The Implementation of HOT Lab Activity to Improve Students Critical Thinking Skills

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Abstract. Critical thinking as part of 21st century skills is important to be mastered by students in preparing them to compete in real life challenge. However, verificative lab activity implemented in physics class, is ineffective to provide opportunity to develop the skills. Under those need, a quasi experiment study with pretest postest Verificative Lab Implemented group design was conducted to investigate how is implementation of Higher Order Thinking (HOT) Lab design in improving students critical thinking skills compare to those who conducted verificative lab . The result shown that there was significant improvement of student critical thinking skills in HOT Lab Implemented Group compare to those in Verificative lab group.

Keyword: HOT lab design, 21st Century Skills, Critical Thinking Skill.

1. Introduction

Education nowadays has shifted to new trend in providing students opportunity to foster 21st century skills through educational processes [1]. Critical thinking, is one of skills mentioned in skills required for 21st century challenge. Critical thinking skills is ranked as the most important skills required in STEM work field [2]. Furthermore, critical thinking acts as transferable skill used in problem solving process [3][4], which is a significant process in scientific investigation.

Physics as part of STEM subjects, should be able to foster critical thinking skills as objective of learning. Previous research has been conducted in developing learning innovation to prepare students with critical thinking including developing learning approach [5], learning model and activity[6][7], as well as assessment to measure critical thinking skills[8].

One of learning activity that can be apply in fostering critical thinking is laboratory activity. Laboratory activity is often preferred to be used in physics classroom. Generally this activity is used to build conceptual understanding as well as strengthen concept that has been deliver. Laboratory activity is expected to engage students with scientific investigation that fostering higher cognitive skills as well as practical skills [9]. However, type of laboratory activity such verification lab is failed to meet the expectation in fostering higher order thinking since the activity of verification lab is mainly focusing on following lab procedure that require low order thinking processing.

In a way give alternative solution in training critical thinking skills, Higher Order Thinking lab (HOT) lab activity is developed. The objective of this activity is to facilitate students to improve their higher order thinking skills, in this case is critical thinking skill [10]. Previous study presented that HOT lab has been implemented in university level and has showed satisfactory result in training students with
higher order thinking skills, including critical thinking[11]. This study is aimed to investigate the implementation of HOT lab activity in improving critical thinking skills of high school students in physics subject.

2. Higher Order Thinking (HOT) Lab Activity
HOT Lab is laboratory activity which is focusing on training student in higher order thinking skills through laboratory activity. This lab activity is being developed under the needs of having laboratory activity which not only training student on laboratory skills and concept mastery but also could improve HOT skills. HOT lab framework is developed by combining Creative Problem Solving Model of Learning (CPS) and Problem Solving Lab Model (PSL)[10]. The activity consists of eight main stage including: 1) Real World Problem Determine and evaluate ideas, 3) Experimental question, 4) materials and Equipment 5) Prediction, 6) Question of the method, 7) Exploration, 8) Measurement, 9) Analysis, 10) Conclusion, and 11) Presentation.

3. Research Methods
A quasi experiment study with pretest - posttest control group design was conducted. The subject of this study are 72 students of grade XI in one of Public High School in Tasikmalaya which were chosen by using random sampling. Later, they were divided into experimental and control group. Experimental group were given HOT Lab activity as treatment. On the other hand, control group were given verification Lab activity as comparison.

All subjects were given critical thinking test (CTT) which is developed using framework of critical thinking by binkley, et.al [12]. The framework then was summed up into seven indicator group including:

CI.1 Analyse, analysing and identifying ideas, arguments, and information,
CI.2. Explain, presenting and clarify ideas, argument, and information
CI.3 Evaluate, evaluating ideas, argument, and information
CI.4 Interpret, interpreting one idea, argument, or information
CI.5 Synthesize, connect and combine information/data to build argument/claim
CI.6 Conclude, concluding idea, argument, and information
CI.7 Inference, inferring information, making a scientific guessing based on pattern.

CTT was used to measure students’ critical thinking skill before and after the implementation. The improvement were then analysed and categorized by calculating normalized gain index [13]. Whereas the comparison of CTT score between HOT Lab Implemented Group and Verification Lab Implemented Group was analysed by using Independent T-Test and Mann-Whitney Test.

4. Result and Discussion

4.1 Implementation of HOT lab:
The topic of heat transfer was selected to be used in the implementation of HOT lab. Two practical modules with different theme of daily life problem were implemented. Solar energy problem was used for the first module. In this activity, students required to arrange an experiments to test ideas about how to boil water by using solar energy and compare the results to find the most effective ideas.

On the other hand, the second module is arranged based insulation problem theme. The students were given problem how to make a simple thermos by using household material such as Styrofoam, aluminium foil, and sponge. The ideas that should be tested are “which insulator that is the best to be used in thermos?” Similar with the first module, student then conducted the experiment and compare the result.
4.2 Improvement of Critical Thinking Skills

Based on the result of compared mean CTT pretest score between experimental group and control group in table 1, it indicates that there is no different result between experimental group and control group. Hence, it is interpreted that critical thinking skills in both group before the treatment is initially similar. On Contrary, the result of CTT postest represents different result which means that there were different result of implementation in both group.

