test and the results can be seen in table 4 below.

Table 3. Homogeneity test

Critical thinking skill	Df2	(Sig.)
Pre-Test	49	0.480
Post-Tets	49	0.786

With a confidence level of *a* 0.05 (95%), it was found that the data, pre-test and post-test of students in the experimental and control classes had a significance value of> 0.05. So that it can be said that the data is homogeneous or has the same variant. The data is confirmed to be homogenous but not normal. So Mann Whittney is conducted to determine weather free inquiry approach-module based case study can practice the students' critical thinking or not. The result can be seen in table 4.

Table 4. Mann Whitney Testt

Source	Variable	z	(Sig.)	Description
Experiment and Control class	Gain score post-test and pre-test	-4.242	0.000	Significantly different

Based on table 4 it is known that the variable gain score Pre-test and Post-test critical thinking skills of students in the experimental class and control have p value (Sig.). <0.05. This shows that there is a significant difference between the critical thinking skills of students in the experimental and control classes. So that it can be stated that H_0 is rejected and H_a is accepted. This indicates that there is influence from the learning by using free inquiry approach module-based case study in practicing critical thinking skills of undergraduate biology education students on environmental impact analysis material.

4. Discussion

The implementation of the free inquiry approach module-based case study in learning environmental science course, especially Amdal material, is expected to be able to train students' critical thinking skills. So that experimental research have been conducted to determine the effectiveness of the free inquiry approach-module based case study in training students' critical thinking skills compared to students taught without using modules. Based on table 4 above it is known that the variable gain score Pre-test and Post-test critical thinking skills of students in the experimental class and control have p value (Sig.). <0.05. This shows that there is a significant difference between the critical thinking skills of students in the experimental and control classes. So that it can be stated that H_0 is rejected and H_a is accepted. This indicates that there is influence from the learning by using free inquiry approach module-based case study in practicing critical thinking skills of undergraduate biology education students on environmental impact analysis material.

There are several studies that investigate the training of critical thinking skills through the implementation of models of inquiry learning by previous researchers, such [15] showing that prospective teacher critical thinking skills increase when inquiry-based learning is implemented. Meanwhile according to [16] said that inquiry-based learning is an alternative solution that can replace conventional learning to improve students' critical thinking skills and clinical reasoning. There was a tendency for students to develop critical thinking skills with the implementation of inquiry learning models compared to direct learning models [17]. In another way this free inquiry approach-module based case study has integrated case study methods with a free inquiry approach. The position of the instructor or lecturer is as a facilitator and the development of a flexible learning environment. Problems that arise when the discussion becomes the focus, stimulus and guide in the learning process.

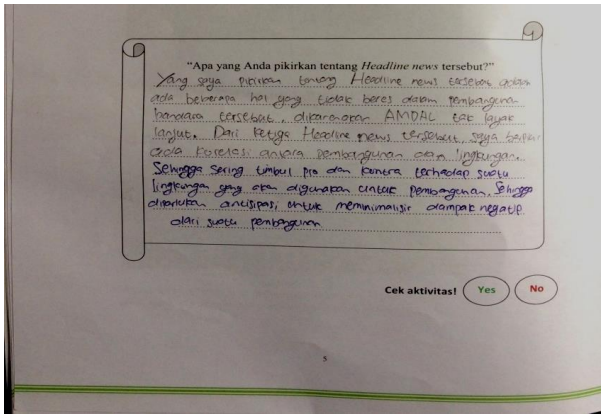
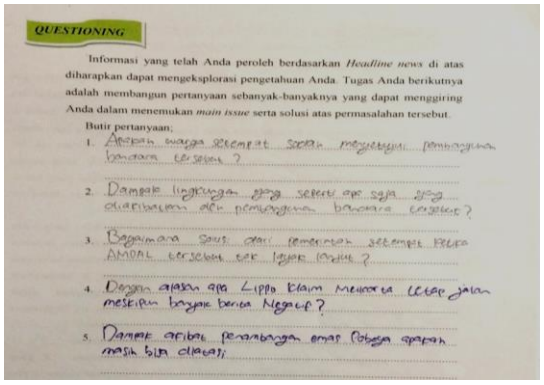


Figure 1. Open Ended component

Each component in the module has an activity check circle in the lower right corner which is intended to check whether the student actually filled in the question column or not. Then in the initial part of the module, the Open Ended component is presented in an open column where most students are able to criticize openly the news presented in accordance with what they perceive. It can be seen in

the figure 1 above. Through this section students are initiated to compile a number of questions in the next column, namely Questioning. It can be seen in the figure 2 below. After the students have finished developing several questions, then they are asked to fill in the Engaging column. In that section, the average student has been able to analyze abiotic, biotic, cultural, process, and the consequences of an activity or business on certain area. They are also asked to classify positive and negative impacts and determine conclusions from activities or efforts towards the certain region they analyzed. Before students work on the decision forcing component, students are required to read material I and II in the module. In this last section, we will see which students really learn the module and vice versa.

