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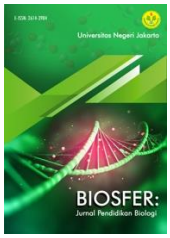

Demonstration and experiment on archaebacteria and eubacteria: effectiveness for cognitive learning outcomes (CLO) based on critical thinking skill

Muhammad Hamdani*, Baskoro Adi Prayitno, Puguh Karyanto

Biology Education, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Indonesia

*Corresponding author: hamdani.pasca.uns@gmail.com

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ABSTRACT

The purpose of this study was to determine differences in students' cognitive learning outcomes (CLO) using demonstration and experimental learning methods. The Clo differences are in students who have high critical thinking skills (HCTS) and low critical thinking skills (LCTS), and whether there is or not the interaction between learning methods and critical thinking towards students CLO. Hopefully, this research could strengthen existing theories and inform other teacher colleagues by using demonstration and experimentation methods in other subjects to improve the quality of a school. The study design used a 2 x 2 factorial design. The study population was students of X science class in one of the state high schools in Central Lombok, Indonesia, which amounted to 18 schools. The study sample amounted to 2 schools. In order to select the research sample, we used purposive random sampling. CLO and critical thinking skills were measured by using essay tests. Testing on the validity and reliability of CLO tests and critical thinking skill showed valid and reliable results. Data were analyzed using ANCOVA with pre-test scores as covariates. The results showed that there were significant differences in CLO between students learning to use the demonstration and experimental learning method. There was a significant difference in CLO between students who have HCTS and LCTS, and there was no interaction between learning methods and critical thinking on student's CLO. Experimental method learning is more optimal to improving student CLO when When it is applied to HCTS students rather than LCTS students on *Archaebacteria* and *Eubacteria*.

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INTRODUCTION

The rapid growth of development in all fields in the 21st century is determined and influenced by the spread of global information and technology (Putra, Prayitno, & Maridi, 2018). Changes and developments in information and technology are so fast that a person needs to have specific skills; one of them is critical thinking (Hadiati, Kuswanto, Rosana, & Pramuda, 2019; Wardani, Lindawati, & Kusuma, 2017; Sümen, 2017). Critical thinking is a higher-order thinking skill (Sahoo & Mohammed, 2018). Critical thinking is needed by someone in evaluating the truth of information before it is used in making decision (Putra, Prayitno, & Maridi, 2018). Critical thinking training is also needed in supporting the success of learning Biology (Bustami, Syafruddin, & Syafruddin, 2018).

Critical thinking is a cognitive process related to decision making, problem probing, and problem-solving or investigation (Alazzi, 2004). Facione & Gittens, (2011) states indicators of critical thinking skills include proficiency: (1) Interpretation; (2) conclusion; (3) evaluation; (4) explanation; (5) analysis; and (6) self-regulation. Developing critical thinking skills requires time and process (Bezanilla, Fernández-Nogueira, Poblete, & Galindo-Domínguez, 2019). In this process, the teacher needs to adjust or pay attention to the learning methods that will be used in the learning process that are appropriate to improve student thinking.

Program for International Student Assessment (PISA) survey had revealed the results of the 2015 survey. It turned out that the results have placed the high-level thinking skills of Indonesian students ranked 62 out of 69 countries evaluated (Prayitno, Suciati, & Titikusumawati, 2018; Prayitno & Suciati, 2017). Many studies have convinced that students' critical thinking in Indonesia is a cause for concern (Ristanto, Djamahar, Heryanti, & Ichsan, 2020; Permana & Chamisijatin, 2019; Izzaty, 2014; Suratno, 2017). The low critical thinking of students in Indonesia, one of which is caused by the use of learning methods that emphasize memorization, less encouraging students to do proving activities or conduct investigations (Prihatni, Kumaidi, & Mundilarto, 2016; Suratno, 2017).

