Reinforcing Scientific Skills Based on Laboratory for Pre-Service Physics Teacher by Measurement System Understanding

N A Lestari*, U A Deta, M Yantidewi, and R Firmansyah

1Department of Physics, Universitas Negeri Surabaya, Surabaya, Indonesia
2Department of Electrical Engineering, Universitas Negeri Surabaya, Surabaya, Indonesia

E-mail: nuritalestari@unesa.ac.id
*Corresponding author

Abstract. The laboratory skills of pre-service physics teacher need to be improved, especially for first-year students. Students in the first level need a primary material that will be useful in conducting activities in the laboratory. Because as a potential physics teacher, pre-services are required to have good basic skills to apply for the next level nicely. One of the materials that must be mastered by students is related to measurement systems including knowledge of the types of measuring instruments, physics units, and how to use the measuring tool. The research based on this mixed method will explain the value of the students' needs in the first level of the measurement material in the laboratory. The resulting data is in the form of quantitative and qualitative data. Quantitative data include survey results related to the material requirements of the measurement system for students, while the qualitative data includes the results of interviews with the students about the extent of their knowledge in laboratory activities. The results of the data analysis show the teaching materials needed to improve the students' knowledge of the measurement field. Further data analysis results will be used to develop textbooks relevant to the needs of students in the material of measurement systems.

1. Introduction

Students at a university as pre-service teachers are required to not only can understand physics material but also teach it both in class and in the laboratory. Supported by a background in the field of physics is not just about the concept of nature but also its application in human life [1]. Skills in applying concepts are a form of assessment of activities which are essential elements in teaching and learning interactions [2,3]. Sardiman [4] explains that knowledge obtains by self-observation, self-investigation, with self-created facilities, both technically and spiritually. Without activities, the learning process will not be possible to do. Based on these explanations, the learning activities of students must be active in constructing their knowledge with the teacher as a facilitator [5]. In other words, that learning requires actions so that the learning process runs well. Therefore, the pre-service teacher needs to be equipped with work skills in the laboratory through in-service education in universities.

Activity-based learning indicates a higher learning experience for students. The high experience of students in laboratory work will affect the ability of scientific work which consists of investigation, research, communication science, creativity development, and problem-solving [6]. Students in their
activities explore knowledge related to nature and technology products through reflection and analysis to be able to plan, collect, process and interpret data, communicate conclusions, and assess procedures and results. Through laboratory-based learning, students can gain direct experience, so that they can add strength to receive, store, and produce impressions about the things they learn. Thus, trained students can find their various concepts that are thoroughly studied (holistic), meaningful, authentic and active [7].

The component associated with laboratory-based learning is the ability to master the field of measurement physics. The measurement system is the basic knowledge of students when carrying out activities in the laboratory. The measurement system includes a discussion of (1) the basic concept of measurement, which consist of the definition and description of measurement as well as the introduction of measuring quantities especially in the field of physics. (2) important number rules, namely the knowledge of writing the results of measurements accurately and according to applicable regulations. (3) types of measurement, including an understanding of the types of measurement techniques both single, repetitive, direct or indirect. (4) Measurement Uncertainty, which is the rule in calculating uncertainty from the results of measurements that have been made, commonly known as the errata system. (5) data analysis, namely knowledge of the ways in analyzing the results of practicum data in the laboratory, both in the form of quantitative, qualitative analysis and the presentation of measurement results in the form of tables and graphs. (6) types of measuring instruments, namely knowledge of measuring tools used during activities in physics laboratories, especially those related to measuring the magnitude of length, mass, time, electric current, light intensity, number of substances, and temperature. (7) how to use measuring instruments, including skills in designing, compiling/assembling, and operating measuring apparatus by their functions.

Laboratory-based learning is one aspect that can affect the scientific process in students so that it can produce meaningful learning through the process of knowledge construction. In the implementation of the scientific system involves process skills such as observing, classifying, measuring. The scientific process is also interpreted as an activity of gaining knowledge with procedures based on a scientific method [8]. The learning process must be protected from non-scientific characteristics or values. The non-scientific approach is intended solely based on intuition, common sense, prejudice, discovery through trial and error, and the origin of critical thinking [9,10]. This definition is in line with the processes that occur during activities in the laboratory so that it can be said that later each component of work in the laboratory will be able to influence the scientific abilities of the pre-service teacher.

2. Research Method

This research is preliminary actions as the basis for developing relevant learning resources for pre-service teachers to improve performance in the laboratory. This research is qualitative research with analysis-descriptive technique. Data retrieval is done quantitatively and qualitatively, that is through ability test instruments in physical measurements and interview instruments. The test is carried out to the pre-service teacher who is taking the first level lecture to find out the extent of his understanding of the material measurement system.

The results of the next test are analyzed simply by determining the average score of the achievement of the value of the understanding of the measurement system material. The findings of the quantitative score data are further supported by qualitative data in the form of interview statements for the pre-service teacher regarding the importance of measurement skills in activities in the laboratory. Interview process is done by given some questions related to measurement system material and to know the pre-service physics teachers interested in that concept.

