The Correlation between Critical Thinking Skills and Academic Achievement in Biology through Problem Based Learning-Predict Observe Explain (PBLPOE)

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***Abstract*—This study aimed to investigate the correlation between critical thinking skills and academic achievement in Biology through the implementation of problem-based learning-predict observe explain (PBLPOE) learning model. The study was conducted from February to June 2018 in the even academic year of 2017/2018. A correlational design was employed in this study. The participants consisted of tenth graders from Public Senior High School (SMAN) Number 5 in Bengkulu, Indonesia. The students' critical thinking skills and academic achievement were measured using essay tests. The result of the regression analysis showed that there was a significant correlation between students' critical thinking skills and academic achievement in biology, where Y=7.383 + 0.500x. The regression equation suggests that students' academic achievement may improve as the students' critical thinking increases. Therefore, it is advisable for the educator to promote critical thinking skills in the classroom in order to improve students' academic achievement by, for example, implementing PBLPOE learning model.**

***Index Terms*—academic achievement, critical thinking skills, PBLPOE**

I. Introduction

Education is the key to national prosperity. It affects the development of science and technology in the country. Scientific advancement contributes significantly to the effort of the country to compete globally [1]. This suggests that education needs to be designed in such a way to equip graduates with a set of skills that can help them become high quality human resources. Education has to accommodate the development of students' higher-order thinking skills [2]. These skills play a vital role in achieving goals of education because they enable students to produce ideas and solve complex problems [3]. One of the parts of higher-order thinking skills is critical thinking [4].

Critical thinking can be defined as the ability to think logically [5] from multiple perspectives to find solutions to problems [6]. According to Zane [7] explains that critical thinking skills are generated from an intellectual process through analysis, synthesis, and evaluation of information collected from experiences, reflection, reasoning, and communication. Ennis [8] defines critical thinking as a reflective and logical skill to focus on what to do. Critical thinking, based on [4], consists of fundamental skills in discovering sources of problems and finding appropriate solutions to the problems.

Critical thinking is comprised of the ability to analyze and evaluate evidence, identify questions, and use information effectively to construct a logical conclusion [9]. Analysis skills, reasoning skills, decision making skills, identifying skills, integrating and evaluating skills are skills needed to solve problems critically [10], [11] and acquire new knowledge [12]. Facione [13] points out that critical thinking skills involve interpretation, analysis, evaluation, inference, explanation, and self-regulation skills. In addition, Greenstein [14] explains that critical thinking also covers the ability to analyze information, apply strategies to make decisions, consider ideas, do logical investigations, obtain evidence, and analyze assumptions.

Critical thinking not only becomes a part of educational goals [15] and 21st century demand [16], but is also required to solve social and scientific problems found in every day life [17]. It is even considered as an intellectual need to achieve academic success [18]. Critical thinking helps students absorb knowledge and improve their performance. Students will become effective communicators, critical and dynamic thinkers, competent problem solvers, and professionals in their career [19].

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Critical thinking skills can help students improve their academic achievement because higher-order thinking requires students to explore information to learn [20]. In addition, Kelly and Lincona [21] explain that education is based on thinking, and critical thinking requires students to think rationally. The more knowledge possessed, the higher the level of critical thinking is [22]. Critical thinking consists of cognitive processes [23]. These processes involve problem-solving, analysis, argumentation, and conclusion drawing [24], [25]. Critical thinking is one of the factors that contribute to academic achievement [26].

Academic achievement can be defined as the level of knowledge and skills acquired by students in academic studies [27]. According to Shoval, Sharir, Arnon, and Tenenbaum [28], academic achievement shows the extent to which students absorb and understand the material being taught. When students understand the concept well, it is assumed that they will be able to overcome daily problems easily. Academic achievement also includes knowledge acquisition that allows students to integrate new knowledge into their learning experiences [29].

Academic achievement is one of the determining factors of students' success in the future. Intellectual abilities allow students to develop skills in discovering, using information to expand their thinking abilities [30]. Students with good intellectuals will become more responsible, independent, brave and respectable at schools and in society [31]. Students who are able to process information, organize, and explore knowledge based on experiences are the ones who possess high academic abilities [32].