A pilot study using observations at a public senior high scool in Praya Tengah, Indonesia, found that the teaching and learning process still used the lecture method. Learning biology using the lecture method does not allow students to think and participate actively, it only trains the ability to memorize, so students do not develop ideas and critical thinking (Putra, Prayitno, & Maridi 2018; Hayes & Devitt, 2008). Learning biology about *Archaebacteria* and *Eubacteria* with conventional learning provides less understanding related to the material being taught. It resulted in students being passive in learning, less interaction between teachers and students, more listening, notes, so as not to develop students' critical thinking skills. (Labibah & Ernawati, 2017).

Based on the students' high and low CLO students, there is a gap between the world of education and conditions in the field that is found (Ozguc & Cavkaytar, 2015). Students' low CLO can be caused by a variety of factors, which can be from a teacher, student, or other learning support factors (Ozden, 2008). A suitable method is necessary for developing CLO (El Soufi & See, 2019). The teacher has a vital role in improving students' CLO (Van Peppen, et al., 2018). These observations found that it is necessary to have a learning method that can actively involve students in learning biology to improve student CLO.

Teaching and learning processes are conducted at school so that students can construct, find, and develop their ideas to create a solution due to problems about biology (Prayitno, Suciati, & Titikusumawati, 2018). The right way of learning biology is for students to carry out practical activities as biology is essentially a life and environment-oriented education (Putra, Prayitno, & Maridi 2018; Prastiwi, Sigit & Ristanto, 2019). Biological learning outcomes and critical thinking can be developed using appropriate learning methods (Suwono, Pratiwi, Susanto, & Susilo, 2017). Therefore biology learning must be carried out with processes that make students active and facilitate students to achieve learning outcomes (Azizah, Masykuri, &

Prayitno, 2018). The demonstration method is a method that demonstrates a process shown by the teacher or student (Sever, Yurumezoglu, & Oguz-unver, 2010). The experiment method is a way of presenting subjects where students can prove what they are learning (Yuliana Subekti, 2016).

Students' critical thinking skills can also influence the use of experiment and demonstration methods in learning. According to Ozden (2008), if a group of students with sufficiently balanced academic skills is given the same method and learning period, the learning outcomes will form a standard distribution curve. Changwong (2018) stated his opinion that critical thinking is identifying problems, thinking about goals, and looking for possible solutions. Students have different critical thinking abilities caused by variations in each individual (Prayitno et al., 2017). Previous research conducted by Purwanti (2017) did not see one internal factor that can make students think at a higher level demanded in the 21st century today. However, in this study, it is seen that internal factors can improve student CLO, one of which is critical thinking, which is also related to the determination of learning methods, namely the demonstration method and the experimental method. The results of the research conducted by Triwiyono (2011) shows that the experimental method is effectively applied in learning. Students' different thinking abilities will contribute to different learning outcomes. Based on the description that has been described, this study aim to test

1. differences in CLO with demonstration and experiment methods;
2. differences in CLO of students who have HCTS and LCTS; and
3. whether there is an interaction between learning methods and critical thinking on the CLO of students.

METHODS

Research Design

The research method used is quasi-experimental research with a 2x2 factorial design (Marliani, 2013). The study population was students of X science class in one of the public high schools in Lombok Tengah Regency, Nusa Tenggara Barat, Indonesia, which amounted to 18 schools. The study sample amounted to 3 schools. The research samples were selected by purposive random sampling. Random sampling was used because the population is homogeneous, and each member of the population had the same opportunity to be elected. The study was conducted in March-November, 2019. CLO were tested at the end of learning. Students' critical thinking skills were taken as a moderator variable, and it was determined before treatment for the classification of HCTS and LCTS. The classification of students' critical thinking used the regular curve reference. Pre-test scores were used as covariates to eliminate variations in CLO among study samples. Analysis of research objectives using ANCOVA. The research design is illustrated in Table 1.

