Critical Thinking Ability after Project-Based Learning: A Comparative Study on Students Who Have Different Cognitive Styles

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Abstract This research aims to compare critical thinking skills between students who have different cognitive styles namely reflective and impulsive. The research design used was a Pre-Experiment One-Shot Case Study, where a group of students was given project-based learning treatment in plant development subjects, this study did not use a group of control. The student's cognitive style was measured using the MFFT (Matching Familiar Figure Test) instrument that is carried out before the project-based learning is implemented. Furthermore, students' critical thinking skills are measured by using a critical thinking skills test conducted at the end of the project-based learning process. The test resulted in students' critical thinking skills between those who have reflective cognitive styles and those who are impulsive. The data analysis results showed that there were differences in critical thinking ability between students who have reflective cognitive styles and those who were impulsive. Students' reflective abilities in terms of critical thinking are better than impulsive. Information about differences in the ability of reflective and impulsive students to think critically is important for educators as a consideration in choosing a suitable learning model.

Keyword: Critical Thinking, Project-Based Learning, Cognitive Styles

1. Introduction

Critical thinking ability is an aspect that needs to be developed in the learning process. It aims to produce graduates from a study program to meet the demands of the 2012 IQF curriculum. Permenristekdikti No.44 of 2015 concerning Higher Education Standards confirms that critical thinking is an ability that must be developed by educators in learning. This means that students' critical thinking ability does not appear on their own, but it is important to be trained or taught in the learning process [1]. The IQF curriculum is designed to be relevant to the conditions of the 21st century. One of the demands is that critical thinking ability is important for an individual to be able to gather information, investigate, and communicate [2].
The learning process is generally done more for the achievement of learning outcomes, not yet optimally made as a means to develop critical thinking. Critical thinking is an accumulation of knowledge and experience; therefore educators must begin to develop the critical thinking ability of students not only teaching for exams [3]. An educator in developing students’ critical thinking needs to consider the learning method or model that will be used. It is important so that critical thinking ability involved in the process of critical thinking can be trained. The core of critical thinking ability involved in the process of critical thinking consists of interpretation, analysis, evaluation, inference, explanation, and self-regulation [4]. Through critical thinking ability, students, when faced with a problem, will do the following: 1) think rationally in addressing a problem; 2) make the right decisions in solving problems; 3) analyze, organize, and explore information based on facts; and 4) draw conclusions in solving problems and formulating arguments correctly and systematically.

The method and learning model was chosen to develop critical thinking must be able to create interactions between students, provide opportunities for students to reflect on the problems given, and optimize the knowledge and experience of students [5]. Some examples of interactive learning models that can improve critical thinking are Discovery Learning [6], Inquiry-Based Learning [7-8], Problem Based Learning [8], and Project-Based Learning [9]. Cash [9] states that Project-Based Learning as a student-centered strategy promises to develop critical thinking, which is ignored by traditional curricula. Birgili [10] explained that if you want to make students as young scientists in the future, critical thinking ability needs to be developed through the design of the learning process.

An educator also needs to consider student learning styles in designing learning in addition to critical thinking ability. Learning style can improve academic achievement and learning satisfaction when aligned with the teaching style. Therefore, teachers in presenting topics must be based on students' learning styles [11]. An individual's learning style is influenced by cognitive style. Cognitive style is intended as a characteristic of individual differences in organizing and processing information [12]. Besides individual choice, a habitual approach to organizing, presenting information, and cognitive processes of someone is a characteristic of cognitive style [13]. One way to understand the learning styles of students needs to research in the field of education [14]. Information about students' learning styles is important to know because learning styles are the chosen way of individuals in analyzing and understanding, which is innate and influences the learning process of a person [15]. Cognitive style is distinguished based on the speed of time to respond to stimuli that include cognitive style of reflective and impulsive [16].

Another thing that educators need to consider is the course that will be used as material for the study of students in training their critical thinking ability. Plant development subject is considered suitable to be used as material for the study of students in training their critical thinking ability in the form of projects. Concepts on the development of plants, for example, the concept of growth and development to be understood by students requires thinking ability.

Many studies have analyzed critical thinking through the application of project-based learning models, but not many have reviewed it in terms of cognitive style. Therefore, it is necessary to conduct a study on students' critical thinking after applying the project-Based Learning model in terms of differences in cognitive styles. The cognitive styles in this study focusing on reflective and impulsive. Based on the description, the problem in this study is how are students' critical thinking skills after applying a project-based learning model reviewed in terms of reflective and impulsive cognitive styles?
2. Method
The research used Pre Experimental Design in the form of a One-Shoot Case Study, namely research without a control class. The subjects of the study were 14 students of the biology education study program in 2016 consisting of 7 students with reflexive cognitive style and 7 students with impulsive cognitive style. In the class, project-based learning was applied which accommodated the cognitive style of reflective and impulsive for one semester as independent variables and students’ critical thinking abilities as the dependent variable. There were two instruments used in this study, namely: 1) MFFT (Matching Familiar Figure Test) developed and modified by Warli (2010). This instrument was used to measure the tempo of the concept in determining the cognitive style of students, and 2) critical thinking test sheets that refer to Ennis [18]. The measurement of cognitive style was done at the beginning before the learning was carried out. Differences in student cognitive styles (reflective and impulsive) are the basis for group division when working on projects. The measurement of critical thinking was done at the end of learning. Questions for critical thinking tests were 10 questions. Data on students' critical thinking were then analyzed using non-parametric statistics by the Mann Whitney test. The Mann Whitney test results were used to determine differences in the critical thinking ability of students reviewed based on cognitive styles of reflective and impulsive.

