Journal of Engineering Science and Technology
Vol. 17, No. 3 (2022) 1792 - 1809
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SOLUTIONS TO OVERCOME INEQUALITY IN LABORATORY FACILITIES AND LABORATORY SHARING IN SIMILAR INSTITUTIONS REMOTE LABORATORY BASED

JAJA KUSTIJA[1,*], PURNAWAN[2]

[1]Departemen Pendidikan Teknik Elektro , Universitas Pendidikan Indonesia,
Jl. Dr. Setiabudhi no 299, Bandung, 40154, Indonesia
[2]Departemen Pendidikan Pendidikan Teknik Mesin, Universitas Pendidikan Indonesia,
Jl. Dr. Setiabudhi no 299, Bandung, 40154, Indonesia
*Corresponding Author: jaja.kustija@upi.edu

Abstract

Problems in the limited budget for laboratory purposes, the imbalance in the number of tools and the number of users, and the inequality of laboratory facilities at the same institution have been widely discussed but in reality, it is still difficult to overcome, to overcome this problem, a remote laboratory solution that can be accessed by internet-based users is presented. This study aims to design, manufacture, measure the performance (delay, server response, GUI display) of a remote laboratory and test it for embedded systems practicum courses, then measure user responses about the effectiveness of the remote laboratory as a support for embedded systems courses, ease of use. , ease of achieving competence, and time flexibility. The method used is the Analyse, Design, Development, Implementation, Evaluation (ADDIE) approach. The results showed that the remote laboratory that was created met the criteria of ease of use, ease of achieving competence, and ease of time flexibility. The impact of the results of this study is that the remote laboratory is expected to be a solution for sharing laboratories between institutions if the laboratory facilities are not evenly distributed.

Keywords: Embedded systems, ESP32, Internet of things, Learning media, Training kits.

1. Introduction

A remote laboratory is designed starting from its global architecture [1]. It is then developed into a prototype and realized in the form of a system that can be used as a practical tool. , and management of its use was arranged both by the supervisor, laboratory (technician) and user side, then tested for one of the competencies. certain lectures and measuring the performance (delay, server response, GUI display) of the remote laboratory, and also measuring the increase in competence, time flexibility, and ease of use. The results of previous studies [2] said that remote laboratory can be used for the measurement of electronic components, but the results cannot be used for remote laboratories or cannot be accessed via the internet [3]. Some research results can be used properly and can be accessed via the internet but on specific content about PLC [4]. Other research can be used for distance learning and remote laboratory on case studies of electro-pneumatic mechatronic content [5]. In addition, other research results can be accessed via the internet with a computer lab case study making animation for video tutorials [6]. Then, some papers can train science skills in formulating and analysing junior high school science [7-9], and some using phET software [6]. Some software can be accessed using android [10, 11], which in turn it can increase the students' understanding [12, 13].

The method used is Analyse, Design, Development, Implementation, Evaluation (ADDIE) by studying the literature to analyse the research object [14], designing, and developing the design results as well as implementing the design results and applying them on the research object. All suggestions for improvement are used as evaluations for improvement of remote laboratory. The novelty of this research is to offer a remote laboratory solution that can be used for sharing between educational institutions, which has not been done so far.

Distance Learning is learning where students and teachers are located in separating locations. The effectiveness of the distance learning has been well-documented in many papers [3, 9, 15-28]. Distance learning requires an interactive telecommunications system to connect the two contents. One of the initiators of distance learning is the University of Phoenix, which was founded in Arizona in 1976, the characteristics of distance learning students and instructors together form distance education or online learning using internet tools [29]. There are four characteristics of distance learning:

(i) Done officially (learning institutions are not independent, non-academic, and meet the accreditation requirements and conventional-based learning).

(ii) The existence of geographical separation between students and teachers, accessibility, and convenience are very important in this educational model.

(iii) Individuals in study groups and teachers interact using electronic communication. Teaching resources do not depend on physical proximity because communication can be via the internet, cell phones, email, and others.

(iv) Distance education forms learning groups which are sometimes called learning communities consisting of students, teachers, learning resources.

Many learning sources for the distance learning are available, such as books, videos, graphic displays, and audio.Some of the learning sources are also available in the online-based implementations, such as google meet and google classroom [30-35], Zoom [36], WhatsApp [16, 37-39], Instagram [40], Quiziz [27, 41, 42], TikTok [25, 43], and others.