Academic success varies among students because it is influenced by many factors including motivation, learning styles, learning models, metacognitive skills [33] and critical thinking skills [34], [31]. Student academic success is also determined by learning experiences that are acquired through the implementation of a learning model [35].

Research indicates that there is a significant relationship between critical thinking skills and student academic achievement [36], [9]. Critical thinkers are normally successful academics, while individuals with poor critical thinking skills are more likely to fail in academic fields [37]. Karbalaei [34] argues that strong critical thinking can stimulate critical knowledge in increasing academic success. However, unfortunately, Kanbay [38] could not find a correlation between critical thinking and student achievement. These conflicting results may be caused by student individual differences and educational cultures [39].

Critical thinking and academic success need to be achieved by students; therefore, they need to be stimulated through the learning process. Implementing Problem-Based Learning (PBL) and Predict-Observe-Explain (POE) learning model in the classroom can be the solution. PBL is a learning model that involves authentic and unstructured problems. In PBL, students work collaboratively to define and solve proposed problems as well as develop their communication, presentation, and critical thinking skills [40]. In addition, this type of learning empowers students to conduct research, integrate theory and practice, and apply knowledge and skills to develop solutions to specified problems [41].

On the other hand, Predict-Observe-Explain (POE) learning model provides assistance for students to explore their initial knowledge and play an active role in the learning process. POE is a constructivism-based learning model that allows students to build knowledge-based through a hands-on experience [42]. According to Hilario [43], POE can facilitate students' discussions and exchange of ideas about scientific problems. This type of learning cal also stimulates students' ability to predict phenomena, conduct observations through demonstrations, and finally explain the results.

Some studies show that PBL is able to empower students to think critically [44] and succeed academically [45]. However, since knowledge can also be acquired through the process of remembering without having to involve aspects of students' critical thinking, Masek [46] and Sulaiman [47] found that PBL had no significant effect on student critical thinking. Besides, Kazemi & Ghoraishi [48] and Yadav et al. [49] also discovered that PBL did not contribute significantly to student academic achievement.

To deal with these limitations, Problem-Based Learning (PBL) can be integrated with Predict-Observe-Explain (POE). POE has been proven effective in facilitating students' thinking skills [50]. A study conducted by Dipalaya & Corebima [51] to high school students in Makassar has indicated that POE can promote students' critical thinking skills. Similarly, Hong et al. [52] have also found that POE can help students achieve better in learning. The activities in POE provide opportunities for students to work independently, participate actively, and apply theory into practice [43].

The integration of PBL and POE is based on constructivism learning. Learning activities in PBLPOE help students construct their knowledge based on experiences in various circumstances and phenomena to acquire new knowledge. The students are also empowered to discover solutions to problems in groups.

The correlation between critical thinking and academic achievement has been examined in previous studies; however, none evaluated the relationship through Problem-Based Learning-Predict Observe Explain (PBLPOE) learning. Therefore, this study aimed to investigate the correlation between critical thinking and academic achievement through the implementation of the Problem-Based Learning-Predict Observe Explain (PBLPOE) learning model.

II. Methodology

A. Design of the Study

The current study used a correlational design that involved critical thinking as the predictor and academic achievement as the criterion. The participants of the

study consisted of X IPA 1 (natural science program) students from Public Senior High School No. 5 (SMAN 5) in Bengkulu, Indonesia. This study was conducted in the even semester of the 2017/2018 academic year. The topics discussed during this period of learning included Plant, Animal, Ecosystem, and Environment.