Table 1
Quasi-experimental research with a 2x2 factorial design

Critical Thinking Skills (B)	Learning Method (A)	
	Demonstration (A_1)	Experiment (A_2)
(B_1)	$A_1 B_1$	$A_2 B_1$
(B_2)	$A_1 B_2$	$A_2 B_2$

Annotation:

A	:	Learning method.
A_1	:	Teaching and learning with demonstration method.
A_2	:	Teaching and learning with the experiment method.
B	:	Critical thinking skills.
B_1	:	High critical thinking skills (HCTS).

B_2 : Low critical thinking skills (LCTS).
$A_1 B_1$: Teaching and learning with demonstration method to students with (HCTS).
$A_2 B_1$: Teaching and learning with the experimental method to students with (HCTS).
$A_1 B_2$: Teaching and learning with demonstration method to students with (LCTS).
$A_2 B_2$: Teaching and learning with the experimental method to students with (LCTS).

Population and Samples

This research was conducted at one of the 18 state high schools as a population in Lombok Tengah Regency, Nusa Tenggara Barat, Indonesia, in the 2019/2020 academic year. Sampling was done by purposive random sampling technique to get samples in this study. Simple random sampling was done by the lottery method. One class was selected by using the demonstration method and one class using the experiment method. The class taught using the demonstration method consisted of 27 students, and the class taught using the experiment method consisted of 26 students.

Instrument

CLO and critical thinking skills between students were obtained by using essay tests material *Archaebacteria* and *Eubacteria*. Examples of problems namely *Archaebacteria* and *Eubacteria* are often discussed in the same section in biology books. Students Identifying the similarities and differences between *Archaebacteria* and *Eubacteria*. According to Bloom (2001), indicators of CLO and critical thinking skills indicators refer to Facione & Gittens (2011) are presented in Table 2.

Table 2
Indicators of CLO and critical thinking skills.

No	Learning Outcomes	Critical Thinking Skills
1	Memorizing	Interpretation
2	Understanding	Conclusion
3	Applying	Evaluation
4	Analyzing	Explanation
5	Assessment/evaluating	Analysis
6	Synthesis/creating	Self-regulation

Bloom's revised taxonomy is recognized that phasing is suitable for an integrated learning process. Before starting the assessment, validity and reliability are tested. Validity Tests are carried out through expert analysis and empirical tests. Two experts were involved in testing whether the assessment was suitable for measuring indicators of CLO and critical thinking and whether they were consistent with learning material. After analyzing, the experts stated that the assessment of cognitive learning results was valid with a validity index of 3.65 and critical thinking 3.45. The assessment was given to 26 students of X science class in one of the state high schools in Lombok Tengah, Nusa Tenggara Barat, Indonesia, as a trial. Empirical test results of cognitive learning results showed that the assessment was valid with a validity index of 0.37-0.79 and critical thinking 0.40-86. The reliability index was tested using the Cronbach alpha formula. The results showed that the assessment of CLO with a reliability index of 0.88 and critical thinking 0.75.

Data Analysis Techniques

The data of this study were analyzed by using ANCOVA with pre-test scores as covariates. Parametric statistical tests were done first as a prerequisite for measuring data normality, and homogeneity of variance was performed. The normality test used Lilifors test and homogeneity test used the Levene's test. The difference in mean values of variables was measured using the

LSD test. Statistical calculations were measured using SPSS version 18.0 with a significance level of 0.05.

RESULTS AND DISCUSSION

Based on the results of the analysis using SPSS 18 program. The Kolmogorov-Smirnov test measured data normality. The test results show that the CLO of students using the demonstration method is 0.200, while the CLO of students using the experiment method is 0.093. This finding obtains a significant result of a higher number than the alpha level of 0.05. It means that the sample data taken in this study given treatment does not deviate from the normal distribution.

The Levene test showed that the homogeneity of variance was 0.466, which is higher than the alpha level of 0.05. The result shows that the data is homogeneous. Based on the results, the data of this research fulfill the ANCOVA parametric statistical test's requirements.

The ANCOVA test results of CLO data using experiment and demonstration as learning methods, critical thinking skills, and the interaction between learning methods and critical thinking are presented in Table 3.

Table 3
ANCOVA test results in the effect of learning methods on students with different critical thinking abilities on CLO.