The data analysis techniques used are data reduction, data presentation, and conclusion drawing. As for deciding the measurement system understanding, it is based on the criteria stated in Table 1.
Table 1. Competency Achievement Level

| Average Score | Criteria       |
|--------------|---------------|
| 80 – 100     | Outstanding   |
| 70 – 79      | Meritorious   |
| 60 – 69      | Substantial   |
| 50 – 59      | Adequate      |
| 40 – 49      | Moderate      |
| 30 – 39      | Elementary    |
| 0 – 29       | Not achieved  |

3. Discussion

The first level students as a primary pre-service physics teacher became the object of this research which involved an assessment of the understanding of material measurement systems. They were asked to work on the test instruments that had been prepared including the material components in the measurement system to determine the score of understanding of the material.

Measurement system understanding which was observed and analyzed in (1) Basic Concepts Measurement, (2) Important Numbers’s Rules, (3) Types of Measurement, (4) Uncertainty in Measurement, (5) Data Analysis, (6) Types of measuring instruments, (7) How to use a measuring instrument. Analysis result for the seven measurement system understanding components can be seen in table 2 below:

Table 2. Score of Measuring System Understanding

| Component                        | Score  | Criteria |
|----------------------------------|--------|----------|
| (1) Basic Concepts of Measurement | 80,21  | Outstanding |
| (2) Rules for Important Numbers  | 72,65  | Meritorious |
| (3) Types of Measurement         | 68,10  | Substantial |
| (4) Measurement Uncertainty      | 58,25  | Adequate |
| (5) Data Analysis                | 65,52  | Substantial |
| (6) Types of Measuring Instruments | 70,75  | Meritorious |
| (7) How to use a measuring instrument | 58,16  | Adequate |

Mostly, it can be concluded that pre-service physics teachers have laboratory capabilities that are considered to be quite good, however, based on these results it is known that there are still components that have a reasonably low value.

As for achievement and categories of measurement systems are:

(1) Basic Concepts of Measurement

The basic measurement ability score which includes an understanding of the definition and concept description of the measurement system for pre-service physics teacher is outstanding. So is the knowledge of the magnitude and unit of measurement in the field of physics. This material is indeed the basis of the concept of measurement systems that have generally been taught since the elementary school until high school level.

(2) Rules for Important Numbers

The knowledge possessed by the pre-service physics teacher towards writing significant numbers is considered quite good. The need for accuracy in writing significant numbers becomes an aspect that cannot be ignored when carrying out activities in the laboratory. We cannot arbitrarily write down the results of the lab and must be adjusted to the scale of the measuring instrument used as well. Writing numbers, decimals, fractions, and exponent forms must be following by the rules that have been applied.
(3) Types of Measurement
They have abilities that are said to be less related to the kinds of measurements. Chances are they still don't understand and cannot distinguish between single measurements, repeated measurements, direct measurements, and indirect measurements. This condition of course will have an impact when doing lab work in the laboratory.

(4) Measurement Uncertainty
The pre-service teacher's ability score for knowledge regarding uncertainty is of less value. Their average rating is a low range which means less and still needs to be improved again. They are still having difficulties in determining the uncertainty value of a measurement system and analyzing the accuracy value of the measurement results.

(5) Data Analysis
The ability to analyze data, especially practicum results, is of sufficient value, in the sense that it still needs to be improved. The difficulties experienced by the first-level students are the accuracy in adjusting practicum objectives with the data obtained and choosing the right visualization to present data. As it is known that the practicum data can be presented in the form of graphs, tables, drawings, mathematical calculations, and qualitative descriptions. Therefore, the overall data visualization needs to be taught further to them.

(6) Types of Measuring Instruments
In conducting activities in the laboratory, pre-service teachers need to not only understand the types of measuring instruments used when taking practicum data, but also the accuracy of their functions. Each measuring apparatus has a function to measure certain quantities. They should immediately increase their knowledge regarding the types of measuring instruments in physics laboratories, especially those that function to measure the principal quantities which include mass, length, time, temperature, current strength, light intensity, and amount of matter. Based on the test results, the ability to understand the types of measuring instruments is good enough.

(7) How to use a measuring instrument
The practice of using measuring instruments is a problem for most pre-service teachers. For example is a measuring instrument multimeter/Avometer with analog type. Difficulties occur when you have to install the measuring device on an electrical circuit, given that a multimeter can be used to measure electrical quantities such as current, voltage, and resistance. Errors in the installation of a multimeter measuring device can cause damage to the tool. This condition must be avoided to maintain the quality of the measuring instrument.

The data is supported by a statement from the pre-service teacher based on the results of interviews related to the importance of debriefing the ability of the system of measurement of activities in the laboratory. An interesting finding from the results of interviews was that most of them stated that there was still a lack of ability to use the measuring instruments appropriately. There is a parallax error caused by the meter, especially when reading the measurement results. This data can positively affect the value of the measurement results. Besides that, they sometimes forget to calibrate the measuring instrument before using it to measure a quantity. As a result, the value of certainty in the measurement results becomes irrelevant. Therefore it can be concluded that they still have some weaknesses in practicing measurement in the laboratory.
4. Conclusion

The conclusion from the experiment is the pre-service physics teacher's ability to do activities in the laboratory is influenced by an understanding of the measurement system and the skills in using measuring instruments. Errors in using the tools in the laboratory will cause damage not only to the tools used but also other components that are interrelated. Therefore, it is necessary to carry out activities to increase the knowledge of prospective physics teachers, especially in the measurement system both concerning material and practice. The aim is to provide positive reinforcement for the ability to work in a laboratory which is one aspect of the scientific process.

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