Media is a technology used to deliver learning materials from learning resources [44]. One of the media is internet of things (IoT) [3, 45]. The IoT32 media training kit functions for students participating in embedded systems practicum courses that can be accessed at flexible times and from where the user is as desired.

Practical activities are very important because they can improve students' abilities, understanding, and motivation [46-48]. Practical activities are usually carried out by accessing laboratory equipment directly to improve student skills [2]. However, during the Covid-19 pandemic, conditions will be difficult because learning must be done online [49].

The Internet can be one solution to overcome these problems. A laboratory that uses internet technology to access it can be called an online laboratory. Online laboratories can be divided into virtual laboratories and remote laboratories. The virtual laboratory can only be accessed by participants who are simulating, while the remote laboratory equipment can be run directly from where the participants are from and accessing [50].

A remote laboratory is a laboratory that can be accessed remotely as long as there is an internet connection with several advantages, including students can practice remotely without having to come to the laboratory to reduce costs, with better management being able to schedule the use of the laboratory flexibly so that with the number of equipment which can serve many users, the remote laboratory can improve safety and security because there are no failures due to physical errors during the experiment. The remote laboratory consists of three main components including a server, internet network, and user [5]. Based on good management, a reliable remote laboratory can serve users from other institutions or universities as sharing.

2. Materials and Methods

The research method used is ADDIE. ADDIE is often used in research to produce industrial products and can also be used to produce learning media. This study aims to design, manufacture, and measure the performance of a remote laboratory and test it for embedded systems practicum courses then measure user responses about the effectiveness of the remote laboratory as a support for embedded systems courses, ease of use, ease of achieving competence, and time flexibility. With good management, it can help participants access remotely at a flexible time. The research procedure carried out is shown in Fig. 1.

Based on Fig. 1, it is explained the research procedure and the steps taken in this study through several stages, including:

(i) Studying the content of the course material, the number of available equipment, and the participants who use it, as well as reading some literature that supports the remote laboratory design

(ii) Perform remote laboratory design according to course material and user conditions

(iii) Conduct discussions with the team to improve the existing design

(iv) Implement the results or designs that have been carried out

(v) The results of the designs that have been implemented are discussed with experts in the field of media and materials, the input provided becomes an improvement in the implementation of the next tool

(vi) The next step is to implement the equipment on participants

(vii) The last step is to analyse user opinions to get the level of feasibility of the tool made.

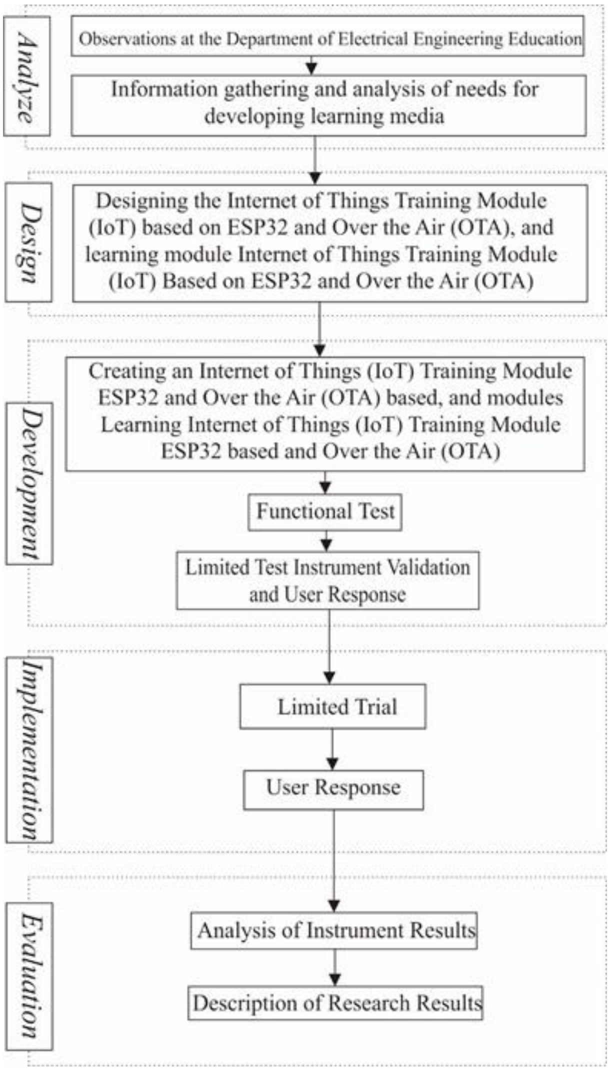

Fig. 1. Research procedure.