Source	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4819.713[a]	4	1204.928	16.893	.000
Intercept	12066.959	1	12066.959	169.182	.000
Pre_Test	72.933	1	72.933	1.023	.317
Method	1313.496	1	1313.496	18.416	.000
Critical_Thinking_Skills	1292.630	1	1292.630	18.123	.000
Method* Critical_Thinking_Skills	.640	1	.640	.009	.925
Error	3423.608	48	71.325		
Total	297584.000	53			
Corrected Total	8243.321	52			

a. R Squared = ,585 (Adjusted R Squared = ,550)

Table 3 indicates the significance of learning methods variation as p <0.000, less than the value of alpha = 0.05 (<0.05), which means the learning method significantly influences students' CLO. The results of the analysis of the differences in learning methods on CLO are presented in Table 4.

Table 4
CLO in different learning methods.

Method	Mean	Std. Error	Lower Bound	Upper Bound
Experiment	79.273[a]	1.908	75.438	83.109
Demonstration	67.791[a]	1.763	64.246	71.336

Table 4 shows that the effects of the demonstration method differ significantly from the experiment learning method. The experiment learning method has an average CLO value of 79.273. It is higher than the demonstration method, which only has an average value of 67.791. These findings on calculation show that groups of students using the experimental method have higher CLO compared to groups using the demonstration method.

Based on Table 3, significant critical thinking is sig. = 0,000, less than the alpha value = 0.05 (<0.05), which means that critical thinking significantly influences students' CLO. Correction scores of the average CLO in different critical thinking are presented in Table 5.

Table 5
CLO in students who have high and low critical thinking skills.

Critical Thinking Skills	Mean	Std. Error	Lower Bound	Upper Bound
High (HCTS)	78.901[a]	1.659	75.566	82.236
Low (LCTS)	68.163[a]	1.897	64.349	71.977

Table 5 shows that the average correction score on CLO in HCTS was 78.901, and in LCTS was 68.163. This finding shows that the CLO of HCTS students is different from those of LCTS students. HCTS students have better CLO than LCTS students, and it reflects on the students' achievements.

Based on Table 3, the influence of interactions between different learning methods and critical thinking and the effect on students' CLO is sig. = 0.925, this number is significantly higher than the alpha value of 0.05. We can conclude that there is no significant effect of interaction between different learning methods and critical thinking on students' CLO. The interaction between learning methods and critical thinking and how they affect students' CLO is shown by the LSD test results presented in Table 6.

Table 6
LSD test results showcasing the interaction between learning methods and critical thinking skills in cognitive learning outcomes.

Method	Critical Thinking Skills	N	Subset			Notation
			1	2	3	
Demonstration	Low (LCTS)	17	60.94			a
Experiment	Low (LCTS)	7		71.43		b
Demonstration	High (HCTS)	10		72.40		b
Experiment	High (HCTS)	19			85.05	c
Sig.			1.000	.992	1.000	

Table 6 shows students with HCTS applied to the experiment method differ significantly from the group of LCTS applied to the experimental method and the demonstration method applied to HCTS and LCTS students. This can be seen from the average correction of interactions between the experiment method, and HCTS has the highest score of 85.05. The results show that the experimental method applied to HCTS students is more effective than other interactions.

The demonstration method for HCTS students has the same notation as the experiment method notation for LCTS students. The results shows that there are no significant differences in students' critical thinking skills between the two interactions. However, the average correction demonstration method applied for HCTS students has higher critical thinking than the experimental method applied for LCTS students. The learning process with the applied demonstration as a learning method for LCTS students shows the results of the ability to think critically is the lowest of all contractions.

