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Whats wrong with cookbook experiment? a case study of its impacts toward learning outcomes of pre-service physics teachers

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Abstract. Cookbook experiment is familiar type of experiment in which students have to follow some procedures to carry out a practicum in laboratory. Due to its easiness, not only students in high school but also students in college recognized this. However, there is no clear role of cookbook experiment toward learning outcomes of pre-service physics teachers. This study investigates the impact of cookbook experiment toward learning outcomes. A single case study was carried out in one private university in east Indonesia in which all participants were students from physics department. The finding results reveals that cookbook experiment was used almost eight years. This affected two pivotal aspects of students: achievement of cognitive learning ability and students' interest toward learning process. In these aspects context, the cookbook experiment did not facilitate students who are pre-service physics teachers to construct and strengthen deep understanding, to make a joyful and meaningful learning process, and to flourish the diverse skills needed by students such as higher order thinking skills. This article indeed presents a consideration of the implication of physics practicum in Indonesia in deep insight and wider context.

1. Introduction

Teaching and learning physics always need the existing laboratory activities. Some concepts and laws of physics can be taught to students using laboratory activities. Students can prove and inquiry a certain concept both individually and collaboratively in laboratory activities. This shows that laboratory activities have crucial roles in teaching and learning physics in constructing meaningful experiences [1,2].

Despite developing meaningful experiences, the role of laboratory activities is essential for students in experimental sciences because several specific learning objectives can be trained and achieved in this context [3]. For instance, official curriculum of senior high school in Indonesia emphasizes the importance of scientific inquiry. This goal indeed can be obtained by applying the learning process which is based on laboratory activities. In the context of learning process, laboratory activities provide great opportunities so as students familiarize with physical manipulation of real world and recognize the

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scientific instruments. In addition, the role of laboratory activities can help students develop a deep understanding of complexity of empirical work.

In several decades, the laboratory activities still develop in form of how they are conducted by students. Real laboratory is the familiar laboratory activities, which students experiment uses the real apparatus directly in laboratory. The drawbacks of this type of laboratory activity are spending much time for investing some concepts of physics, needing the must cost for some apparatus, and need high technology for several concepts of modern physics. On the other hand, the developmental technology urges the alteration in form of how laboratory activities were conducted. Virtual laboratory [4] and augmented laboratory are the example how the real laboratory is developed in different context. The supporting computer and information technology alter the laboratory activities carried out efficiently and effectively both in time and cost. However, there is no different role from both of laboratory activities in constructing the learning skills and giving meaningful experiences [5, 6].

Based on the characteristic of laboratory activities, which refers to the activity of students to accomplish what they should do. The laboratory activities can be divided into two types: conventional and inquiry lab. Conventional lab, which is commonly known as "cookbook experiment" tends to urge students do several procedures in taking and analyzing data of experiment while inquiry lab refers to great opportunities to students to work independently in laboratory [1].

Although the cookbook experiment is obsolete, it is still utilized to train students dealing with hands on skills. There are a little benefits of cookbook experiment, for instance, students can study to use real apparatus in laboratory correctly by following the correct procedures. This mean that a number of correct procedures are trained so as students have experiences how they construct the systematic procedures in conducting the experiments. This experience will be brought when they carry out the laboratory activity independently. Another benefit from cookbook experiment indeed can be applied to guide students who never have the laboratory experiences. When students never having lab experiences, they feel challenging to conduct the experiment or cookbook experiment can be the basis experiences in conducted scientific experiment.

Additionally, in perspective skills that were obtained by students, there is also role of laboratory activities which carried out in cookbook experiment toward the learning outcomes, cognitive ability, and retention. Despite having a little contribution, the impact of this is still useful in forming early conceptual understanding of students. Indeed, this situation has the significant difference when the laboratory activities conducted in scientific inquiry. In other words, the cookbook experiment can be "bridge" before students are trained the inquiry lab both guided and open or free inquiry.

Another impact that should be noticed is the students' interest when they are actively conducting laboratory activities. There is no evidence how cookbook experiment can improve students' interest. This contradicted that the previous study depicts that perception of students is positive when lab activity was processed in inquiry [6]. This is rational because cookbook experiment gives less freedom to students in exploring the laboratory activities [7]. In addition, there is no contextual problem given to students in cookbook experiment. They just did several scientific procedures to prove some concepts and laws of physics and never obtained learning experiences that boost students' interest like scientific inquiry [8].

