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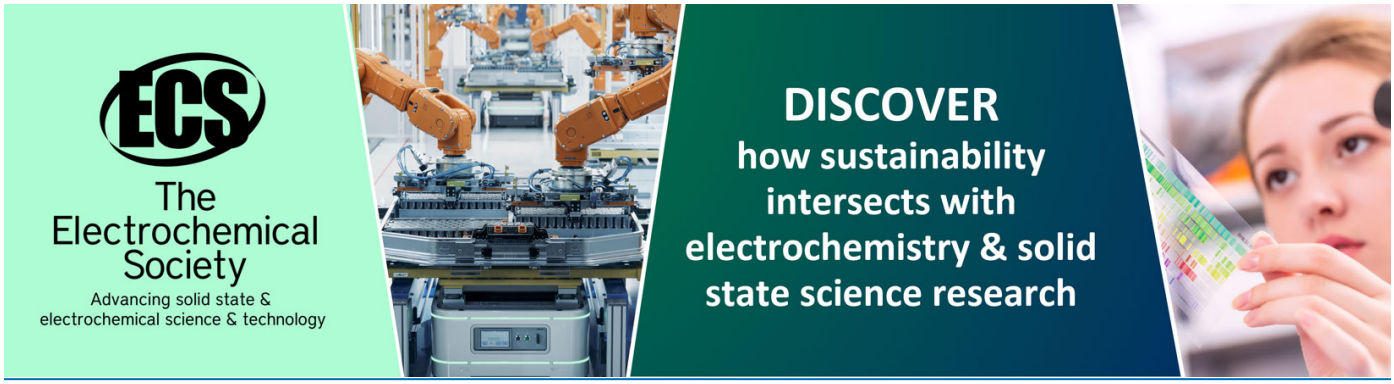

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Using Inquiry-Based Laboratory to improve students' Higher Order Thinking Skills (HOTs)

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Abstract. Higher order thinking skills (HOTs) is 21st century learning trend. This study to determine the effect of inquiry-based laboratory on the Students' HOTs in learning harmonic vibration. The method used descriptive quantitative true-experiment. Sampling technique using randomized control group pre-test and post-test design. The sample was 69 students, consisting of two experimental groups (n=46 students) and one control group (n=23 students). The experimental group is taught by inquiry-based laboratory activities, while the control group is taught by not inquiry-based laboratory activities. The result of this research shows that the experimental groups got gain score are 0.57 and 0.54, while the control group got gain score is 0.13 and both groups proved to have statistically significant different improvement. It means experimental groups have ability to Analyse, evaluation and create.

1. Introduction

Higher order thinking skills (HOTs) is 21st century learning trend, which includes transfer, critical thinking and problem solving [1]. In the Taxonomy Bloom, it is part of analyse (C4), evaluate (C5) and create (C6) [2-3]. Many education systems have integrated creative and critical thinking elements in the learning process by instilling HOTs in students [4]. One of the education systems is laboratory activity.

The laboratory has been a center in science education, through simulation and laboratory activities can help students' understanding Process, nature system and phenomena [5]. In laboratory activity, the students trained to have good scientific performance [6-7] and can communicate the results of experiments both orally and in writing [8].

Inquiry learning is a student-centered learning model, teachers provide opportunities for students widely to find theories and concepts learned through experimental activities [9] as well as focus on how to learn [10]. Based on Hasanah's research et al [11] and Fatmaryanti et al [12] stated that inquiry learning is effective in communicating aspects through learning discovery, prediction, hypothesis and interpretation data. In addition, the inquiry-based learning can achieve higher levels of understanding and development of better reasoning skills as well as the development of scientific process skills [13].

Worksheet laboratory activities provide an important role in guiding the student to discover concepts and theories. Inquiry-based laboratory activity improves students understanding about the nature of science, because students allows to try, how the scientist works [14]. Besides that, inquiry-based laboratory activity Inquiry improves the performance of students in conducting experiments [15] to train scientific performance and to improve the critical thinking [16].