**Table 1.** Compare mean test of HOT Lab Implemented and Verification Lab Implemented Group.

|                | Independent T-Test |       |       |       |       |
|----------------|--------------------|-------|-------|-------|-------|
|                | T                  | Df    | Sig.(2-tailed) | Mean Difference | Std error Difference |
| Pretest        | 1.100              | 70    | 0.275                        | 2.49444          | 2.26688           |
| Postest        | 5.572              | 70    | 0.000                        | 18,60556         | 3.33923           |

According to data of mean score in both group, it indicates an improvement. However, the quality of improvement between each group is different. The improvement of critical thinking skills is analysed by calculating normalized gain index (n-gain). Result shows that n-gain value of HOT Lab Implemented group is 0.34 which categorized as medium, whereas n-gain value of Verification Lab Implemented group is 0.13 which categorized as low. The result indicate that the improvement of critical thinking skills in HOT Lab Implemented group is higher than Verification Lab Implemented group.

Furthermore, the value of normalized gain from each group were analysed by using compare mean test by using Mann-Whitney U test to analyse the significance difference between the value. Table 2 below represent the result of the test.

**Table 2.** Compare Mean Test for N-gain Score between HOT Lab Implemented and Verification Lab Implemented Group

|                        |                    |        |        |        |        |
|------------------------|--------------------|-------|-------|-------|-------|
|                        | Mann-Whitney U     | 199,500 |      |       |       |
|                        | Asymp. Sig. (2-tailed) | .000  |      |       |       |

According to the result on table 3, it can be seen that the significance value from Mann-Whitney Test is smaller with $\alpha = 0.05$. Hence, it can be interpreted that the value of N-gain between Verificative Lab Implemented group and HOT Lab Implemented group is significantly different. Improvement of critical thinking in each indicator is then analysed by calculating their N-Gain Values. The result is presented in figure 1 below.

![Figure 1. Comparison of Normalized Gain Value for Each Critical Thinking Skill Indicator between HOT Lab Implemented Group and Verification Lab Implemented Group](image_url)
Figure 1 above, distinguishes the different improvement of critical thinking for all aspect between class with HOT lab activity and class with verification lab activity. The improvement of critical thinking skills for all indicators in HOT lab group is higher than those in verification lab group. Thus, it can be interpreted that HOT Lab is more successful training students for their critical thinking skills compare to verification lab.

Despite the result mentioned before, it is found the improvement of each aspects is not the same. According to graph in picture 1 it shows that C1 indicator are the highest improvement of all with improvement quality categorized as medium, followed by C12 and C16 Indicators with improvement quality categorized as medium. However the improvement of C13, C14, and C15 are categorized as low improvement.

The finding indicates that the activities of HOT Lab is more emphasizing in providing activity in idea, argument and information analysis and identification. It is in line with explanation that the skill of analysis and identification is claimed to be trained in several stages on HOT lab such as in Real World Problem Stage, Determine and Evaluate Idea Stage, and Data Analysis Stage.

Accordingly, the result also shows that HOT lab activity provides activity to train student in presenting arguments, idea, data, and information as well as justify them. These skills are trained through the activity of data presentation. This stage is one of rather novel stage in Laboratory Activity which objective to provide opportunity to train students in presenting and elaborating data.

Although the result shows lower quality of improvement, other skills such as interpretation, synthesize, evaluation, and making conclusion was also trained in HOT lab activity. In every stage of HOT lab, the activity is conducted based on problem based activities which enable students to apply their higher order thinking skills [14].

HOT lab activity has its uniqueness in presenting real world problem stages. One way to train students with critical thinking is to present the problem that familiar with students. Real world problem will leads students to ill-defined problem solution [15], whereas activity with ill-defined problem is effective method in training critical thinking skills [16].

One of issue arise when any type problem solving activity implemented in low level grade, is that students are still not familiar with the type ill-defined problem solving, hence the activity is ineffectively implemented. Alternative solutions presented in real world problem can be used as alternative scaffolding for student in low level grade to be familiar with ill-defined problem solving.

Despite of its positive result, the implementation was having some resistance. This is indicated by lower level of improvement in several indicators. The resistance is identified to be result of cognitive load. Cognitive load is one of resistance that is usually occurred during problem solving activity [17]. In this case, students in low level are still not able to categorized concept used in problem solving activity. Hence, low improvement of skills occurred. However, this resistance identification is still needed to be studied further to improve the development of HOT lab activity.

5. Conclusion

Based on the elaboration above, it can be concluded that every stage in HOT lab activity giving students opportunity to develop their critical thinking skills. This type activity is encouraged to be implemented in physics subject class as alternative solution to develop students’ higher order thinking especially in thinking critically.

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