3. Research Results
The data collected from this study are of two kinds, namely: 1) Average score of each question on the ability of critical thinking reviewed based on cognitive styles of reflective and impulsive as presented in Table 1, and 2) Average score the ability of students' critical thinking is reviewed based on cognitive styles of reflective and impulsive as presented in Table 2.

| Student Cognitive Style | Average Score for Each Indicator the Ability of Critical Thinking |
|-------------------------|---------------------------------------------------------------|
|                         | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   |
| Reflective              |      |      |      |      |      |      |      |      |      |      |
|                         | 3,14 | 4,71 | 4,71 | 4,14 | 4,86 | 5,00 | 4,86 | 4,14 | 4,71 | 5,00 |
| Impulsive               |      |      |      |      |      |      |      |      |      |      |
|                         | 3,57 | 3,71 | 2,71 | 3,86 | 3,71 | 3,86 | 4,57 | 3,29 | 3,29 | 4,86 |

Information:
1 : Identify or formulate criteria for judging possible answers.
2 : Identify conclusions
3 : To provide a simple explanation
4 : Ability to give reasons
5 : Using the right evidence
6 : Interpretation
7 : Conclusions fit the facts
8 : To provide further explanation
9 : Choosing Criteria to Consider Possible Solutions
10 : Argument

| Average Score of Students’ Critical Thinking Ability in Reflective Cognitive Style | Total | Average Score of Students’ Critical Thinking Ability in Impulsive Cognitive Style | Total |
|---------------------------------------------------------------------------------|-------|---------------------------------------------------------------------------------|-------|
| 3,90                                                                             | 1     | 3,20                                                                             | 1     |
| 4,20                                                                             | 1     | 3,40                                                                             | 1     |
| 4,50                                                                             | 1     | 3,80                                                                             | 4     |
| 4,70                                                                             | 1     | 4,40                                                                             | 1     |
| 4,80                                                                             | 3     |                                                                                  |       |

TOTAL 4,529 3,743
Furthermore, the data about the ability of critical thinking based on cognitive styles of reflective and impulsive were analyzed using non-parametric statistics with the Mann Whitney test, whose results are as shown in Table 3.

Table 3. Results of Data Analysis the Ability of Students’ Critical Thinking Based on Cognitive Style of Reflective and Impulsive

| Sub Indicator | U   | W   | Z       | Sign | Ho    |
|---------------|-----|-----|---------|------|-------|
| 1             | 17.00 | 45.00 | -1.209  | 0.227 | accepted |
| 2             | 14.00 | 42.00 | -1.566  | 0.117 | accepted |
| 3             | 5.50  | 33.50 | -2.551  | 0.011 | rejected |
| 4             | 16.00 | 44.00 | -1.190  | 0.234 | accepted |
| 5             | 9.00  | 37.00 | -2.208  | 0.027 | accepted |
| 6             | 14.00 | 42.00 | -1.566  | 0.117 | accepted |
| 7             | 24.00 | 52.00 | -0.105  | 0.917 | accepted |
| 8             | 17.50 | 45.50 | -0.961  | 0.336 | accepted |
| 9             | 13.00 | 41.00 | -1.715  | 0.086 | accepted |
| 10            | 21.00 | 49.00 | 1.000   | 0.317 | accepted |
| **TOTAL**     | 2.00  | 30.00 | -2.920  | 0.003 | rejected |

4. Discussion

There are three types of data obtained from this study, which are used to describe the critical thinking abilities of students after the application of the project-based learning model based on the cognitive styles of reflective and impulsive.

First, based on the average score of each critical thinking indicator tested, in this case, there are 10 indicators as presented in Table 1. In students who have the cognitive style of reflective the score is still low, which is 3.14. According to the critical thinking scoring rubric modified from Finken and Ennis (1993) in Prihatiningsih [19] that the indicator is not yet visible or not well developed. As for indicators: 1) identify conclusions; 2) to provide a simple explanation; 3) ability to give reasons; 4) using the right evidence; 5) interpretation; 6) conclusions fit the facts; 7) to provide further explanation; 8) choosing criteria to consider possible solutions; and 9) arguments, already visible or well developed, because the average score is greater than 4. Based on the data in table 1, 90% of the indicators of critical thinking ability tested, can be achieved by students who have the cognitive style of reflective.