2. Method

Participants of the research included 66 students at senior high school 2nd Muhammadiyah Surabaya, Indonesia. Which are distributed from three groups, which one group for control group, group A (23 students) and two groups for experimental groups, group B (24 Students) and group C (22 Students). The study used a descriptive quantitative approach by using inquiry-based laboratory on the harmonic vibration topic [14].

This research used true-experimental methods, randomized control group pre-test and post-test design. The sample that used, randomly selected to be the control group (group A) and the experimental group (group B and C) [17-18].

Table 1. Pre-test and Post-test Design

Group	*Pre-test*	Treatment	*Post-test*
A	O_1	Not using Inquiry Based-Laboratory	O_2
B	O_1	Using Inquiry Based-Laboratory	O_2
C	O_1	Using Inquiry Based-Laboratory	O_2

In this study, to analyse the data result use t-test (two-tail) and gain score to know how much improvement of HOTs after getting treatment. In other hands, clarifying of students' skill, that is the ability to analyse (C4), evaluate (C5) and create (C6).

3. Result and Discussion

This study used t-test (two-tail) and gain score to analyse the result data. But before it, the normality and homogeneity of the data have to be calculated in order to decide which statistic method was appropriate, whether parametric or non-parametric.

Table 2. The normality test.

Group	Significant		Conclusion
	Kolmogorov-smirnov[a]	Shapiro-Wilk	
A	.200*	.177	Normal
B	.200*	.404	
C	.200*	.506	

Table 3. The homogeneity of variance test.

	Mean Square	F	Sig.
Between Groups	63.519	.352	.705
Within Groups	180.536		

In the result of the normality test (Table 2) there are two types of calculation which are Kolmogorov-Smirnov[a] and Saphiro-Wilk. [19]. Base on Table 2, show that the significant is greater than 0.05, it indicated that the data is normally distributed (Sig> 0.05) (for the educational field). For the homogeneity of variance test (Table 3) it shows a significant number of 0.705 which is also bigger than

0.05. It indicated that the data is distributed homogeneously. Based on both test, it can be passed on to the next test. That is t-test (two-tail), which is included in the parametric analysis and gain score, to know how much improvement of HOTs.

Tabel 4. t-test (two-tail).

Group		t	df	Sig. (2-tailed)	Conclusion
A	B	8.840	45	0.000	Significant Different
	C	7.820	43	0.000	Significant Different

The Table 4. present the results of the analysis of t-test (two-tail), between group A versus group B and group A versus group C. both of them (two versus) show that, there are significant difference for the post-test ($p<0,05$). This is due to the different treatment, group B and C using inquiry based-laboratory but group A not using inquiry based-laboratory, with the value of t are -8.840 (group A vs group B) and -7.820 (group A vs group C).

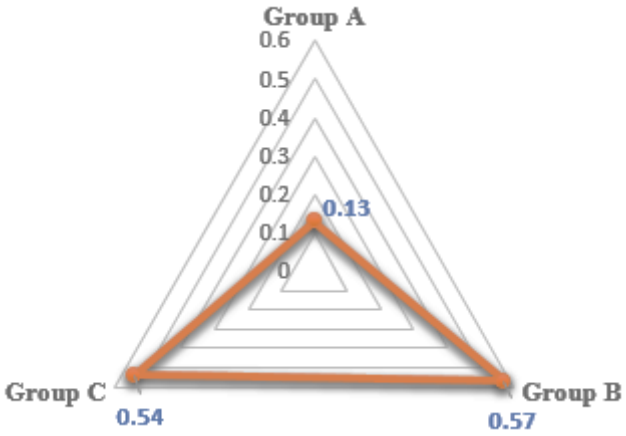

Figure 1. Gain score.

Based on Figure 1. Gain score, for group B the value of gain score is 0.57 and for group C the value of gain score is 0.54 both of groups are the medium category, while for group A the value of gain score is 0.13, where that value included in the low category.

Base on Table 4. t-test (two-tail) and figure 1. Gain score, show that there is a significant difference between group A versus group B and group A versus group C, and the difference of gain score category on the students' HOTs after applying the inquiry based-laboratory activity on harmonic vibration topic. This supports the research of [10,20-21], which states that there is a significant difference between the control and experimental groups on the students' critical thinking ability and conceptual understanding.

