The Effect of Laboratory Based Learning in Developing Physics Teacher Candidates’ Skills on Applying Measurement Instruments

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Abstract. Laboratory based learning is one kind of blended learning that combines the aspects of knowledge, skills, and attitudes. Simultaneously, students can apply the knowledge they have possessed, practice the skills, as well as growing their scientific attitude. Laboratory based learning method has been conducted for studying about measurement instruments, up to measurement data processing. This research aims to determine the effect of laboratory based learning in developing physics teacher candidates’ skills on applying measurement instruments. The design of this research is qualitative in nature involving one class of undergraduate students of Physics Teacher Education Department at STKIP Al Hikmah, which is consist of six students, as the research subjects. Data collecting is obtained through interview result with physics teacher candidates and their laboratory report. Subjects showed higher improvement skills in using measurement instruments through laboratory based learning. Physics teacher candidates have a deeper understanding about measurement instruments that includes using measurement instruments, taking and analysis data, estimating measurement errors, and communicating the result both in written and oral. Laboratory based learning also improves concepts understanding (knowledge aspects) and students' scientific attitudes.

1. Introduction

One of the main skills of a physics teacher is to be able apply measurement instruments properly. Almost all courses of physics education in college will include measurement instruments skill as their subjects and must be taken by students. However, the lecture material is often limited to knowledge only. Students only know about measurement instruments from the books and explanations given by the lecturer. This kind of thing will only be memorized by them. Students should be practicing the knowledge they have received directly, so that they can interact directly with the measurement instruments. How can a physics teacher candidate have good skill on applying measurement instruments if he only gets a theory. Therefore, giving direct experience to physics teacher candidates to apply measurement instruments is important. Students’ skills on applying measurement instruments will be develop if classroom learning can be integrated with laboratory activities. Students will interact with those measurement instruments so that their knowledge will be stronger because of direct experience.
Laboratory Based Learning

Laboratory based learning is often applied to science based learning [1]. It is because by applying laboratory based learning, students will have direct experience in finding knowledge. Almroth explains some advantages of laboratory based learning, such as trigger the curiosity of students and students can learn in small groups so that social interaction can be intertwined [2]. Besides, students who have less understanding can ask their friends in one group who have more understanding so that peer teaching will be happen. Laboratory based learning can also develop technical skills, for example applying measurement instruments. Furthermore, Almroth added, that by applying laboratory based learning, the learning will achieve several things at once, such as conceptual understanding, scientific thinking, general understanding of science, and laboratory skills [2].

Laboratory based learning proved can increase learning interest and success in science studying [3]. Laboratory based learning is appropriate to make students think, discuss, and solve the real problems. In addition, laboratory based learning is the best learning model in developing students' skills at once, including: academic skills such as critical thinking and problem solving, communication skills both written and oral, data handling, self management such as time management and planning, and interpersonal skills such as teamwork and leadership [4]. Therefore, laboratory based learning is one kind of blended learning that combines the aspects of knowledge, skills, and attitudes. Simultaneously, students can apply the knowledge they have possessed, practice the skills, as well as grow their scientific attitude.

Applying Measurement Instruments Skills

Applying measurement instruments skills is important to develop because it is a basic skill when conducting experiments in the laboratory. Especially for physics teacher candidates who will give an example for their students. The applying measurement instruments skills in this research include:

- **Calibration**
  Calibration is the first thing to do before taking measurement. Calibration aims to make sure whether the measurement instrument is still in standard conditions or not.

- **Smallest scale value determination**
  The smallest scale value of each measurement instrument depends on the number of lines on the main and nonius scale.

- **Measurement**
  Measurements using measurement instrument should be done carefully. Each measurement instrument have different sensitivities. For example, a thermometer should never be touched by a hand or a fluid container as it will affect the measurement result.

- **Measurement data reading**
  Measurement data reading should be done perpendicularly to avoid parallax errors. Furthermore, we must pay close attention to the measurements shown by the main and nonius scales carefully, along with the smallest scale values of the instrument (especially for vernier calliper and micrometer secrup).

- **Measurement data writing**
  Measurement data writing should always be accompanied by the measurement error. The measurement error is half of the smallest scale value of the measurement instrument.

- **Measurement data processing**
  Measurement data processing shall correspond to the type of measurement, whether single or repeated measurement, and whether direct measurement or not. On a single measurement, we simply write down the measurement result along with the measurement error. However, if repeated measurements must be searched for its mean and standard deviation first.
2. Methodology

This research is a qualitative research that aims to determine the effect of laboratory based learning in developing physics teacher candidates’ skills on applying measurement instruments. The subject of this research is one class of undergraduate students of Physics Teacher Education Department at STKIP Al Hikmah, which consists of six students. The research design consists of three stages. The first stage is the description stage. At this stage, the research subjects are observed during doing measurement activities in the laboratory. All activity aspects are observed, that is cognitive, psychomotor, and affective. The second stage is the reduction stage. At this stage, the information that has been obtained in the first stage is reduced to determine the research focus. The selected research focus is the skill of applying measurement instruments. The last stage is the selection stage. At this stage, the research focus that has been selected in the previous stage is described deeper based on the interview results and laboratory reports. So, the description of applying measurement instruments are: how the subject calibrate the instruments, determine the smallest scale value, do measurements, read, write down, and analyze the measurement results. According to [5], the design of qualitative research generally can be described in the Figure 1 below.

