PLC (Programmable Logic Controller) distance learning using remote lab system

R D Purnomo*, B Mulyanti and J Kustija
Department of Electrical Engineering Education, Universitas Pendidikan Indonesia, Bandung, Indonesia

*rizkipurnomo@student.upi.edu

Abstract. The aims of the research were to study PLC (programmable logic controller) distance learning using remote lab system, in term of student’s responses. This study used survey data collection techniques and quantitative descriptive methods for data analysis. The respondents are public and private Vocational High Schools students in West Java, Indonesia. The results of the research indicated that the remote lab system developed by researchers is easy for students to use. The use of remote laboratories helped students in practicing PLC programming. Most of VHS’s students in West Java said that they would recommend the remote lab developed to other students. This indicated the satisfaction of students in using the remote lab for distance learning. In addition, students’ stated that the overall remote lab system can worked well, easy to use, and they were satisfied with PLC distance learning using the remote lab.

1. Introduction
Currently Indonesia and the rest of the world are facing a pandemic of Corona Virus Disease (COVID-19). The spread of the COVID-19 virus forced most of school students in Indonesia and other parts of the world to study from home through distance learning. The results of a survey conducted by Mulyanti showed that not many Vocational High Schools (VHS’s) in West Java, Indonesia had virtual laboratory facilities to support distance learning [1]. VHS is one of the national education system in Indonesia that plays an important role in preparing and developing human resources. VHS’s graduates are expected to be able to compete in the world of work with their competencies [2]. In realizing this goal, the laboratory equipment available at VHS’s have to meet industrial standards in order to prepare the students accustomed to the industry [3].

Today industry standard equipment that is widely used for system control is the Programmable Logic Controller (PLC) [4]. PLC is a compulsory for VHS’s especially in the Electrical Engineering program as one of laboratory equipment. Unfortunately, the number of PLCs available at VHS’s is often out of balance with the number of students [4]. The relatively high cost of PLC became a significant factor in the lack of PLC availability in VHS’s in Indonesia [5].

Remote lab system is one of solution to overcome the lack of laboratory equipment availability, that allows students to access the laboratory equipment from anywhere at a certain time [6]. The remote lab system should be equipped with an organized scheduling system. Remote lab system basically has standard features such as the LMS (Learning Management System) including message delivery systems, practical guidelines, and the worksheets [7].
Remote labs have been widely developed in many countries for research purposes [8]. One group of researchers had developed remote lab as a learning media. They studied on students' perceptions of the use of remote lab for Industrial Automation learning courses [9]. Meanwhile, Faozan et al. (2018) has conducted research to analyse the student responses to the laboratory learning media in one of VHS’s in West Java namely Ketapang public VHS #1. The results showed that 63.2% and 35% of students gave a very positive response and positive response to the learning media, respectively [10]. However, research about student’s responses to PLC distance learning using remote lab has not been found. Therefore, in this paper, we present the responses of VHS’s students of Electrical Engineering program in West Java to PLC distance learning using remote lab.

2. Methods
This study used survey data collection techniques and quantitative descriptive methods for data analysis [9]. Primary data were obtained by distributing questionnaires to respondents to determine the response of vocational students to remote laboratories as a medium for distance learning. The respondents came from groups representing the population of public and private VHS’s from the Electrical Engineering program across several cities and districts in West Java such as Bandung, Cimahi, Bogor, Bekasi, and others. This survey reaches many respondents, with a proportion of 380 students from public and private VHS’s in West Java proportionally.

This survey was conducted in June 2020. The data collection procedure was carried out through several stages, namely: (a) compiling a list of statements in the google form for the student response questionnaire on the implementation of the remote laboratory, (b) distributing the questionnaire via email and to the principal and school teacher, and (c) recapitulate and analyse data according to the responses obtained proportionally.

3. Results and discussion
Survey data collection on 380 VHS’s students in the Electrical Engineering program of private and public VHS’s across West Java has been carried out. In this study, we divided the statements on the questionnaire into 4 aspects, namely: 1) the system convenience; 2) system benefits; 3) attitude to the use of system; and 4) system evaluation.

In term of system convenience aspects, the following statements were addressed to the respondents:
- Remote lab system can be used in distance learning;
- The appearance of the system web is interesting and easy to understand;
- The user manual is easy for me to learn the operation of the system;
- I do not have trouble operating the system;
- I can easily change and improve the program in the remote lab system;
- I can use the facilities/features of the remote lab system easily;
- I did not make repeated mistakes in the operation of the remote lab.

The survey resulted on the above aspects are summarized in Figure 1.
Figure 1. The aspect of the system convenience. (a) Percentage of approval of each statement item (b) Average percentage.

Based on Figure 1, it can be seen that the students' responses on the aspects of system convenience are 31.73%, 49.96%, 15.45%, 2.41%, and 0.45% in the category of strongly agree, agree, neutral, disagree and strongly disagree, respectively.

Meanwhile in term of the system utilization aspects, the following statements were addressed to respondents:

- This remote lab can help the implementation of laboratory activities, especially for PLC practising programing;
- In my opinion, using a remote lab makes laboratory activities become easier;
- I can do laboratory activities using remote lab after hours;
- The use of a remote lab system makes me easy in PLC distance learning.

The survey results on aspects of remote lab utilization are summarized in Figure 2.

Figure 2. The aspects of remote lab utilization. (a) Percentage of approval of each statement item (b) Average percentage.

Based on Figure 2 it can be seen that students' responses to the aspects of system utilization are 34.87%, 47.24%, 15.46%, 2.17% and 0.26% are in the category of strongly agree, agree, neutral, disagree and strongly disagree, respectively.

Next, in term of the aspect of attitude to use of the remote lab system, the following statements were addressed to the respondents:

- The remote lab can be a solution for the limited time and place for laboratory activities;
The password authorization feature on the web remote lab makes the account safe;
The upload feature makes me easy to report laboratory activities;
I use supporting software while using remote lab;
I installed an antivirus to protect personal data while using remote lab;
I will use remote lab to develop my interests and expertise even though the PLC subject has been completed;
I would recommend other students to use the remote lab system developed by researchers.

The results of the survey on aspects of attitude towards the use of remote lab system are summarized in Figure 3.

**Figure 3.** The aspects of attitude to the use of remote lab. (a) Percentage of approval of each statement item (b) Average percentage.

Based on Figure 3 it can be seen that the students' responses to the aspects of attitudes towards the use of remote lab are 35.56%, 47.63%, 13.83%, 2.41% and 0, 56% in the category of strongly agree, agree, neutral, disagree and strongly disagree, respectively.

Finally, in term of evaluation aspects, the following statements were addressed to respondents:
- All of the features of the remote lab system can work well;
- All of the features of the remote lab system are easy to use;
- Overall I feel satisfied with PLC distance learning using a remote lab system.

The results of the remote lab evaluation aspects can be summarized in Figure 4.

**Figure 4.** The aspect of the remote lab evaluation. (a) Percentage of approval of each statement item (b) Average percentage.

Based on Figure 4 it can be seen that the students' responses on the aspect of the remote lab evaluation are 35.56%, 47.63%, 13.83%, 2.41% and 0.56 % in the category of strongly agree, agree, neutral, disagree and strongly disagree, respectively.
4. Conclusion
The remote lab system developed by researchers is easy for students to use. The use of remote laboratories helps students in practicing PLC programming. Most of VHS’s students in West Java said that they would recommend the remote lab developed by researchers to other students. This indicates the satisfaction of students in using the remote lab for distance learning. In addition, students' stated that the overall remote lab system can worked well, easy to use, and they were satisfied with PLC distance learning using the remote lab.

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