The present study was carried out in the following stages: a) conducted an observation at SMAN 5 Bengkulu, Indonesia. b) a pretest was administered (once in the beginning) to investigate the students' critical thinking and academic achievement; c) implemented six phases of PBLPOE. First, the students were asked to formulate questions based on a phenomenon. Next, the students worked on the formulation of the problems in groups and made some predictions. At the fourth stage, the students conducted an investigation to find evidence to support their predictions and seek alternative solutions to the problems. After that, the students discussed, presented, and compared their findings with their predictions in order to discover the best solution to the problems. At the last stage, the students were encouraged to do some reflection and evaluation of the process. d) a post-test was conducted to evaluate the students' critical thinking and academic achievement.

B. Instruments

Instruments of this study consisted of a syllabus, lesson plans, student worksheets, and essay tests to measure the students' critical thinking and academic achievement. The validity and reliability of the test items were examined using Pearson Correlation and Cronbach's Alpha analyses. The results of the analyses showed that critical thinking and academic achievement tests were valid and reliable with scores of 0.958 and 0.843, respectively. The students' critical thinking was assessed based on the following indicators: providing simple explanations, determining bases for decision making, drawing a conclusion, making an advanced clarification, making an assumption and integration, organizing strategies and tactics [8]. The critical thinking rubric referred to Ennis [8], while the assessment for student academic achievement referred to Anderson and Krathwohl's [53] revised Bloom's taxonomy cognitive levels.

C. Data Analysis

The research data were analyzed using simple regression correlation analysis at the 0.05 ($P < 0.05$) significance level. Before conducting the analysis, data normality and homogeneity were examined using Kormogolov-Smirnov Test and Levene's Test, respectively.

III. Research Results

The result of the study showed that the students' critical thinking data were distributed normally and homogeneously with a *p-value of* 0.357 and 0.214. The students' academic achievement data were also distributed normally and homogeneously with a *p-value* of 0.419 and 0.055. The result of the post-test was summarized in Table I.

TABLE I. Students' Post-Test Scores

	Post-test Score
Critical thinking	83.12
Academic achievement	87.77

Table I indicates that the students obtained 83.12 for critical thinking and 87.77 for academic achievement. The result of the regression analysis used to explain the correlation between critical thinking and academic achievement in PBLPOE learning was presented in Table II.

TABLE II. The Result of the Regression Correlation Analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	. 665[a]	.442	.365	3.29766

Table II showed a strong correlation between the predictor and the criterion (R= 0.665). The R-squared value (R^2 =0.442) implies that 44.2% of student academic achievement is determined by critical thinking, and 55.8% of it is affected by other factors. ANOVA analysis was performed to investigate the significance of the relationship between the two variables. The result of the ANOVA analysis was depicted in Table III.

TABLE III. The Result of the ANOVA Analysis

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	249.48	1	62.3	5.7	.002[b]
	Residual	315.36	29	10.8		
	Total	564.84	30			

F-value (5.73) with *p-value* 0.002 < 0.05 (Table III) indicates that critical thinking can significantly predict academic achievement. The result of the regression analysis was presented in Table IV. The regression equation for critical thinking and academic achievement is $Y = 7.383 + 0.500x$.

TABLE IV. Regression Analysis Coefficients

	Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	7.383	32.48		.227	.822
	critical thinking skills	.500	.128	.654	3.91	.001

IV. Discussion

Critical thinking is a higher-order thinking skill that can help students succeed in learning. The students successfully obtained 83.12 and 87.77 for critical thinking and academic achievement, respectively. This success was apparently affected by internal factors such as skills, and external factors including learning strategies. Facione [54] explains that critical thinking skills are associated with individuals' cognitive ability. Therefore, critical thinking can affect learning achievement. Thinking is the core of knowledge. Through thinking, one can connect parts of information

[55]. External factors such as learning strategies can also affect students' academic achievement [33].

The result of this study indicates that critical thinking can contribute 44.2% to academic achievement. These findings suggest that critical thinking has a significant correlation with student academic achievement in Biology. Students who learn through problem-solving have rich knowledge because problem-solving fosters critical thinking, and critical thinking triggers the development of knowledge [56]. The result of this study is corroborated with the findings from Ashoori [57], Partido & Soto [15], who found a correlation between critical thinking and academic achievement. According to Abbasi & Izadpanah [17], the empowerment of critical thinking enables students to be successful in education and academic fields. Students with strong critical thinking skills do not easily accept information from the environment. Instead, they use their thinking abilities to study various perspectives and find the best solution [58].