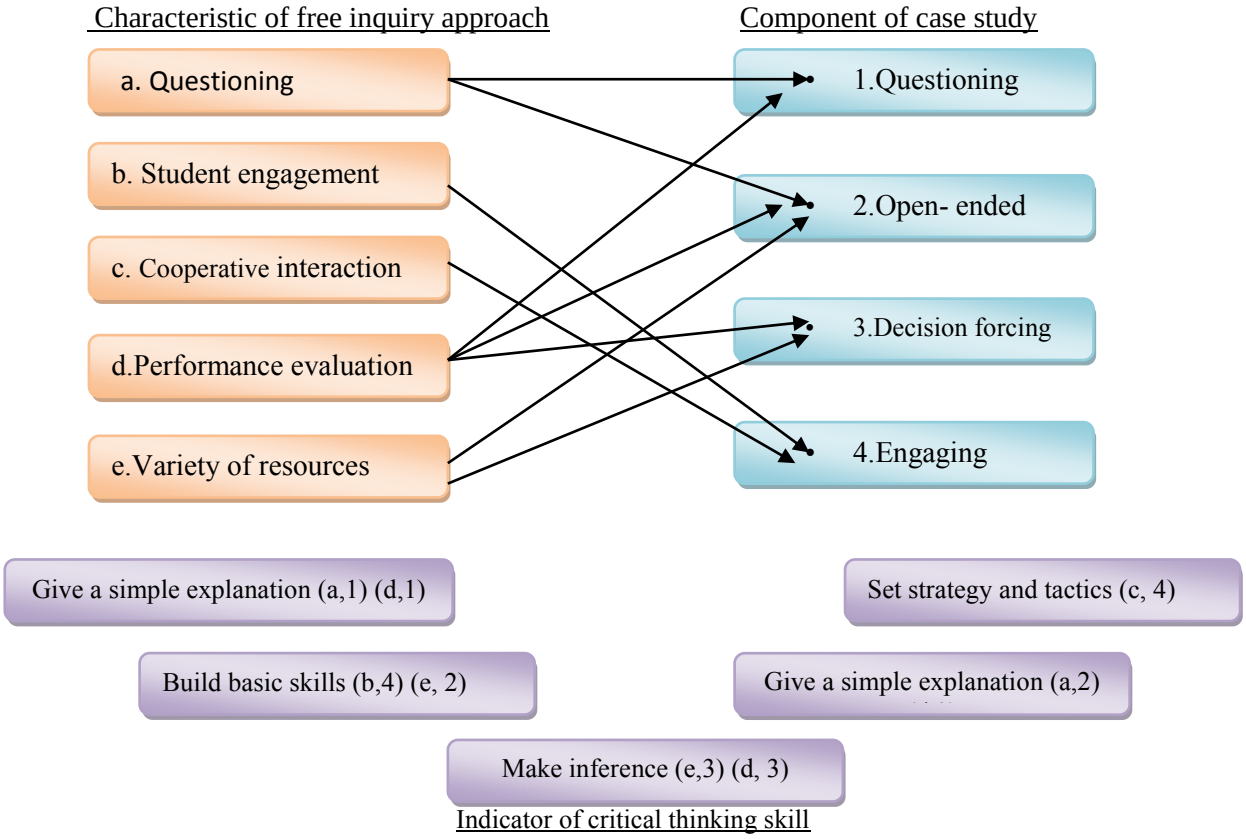

QUESTIONING

Informasi yang telah Anda peroleh berdasarkan *Headline news* di atas diharapkan dapat mengeksplorasi pengetahuan Anda. Tugas Anda berikutnya adalah membangun pertanyaan sebanyak-banyaknya yang dapat menggiring Anda dalam menemukan *main issue* serta solusi atas permasalahan tersebut.

Butir pertanyaan:

1. Apakah warga setempat sudah mengetahui pembangunan bendung tersebut ?
2. Dampak lingkungan yang sekitar apa saja yang dirasakan oleh pembangunan bendung tersebut?
3. Bagaimana solusi dari pemerintah setempat pada AMDAL tersebut oleh lahan [illegible] ?
4. Dengan alasan apa Lippo Plaza [illegible] jalan meski pun banyak [illegible] Negatif?
5. Dampak positif pembangunan emas Pohuwa apakah masih bisa diatasi;

Figure 2. Questioning component



Gambar 1. The relationship beetween free inquiry approach, case study component and critical thinking skill indicator

A series of components of the case study as outlined in the free inquiry approach module can effectively train students' critical thinking skills. Below the relationship beetween free inquiry approach, case study component and critical thinking skill. The main purpose of the inquiry learning is to develop critical thinking, and to develop intellectual skills and to solve problems [18]. Students will collaborate to create new knowledge while studying simultaneously how to think critically through investigation, reflection, exploration, experimentation [19]. As with the implementation of learning case studies in environmental science courses it would be more suitable to use press learning tools or media releases. These press or media releases can include newspapers, magazines, websites or e-bulletins. Usually the tool is used to aim at training the sensitivity of learners about the problems of the general public [11]. When associated with environmental science courses it is very suitable for problems of environmental damage. The media that can be used is through communication teams and looking for news.

Conclusion

Based on the results of research it can be concluded that the environmental impact analysis learning by using free inquiry approach module-based case study is more effective to practice critical thinking skills of undergraduate biology education student when compared using conventional learning only. We hope this research can be as information to teachers especially to teach materials related to the investigation.

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