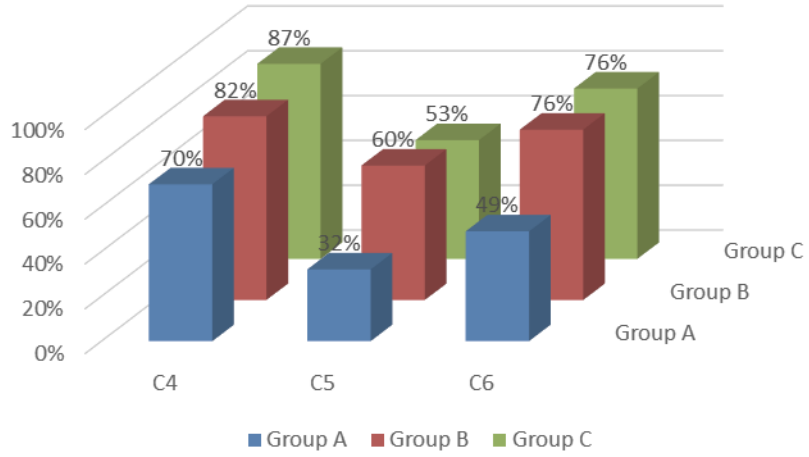

Figure 2. Cognitive domain, analyse (C4), evaluate (C5) and create (C6)

In this research, for pre-test and post-test used essay answers, its aim to know how much students' reasoning ability [13] and students' analysis, evaluation and creating that contained HOTs criteria [3].

Based on Figure 2. Cognitive domain, from the three cognitive aspects, show that HOTs' of the experimental groups are higher than the control group. In the analysis aspect (C4), students' experimental groups can answer the question (post-test) perfectly and regularly in problem solving. The regularity in analyzing problems is the more skill they have, although there is a small part of them still misconceptions about the harmonic vibration topics, with the percentage score are 82% (group B) and 87% (group C). In the control group, the basic ability of the student is quite good, it's known from the results of their pre-test score, but by using traditional learning model, the ability of their analysis is not trained, and the regularity in analyzing the problem is less, in the mathematical aspect they have a strong base, so the score that they get is not much different from the experimental group score, which is 70% (group C).

The cognitive domain of evaluation aspect (C5), between the experimental and control groups equally gets a low score. But, the experimental groups is higher than the control group. This is due to the phenomenon of evaluation aspect question is not familiar to the student, so they are difficult in reasoning and evaluating the problem.

In the create aspect (C6) the average ability of experimental groups are same (76%), while the control group is 49%. In this aspect, the experience of the experimental groups are extensive than the control group, especially in laboratory activities. In the experimental groups used inquiry-based laboratory activities that gave positive values of their ability, from the preparation of tools and materials needed to laboratory activities and result reports, even they could modify experimental designs on harmonic vibration. While in the control group, most of them are still confused with the experiment steps they must do. Laboratory activities are not only to training cognitive abilities, but also emphasize the affective and psychomotor abilities of student [5,22], because activity-based learning can save concepts or materials that student received in the long memory system in the brain [23].

Overall, the three aspects of the cognitive domain did not have a large difference between the experimental and control groups, with a range of 12% to 28%, compared to the gain score that they got, have a large increase difference between the experimental and control groups. This is due to good basic and mathematical skills in the individual group of control, although on average of them, can be argued that among of three groups, one control group (group A) and two experimental groups (group B and C) have same initial ability. This shows that the human condition (Social research) can't be controlled ideally [18] it's the different case in material research, whose conditions can be perfectly controlled.

Conclusion

The result of this research shows that there is significant difference between control and experimental group, after get a treatment (using inquiry based-laboratory) experimental groups have improvement HOTs', with gain score are 0.57 (group B) and 0.54 (group C), while the control group got gain score is 0.13 (group A), and experimental group have good ability to Analyse, evaluation and create in evaluation test. The inquiry-based laboratory treatment as that ability improvement is beneficial to students' accustoming in higher order thinking skill as the 21st century learning outcome. For common use, need the technology integration as the identity of the 21st century learning.

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