Critical thinking has a correlation with academic achievement because critical thinking also constitutes past of the highest cognitive abilities that can produce effective thinking in solving problems [6], [20], enhancing understanding, collecting relevant information, drawing conclusions, and making the best decisions [3]. Also, Elder and Paul [59] express critical thinking as art in analyzing and evaluating thinking through a variety of perspectives.

The relationship between critical thinking skills and academic achievement can also be explained by indicators of critical thinking. Ennis [8] argues that cognitive skills are the core of critical thinking. In an investigation, for example, students are required to find various relevant information to find alternative solutions to problems. Through the process, the students need to make a connection between the findings with the alternative solutions. This activity constitutes parts of critical thinking that are determining the bases for decision making and making assumptions and integration. According to Karagöl & Bekmezci [27], investigation activity can facilitate higher academic achievement by helping students connect and identify accurate information.

PBLPOE activities accommodate students' critical thinking skills. "Learning by doing" provides opportunities for students to learn to solve problems because it actively involves the students, individually and in groups, to become independent learners. The students are asked to identify the available data and information to make predictions from the problem. Students who are able to identify information and formulate it in the form of questions can analyze the problem by predicting the answer. The questions are a tool that can be used to improve students' critical thinking skills [60]. Students who think critically will formulate critical, logical, and effective questions based on data and information. In addition, this learning activity also involves students in accessing, analyzing, and synthesizing relevant information to explore problems by finding various solutions. During this process, students will gain a lot of knowledge. As a result, their academic achievement improves accordingly. The results of Kuhlthau's research [61] show that knowledge can be constructed through discovery of various information. This process of discovering information engages students in understanding the material more clearly and thus being more successful in learning.

Aside from critical thinking skills, other factors that might influence the improvement of student academic achievement include motivation and metacognitive skills. Metacognitive skills increase students' awareness to learn, plan their learning, control their learning process, and evaluate their own strengths and weaknesses [33]. High learning motivation can guarantee better cognitive learning outcomes. Motivation is a mental strength that triggers one's desire to learn and gives clear directions to him/her to obtain optimal results [62]. Academic achievement can also be influenced by self-efficacy because self-efficacy refers to student confidence in solving problems [39]. Another factor that can also contribute to student's success in academic fields is creative thinking skills [63]. Creative thinking is the ability to develop ideas and insights to gain new and meaningful knowledge.

Critical thinking skills are an important intellectual asset and must be possessed by all students. Critical thinking skills need to be developed in students to make them competent in analyzing, solving problems, and making decisions. Critical thinking skills can be promoted through learning. Therefore, teachers can implement the PBLPOE learning model to enhance students' critical thinking skills and improve their academic achievement. This study was limited to the middle school level because it has not involved participants from elementary schools or universities. The researchers were only focused on two variables, that are critical thinking and academic achievement. Based on these limitations, it is suggested for future research to investigate different variables at different levels of education.

V. Conclusion

Based on the results of the study and discussion, it can be concluded that there is a significant relationship between critical thinking and student academic achievement in Biology through the implementation of PBLPOE. Students with good critical thinking skills are trained to think at a high level; therefore, it is more possible for them to obtain higher academic achievement. Educators need to empower students to think critically and successfully achieve good scores in Biology. Further investigations can be done by examining the relationship between critical thinking skills and academic achievement at different levels of education.

Conflict of Interest

We declare that this manuscript material has no affiliation with any organization and with financial or non-financial interests.

AUTHOR CONTRIBUTION

Apriza Fitriani was in charge of this research to formulate research objectives to write down research results. Siti Zubaidah is tasked with coordinating all research and giving direction on manuscripts. Herawati Susilo is in charge of giving directions regarding the results of research and references that will be used. Mimien Henie Irawati Al Muhdhar is tasked with providing direction on references and discussion of research results.

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