![Research design](image)

Figure 1. Research design

The research instruments used are observation sheet, questions list to be asked during interview, worksheet and analysis sheet as laboratory report. The data obtained in this research are the observation result, interview result, and worksheet and analysis sheet as laboratory report. Further research data will be analyzed inductively.

3. Result and Discussion

The data obtained are the observation result during the student do measurement activities in laboratory, the interview result, and the laboratory report consist of worksheet and analysis sheet.

Interview Result

Interview was conducted to each student after they work in the laboratory. Interview aims to confirm subjects' understanding of what they have done when do work in laboratory. Further, confirming whether their understanding is due to laboratory based learning or not. In the interview session, the information that explored and confirmed are calibration capability, determination of the smallest scale value, the way subjects do measurements, and the way subjects read the measurement data.

Calibration

Based on the observation, 67% of subjects were able to calibrate all measurement instruments correctly. They understand the calibration concept of each measurement instrument and can do it appropriately. Based on the interview, it is known that initially they only gain knowledge through reading references. Then, their understanding grew stronger as they practiced the knowledge directly.
While 33% of other subjects are only able to perform a calibration 4 of 5 measurement instruments correctly. This is because they do not perform the calibration of the fifth measurement instrument at the time in laboratory. The fifth measurement instrument is multimeter. Their understanding only knowledge aspect that they get from references but has no direct experience using multimeter in laboratory.

Smallest scale value determination

Based on the observation, 67% of subjects were able to determine the smallest scale value of all measurement instruments correctly. They understand the smallest scale value determination concept of a measurement instrument by watching the smallest scale of major scale (for the Ohaus's balance, thermometer, and multimeter) and the number of lines on a nonius scale (for vernier calliper and micrometer screw). While 33% of other subjects were only able to determine the smallest scale value 4 of 5 measurement instruments correctly. The fifth measurement instrument is vernier calliper. It is because they only get the knowledge from references that generalizes the value of the smallest scale value of a vernier calliper is 0.01 mm without understanding the basic concept. Whereas the vernier calliper used in the laboratory is vernier calliper with the smallest scale value 0.05 mm, so when confirmed in the interview session they can not show the way of determining the smallest scale value correctly.

Measurement

Based on the observation result, all subjects were able to do measurement using all measurement instruments correctly. It is because they have understood the concept of using the measurement instruments. Based on the interview result, shows that their good ability to do measurement caused by they conducted their own measurements based on the knowledge they already had. There were some subjects who initially did not understand how to use a certain measurement instrument, but by working together in groups they were able to help each other so that all subjects were able to do measurement using all of measurement instruments correctly. It shows that laboratory based learning not only develop the knowledge and psychomotor aspect, but also their affective aspects such as collaboration, honesty, and precision.

Measurement data reading

Measurement data reading can be known by observation and interview result. Based on the observation, all of subjects were able to read the measurement results for each measurement instrument appropriately. They also have observed several things in measurement results reading, such as seeing the measurements perpendicular to avoid parallax errors, not touching the thermometer to the body or the container so as not to affect the measured temperature, and pay attention to the smallest scale value in reading measurement result of vernier calliper and micrometer screw. When confirmed through interviews, 17% of subjects not only rely on the knowledge they get through references (using formulas), but also use their logic in reading the measurement results. They calculate the nonius scale by comparing the smallest scale values to the lines that coincide on the nonius scale.

Laboratory Report

Each research subject writes down laboratory report that consist of worksheets and analysis sheet. From the worksheet can be known subjects understanding in writing the measurement results. While from the analysis sheet can be known subjects understanding in processing the measurement results.

Measurement data writing

Measurements data writing can be known from the worksheet of each student. Based on the worksheet, 50% of subjects were able to write the measurement results for each measurement instrument appropriately, while 33% of subjects were only able to write the measurement results 4 of 5 measurement instruments appropriately. They write down the measurements along with the
measurement error that each measurement instruments has. Previously, they only had knowledge from references, but through laboratory based learning they were able to understand that the correct measurement results writing is write the measurement error also. In addition, they must also ensure that the number of significant figure behind comma on the measurement results and the measurement uncertainties are same. They must also ensure that the unit between the measurement results and the measurement uncertainties are same. Examples of measurement data writing by subject are shown in Figure 2.

![Figure 2](image)

**Figure 2.** (a) Example of correct measurement result writing, (b) Example of incorrect measurement result writing

Based on interview results, known that subjects write the measurement results incorrect because forget to equate the number of significant figure behind comma on the measurement results and the measurement uncertainties.

**Measurement data processing**

Measurement data processing can be known from analysis sheet each subject. The measurement that they did in the laboratory is a repetitive measurement. Furthermore, subjects are required to analyze the measurement data as direct and indirect measurements according to their knowledge from references. Based on the analysis sheets, it was found that 83% of subjects were able to analyze the direct measurements correctly, while only 33% of the subjects were able to analyze the indirect measurements correctly. Through further analysis by the researchers, it was found that their inaccuracy in analyzing is because they have not deeply understood yet the equations they used in analyzing, so it caused errors.

4. **Conclusion**

The effect of laboratorium based learning is physics teacher candidates have a deeper understanding of the measurement instruments that includes using measurement instruments, taking and analysis data, estimating measurement errors, and communicating the result both in written and oral. Laboratory based learning also improves concepts understanding (knowledge aspects) and students’ scientific attitudes. The results of this qualitative research can be applied to other research as long as the condition of the research site is not much different from the conditions at this research site.

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