In fact, today, the cookbook experiment tends to be left because it is not to actively engage students in the laboratory. The relevancy of this type of experiment with globalization skills that students have to master is less so that many educators and educational researchers turn out to inquiry lab. For example, researchers [9,10] suggested that the educators should reform the form of laboratory activities that facilitate students obtaining more experiences in which refer to scientific inquiry. In other words, there is assertion that the laboratory activities indeed are faced on demand of globalization era and technological development. Engaging students actively in laboratory activities is an effort to master the globalization skills which students are needed such as critical thinking, creative thinking, argumentation skills, and problem solving.

The point of departure to acquire the globalization skills, it can be conducted by investigating the weakness of the cookbook experiment as a reflection why this type of laboratory activity is weak. What

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is wrong with cookbook experiment so that it is fail to address the needs of students in obtaining good learning outcomes and strengthening students' interest? This present study, therefore, explores the impact of cookbook experiment as a conventional laboratory toward learning outcomes of pre-services physics teacher. The finding result of this present study is a starting point to prepare a need of pre-service physics teachers who have globalization competencies. Despite this objective, the feedback and reflection from finding result are useful to redesign the laboratory activity model that is appropriate with scientific inquiry [11].

2. Methods

The single case study which refers to one of kind case studies that use one sample was carried out to garden the data dealing with learning outcomes and students' interest from participants. All participants who are contributed in this present study are 40 students who are pre-service physics teacher and come from department of physics in private university in east Indonesia. There are two types of participants, namely the students taking and finishing fundamental physics experiment course in this year (first participant), and students who finishing the fundamental physics experiment course in one year ago (second participant). The age of all participants varied from 20-21year olds in which the first participants are dominated students who are 20-year olds, and the age of second participants are 21-year-old.

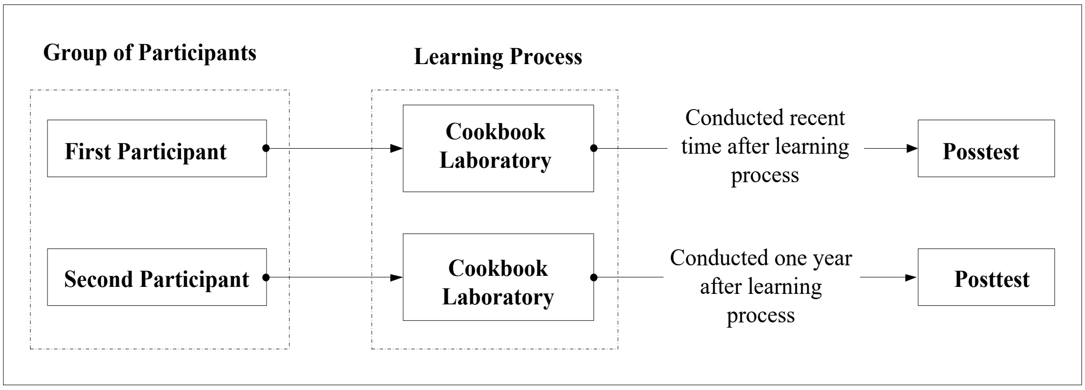

Figure 1. The diagram of research design utilizing single case study.

The diagram (see Figure 1) depicts how the design of this present study was conducted. There are two parts: the first, investigating students' learning outcomes from the first group which encompass students just took the fundamental physics experiment course, and second, then, investigating learning outcomes from students who took fundamental physics experiment course in the previous year. Both of them are given the same instrument dealing with fundamental physic concepts.

The process of taking data was carried out using cognitive test (post-test) related to fundamental physic concepts that are learned by all participants. An instrument of cognitive test was developed which refers to several cognitive abilities by revised Blooms' taxonomy [12] remembering (C1), understanding (C2), applying (C3), and analyzing (C4). There were 10 items which are essay in an instrument used in this present study. The maximum score for each item is ten (10) while minimum score is zero (0). In addition, to investigate the students' interest, the non-structured question was developed. The list of question encompasses ten questions which are focused in three aspects: students' perception dealing with cookbook laboratory, students' experiences in learning process, interest of students related to learning process conducted cookbook laboratory.