In students who have impulsive cognitive style, there are three indicators whose scores are still low, namely: 1) to provide a simple explanation; 2) to provide a further explanation, and 3) choosing criteria to consider possible solutions. So the three indicators for students who have impulsive convoluted styles have not yet appeared or are not well developed, While the indicators: 1) identify or formulate criteria for judging possible answers; 2) identify conclusions; 3) ability to give reasons; 4) using the right evidence; 5) interpretation; 6) conclusions fit the facts; and 7) arguments, already visible or well developed. Based on the data in Table 1, 70% of the indicators of critical thinking ability tested, can be achieved by students who have impulsive cognitive style.

Second, based on a total comparison of the indicators of critical thinking skills tested showing the difference between students who have the cognitive styles of reflective and impulsive. Based on the average total score shown in Table 2, the critical thinking skills of students with reflective cognitive styles are better than students who have an impulsive cognitive style after the implementation of project-based learning models. This is in line with research conducted by Cintamulya [25] on genetic material, where students' critical thinking skills with reflective cognitive style are better than impulsive.
Third, based on the comparison of critical thinking skills between students who have the cognitive styles of reflective and impulsive the Mann Whitney statistical test results as in Table 3. The ability of critical thinking between students who are cognitively reflective and impulsive is not different from the indicators: 1) identify or formulate criteria for judging possible answers; 2) identify conclusions; 3) ability to give reasons; 4) interpretation; 5) conclusions fit the facts; 6) provide further explanation; 7) choose criteria to consider possible solutions; and 8) argument. As for indicators: 1) to provide a simple explanation and 2) use the right evidence, there are differences in the ability of critical thinking between students who have cognitively reflective and impulsive. As for indicators: 1) to provide a simple explanation and 2) use the right evidence, there are differences in the ability of critical thinking between students who have cognitively reflective and impulsive.

Therefore, based on cognitive style, there is a difference in the ability to think critically between students who have the cognitive styles of reflective with impulsive ones. Achieving these indicators is because students who have cognitive styles of reflective make it possible to always read by understanding and interpreting the text [20]. Reflective students always pay attention to detailed information of a stimulus and tend to process information analytically [21]. This is in line with the results of research from Rozencwaig and Corroyer [31] that people who have reflective in responding to information will carry out analytic processes, and they are mature in terms of cognitive. In addition, students who have a reflective cognitive style in remembering information that is far more detailed than impulsive.

Indicators of critical thinking skills achieved by students with reflective cognitive styles are more than impulsive. Indicators of critical thinking ability achieved by students who have impulsive cognitive style are less than those of reflective cognitive style. This is because students are impulsive in making decisions and reporting them very quickly but not paying attention to accuracy. It is different with reflective students with the same intelligence to make a decision that is more concerned with accuracy so that it takes a long time. Therefore an impulsive person is a fast dimension because it consumes little time, spontaneous and unplanned to complete and analyze data and consequently makes a lot of mistakes [22].

Zhang [21] said that impulsive children tend to process information globally by paying attention to overall stimuli. Based on the results of research from Rozencwaig and Corroyer [31] that children who have impulsive in responding to information, through a holistic process and cognitively they are immature. This difference occurs because students who have cognitively reflective and impulsive have different characteristics in forming concepts, solving problems, thinking, and processing information. Where students who are impulsive are easily attracted by new things. They tend to be in a hurry to act without thinking about the consequences. While reflective students have characteristics that like to reflect on the experience and observe things from various perspectives. They tend to need a long time in making a decision [23]. Besides, based on the time in responding to questions, reflective students answer fewer questions but answer them more correctly than impulsively answering more questions with more errors [30].

It was found that children who are conceptually reflective tend to make fewer errors in reading than impulsive children [22]. However, if reinforcement is appropriate for global information processing or analytics, as was done by Carretino [24] in his research by providing a modified conceptual style assignment. It shows that impulsive and reflective students are able to process global or analytical information under appropriate reinforcement. Based on the score of critical thinking indicators obtained by students, the project-based learning model is a learning model that can develop critical thinking skills. Similar research on the implementation of a project-based learning model is able to facilitate the ability of students’ critical thinking as done by Rochmawati [26] in the field of physics. Furthermore, the research conducted by Jamaluddin [27] shows that project-based learning is more effective than conventional learning in improving critical thinking ability. Treacy et al. [28] said that project-based learning can help to learn independently and improve critical thinking ability. According to Hussain, et al. [29], students
become happy with the application of project-based learning, so that it affects their understanding of the subject matter, improves their ability in terms of critical thinking, and their time management skills become better.

The findings in this study that the analysis of critical thinking skills after the implementation of project-based learning models are reviewed in more detail based on different cognitive styles namely the cognitive styles of reflective and impulsive. Based on the results of the study, the project-based learning model is able to develop students' critical thinking skills for both cognitive styles. But the project-based learning model has not been able to develop critical thinking skills optimally for both cognitive styles, still in one cognitive style that is reflective.

**Conclusion**

Implementation of Plant Development learning by using a project-based learning model can make students in terms of their critical thinking skills well developed. The ability of students to think critically after project-based learning shows the differences seen from different cognitive styles namely reflective and impulsive. Students who have a reflective cognitive style of ability in terms of critical thinking are better than impulsive. Information about differences in the ability to think critically in students with different cognitive styles is important for educators as a consideration in designing a learning model.

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