The research sample was conducted using different learning methods. However, the learning material that was used is the same related to *Archaebacteria* and *Eubacteria*. Table 3 shows a significant effect of learning methods on student CLO. Table 4 shows that the CLO of students with the experimental method is more effective than the demonstration method. The comparison of averages shows that the experimental method has the potential to improve CLO more significantly than the demonstration method. This comparison can be seen from the average value of learning outcomes using the experiment method, which obtains a value of 79.273, and using the demonstration method is 67.791. The results of research conducted by Purwanti (2017) with the results of the study shows that the learning of science experiment methods is more effective in improving student learning outcomes compared to science learning using demonstration methods. Learning by using experiments requires students to

actively engage in an activity, think and solve a problem so that student learning outcomes improve. In the experiment method, students can conduct experiments directly related to *Archaebacteria* and *Eubacteria* material. The research conducted by Rati and Dewi (2017) used experimental methods to improve student learning outcomes as cognitive achievement.

The demonstration method is a way of presenting learning by demonstrating the media. When conducting demonstrations, only some of the students are active in learning because the demonstration is only done by group representatives related to the material through pictures so that other group members do not understand the material being demonstrated. The demonstration method is a learning method that is done by demonstrating a process related to learning material that can be done by the teacher or students themselves (Augusto, Castelo-Grande, & Estevez, 2019). The demonstration method is a method that keeps student attention focused on what is being demonstrated (Riswari, Yanto, & Sunarso, 2018).

Table 3 illustrates the correlation between significant differences between critical thinking and CLO. Table 5 shows that students with HCTS have higher CLO compared to students with LCTS. The students are categorized into two groups, HCTS and LCTS. HCTS students have a better ability to accept learning and a faster ability to understand the material delivered from various sources than LCTS students. With these skills, HCTS students will understand learning well; thus, CLO is significantly higher than LCTS.

The result can be seen from the average value of CLO in HCTS students is 78.901 and in LCTS students with an average of 68.163. This shows that HCTS students get better learning outcomes than LCTS students. This is because students who have HCTS are more active in participating in learning, have more significant curiosity, can solve problems, and can draw conclusions well and are more confident in the learning process. While students who have LCTS are less active in participating in learning, lack of confidence in conveying opinions or ideas, and are less quick in accepting material delivered by the teacher. Critical thinking is very important for learning outcomes (Miharja, Hindun & Fauzi, 2019; Perry, Retallick, & Paulsen, 2014). Low learning outcomes indicate that students' critical thinking skills are still low (Kurniahtunnisa, Dewi, & Utami, 2016).

Critical thinking is a cognitive strategy used to effectively solve a problem (Foo & Quek, 2019). Critical thinking involves activity, such as analyzing, synthesizing, making consideration, creating, and applying new knowledge to the real world (Hatari, Widiyatmoko, & Parmin, 2016). Critical thinking makes students rational, choosing the best alternative for a problem (Mc Inerney and Baird, 2016). Before making a decision, one must collect, analyze, evaluate, and synthesize the information needed (Boa, Wattanatorn, & Tagong, 2018).

LSD test results, as presented in Table 6, shows that HCTS using the demonstration method with lLCTS and the other one using the experiment method do not have a significant difference. It proves that the experimental method can still accommodate and elevates LCTS students in improving CLO. It means that if HCTS students are applied in the demonstration method, it will have good student CLO because students with HCTS can solve a problem appropriately. Students who have HCTS will have the ability to explain information clearly, analyze, and evaluate (Anazifa & Djukri, 2017). Students who think critically will be able to make decisions and solve a problem (Syarifah & Sumardi, 2015).

CONCLUSION

Based on the results of this study, it can be concluded that students taught in learning with the experiment method are more effective in improving the cognitive learning outcome (CLO) than the demonstration method. This can be seen from the average value of CLO using the experiment method obtain a value of 79.273, and using the demonstration method is 67.791. CLO can be seen from high critical thinking skills (HCTS) and low critical thinking (LCTS). It indicates that students HCTS have better CLO than students LCTS. This can be seen

from the average value of CLO in HCTS students is 78.901 and in LCTS students with an average of 68.163. The interaction of experiment learning methods on students' HCTS has the highest CLO. On the other hand, the interaction of the experiment method on students' LCTS has the same CLO as the interaction of demonstration methods on students' HCTS.

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