3. Results and Discussion

The data obtained from this present study depict two pivotal aspects, namely cognitive aspect which leads to students' learning outcomes and attitude aspect which is represented by student of interest dealing with learning process. Cognitive aspect is one of the important learning outcomes for students

[13]. To begin with, the achievement of learning outcomes which is presented in four cognitive abilities of Blooms' taxonomy (see the darker color of bar chart on Figure 2) for the first participants is dominated by aspect-C1. The lowest percentage of cognitive ability was achieved by aspect-C4. The aspect of C2 and C3 reach the achievement that is almost similar (30%). The result finding from second participant seems lower than that first participant (see the pale color of bar chart on Figure 2). The highest percentage of achievement dealing with cognitive ability is just two fifth reached by aspect-C1. Almost having similar condition with first participant, aspect-C4 is the lowest percentage of achievement, just one tenth.

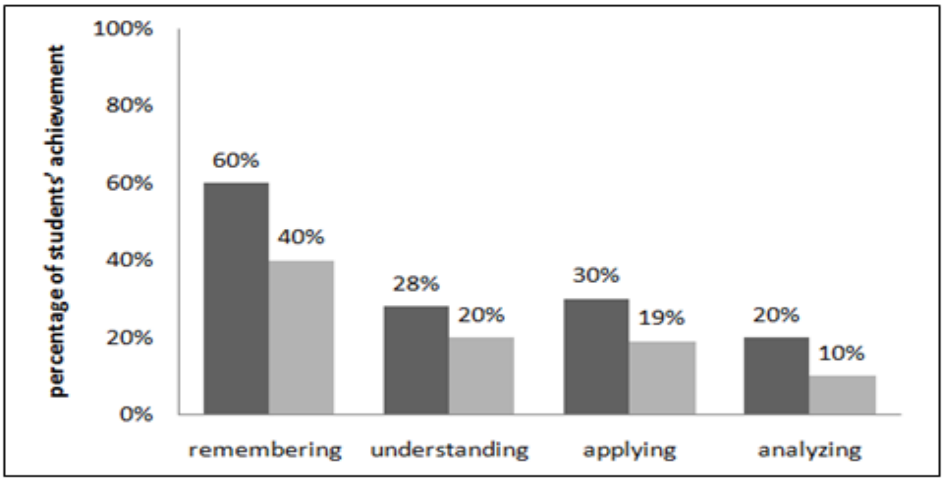

Figure 2. Representation the percentage of students' learning outcomes for first participant (darker color) and second participant (pale color)

The data reveal that cookbook laboratory did not facilitate students to achieve the high level of cognitive ability. The big contribution given by cookbook laboratory is distributed in low level of cognitive ability. These data are to be evidences that cookbook experiment are limited when these are explored to enhance the higher order thinking skills or globalization skills, namely critical thinking, creative thinking, and problem solving. These evidences strengthen why many educator and educational researchers left this type of experiment [8, 9]. The main reason indeed comes from the rationale that cookbook experiment just only trains students to follow the systematic procedures and not to open great opportunity obtaining meaningful learning experiences.

Besides training low level of cognitive ability or learning outcomes, the second data gardened from some students by interview reveal that the cookbook experiment is rigid, facilitating a little experience, and less interesting for students. The context of rigid is simple; some students argued that they just conduct the experiment in limited creativity to explore what they inquiry from laboratory activities. What did the experiences obtain from cookbook experiment? Students carried out the experiment components, namely carrying out scientific procedures, analyzing data, and making conclusion, but all these components provided in their workbook so that they worked like a robot no to making meaning from what they conducted in laboratory. These atmospheres stimulate students feel bored to conduct the experiment, moreover they were not also provided with the problems in which they can connect what they would study with the real situation dealing the concepts and laws of physics.

4. Conclusion

The finding result of this present study is a starting point to formulate the laboratory activities that can enhance learning outcomes and students' interest. A new framework dealing with laboratory activities should be emerged to replace or fix the existing the cookbook experiment that it is still utilized in some level of education (e.g. higher education). Re-designing the framework of laboratory activities should lead to scientific inquiry that connects many higher order thinking skills. For instance, laboratory activities should contain real world problems in the introduction, as a way to attract the students' interest in conducting and exploring the laboratory activities. Indeed, students should be also trained to work independently so as they have large imagination and creativity that will bring them to acquire the better learning experiences. It was properly that we should leave the cookbook experiment and open mind to take action in facilitating students with scientific inquiry laboratory.

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