The use of purposive sampling technique to select participants. 31 students participating in Electrical Engineering Education who took embedded systems and IoT courses. Participants consisted of 17 male students and 14 female students aged 20-22 years. This study uses a closed questionnaire because the approach used is quantitative. The distribution of the questionnaires was carried out online using the Google Form platform. Questionnaires were used to measure participant responses and cognitive, affective, and psychomotor assessments. The participant's response questionnaire consisted of ease of use, ease of achieving competence, and time flexibility.

2.1. Research instruments

The participant response questionnaire was made with five scales on a Likert scale of 1-5 with the predicates “Very Poor”, “Poor”, “Enough”, “Good”, and “Very Good”. The assessment questionnaire was made in three aspects, namely cognitive, affective, and psychomotor based on the competency of the subjects being tested.

Aspects of cognitive assessment are made in the form of multiple-choice which will be carried out by participants with a maximum score of 100 points. Aspects of effective assessment were made with five scales on the same Likert scale as the participant's response questionnaire. Aspects of psychomotor assessment were made with five scales on a Likert scale of 1-5 with the predicate “Very Poor”, “Poor”, “Enough”, “Good”, and “Very Good”. Detailed information about Likert scale has been well-documented and well-implemented in educational-related research [51-56].

2.2. Data analysis

In this study, the data analysis technique used by the researcher is the Mann-Whitney u-test method, which is also known as the Wilcoxon rank-sum test and is a non-parametric version of the t-test. The Mann-Whitney u-test method is used when:

(i) The dependent variable is ordinal.

(ii) The dependent variable is a ratio or interval, but it cannot be assumed that the population forms a normal distribution.

In this study, the Mann-Whitney u-test method was used to compare response trends and measure how significant the difference in responses between male and female participants was to this learning media.

3. Results and Discussion

3.1. Architecture

Figure 2 shows remote laboratory architecture. Based on Fig. 2, the remote laboratory hardware design consists of three main parts, namely the internet as a system that connects the user and server parts. The remote laboratory system uses a remote desktop system as a means for users to control lab computers that are already connected to lab equipment.

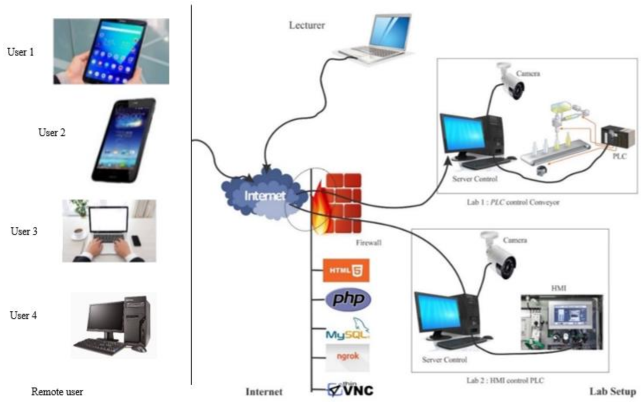

Fig. 2. Remote laboratory architecture.

3.2. IoT32

IoT32 uses the ESP32-Wroom-32 board as the main component connected to several modules. This board consists of WiFi and over the air (OTA) modules. OTA is a system that allows the uploading of programs over the air. On this system, the ESP32 will receive firmware updates over the air without a USB cable connected to a computer device [51]. Once modified, the OTA can be accessed via the internet. This allows the program upload process to be carried out remotely. When uploading programs via OTA, participants are required to log in to the program to receive the OTA again so that the firmware can be updated continuously [51]. In addition to updating firmware wirelessly, OTA can also solve flashing problems on ESP32 when updating firmware using a USB cable which requires pressing the boot button when updating firmware [51].

The power supply for IoT32 is a power bank or 5-volt power supply (see Fig. 3). The ESP32 board is connected to several sensor and actuator modules according to practical needs. Sensor and actuator module for experimental led for digital output, servo motor for pulse width modulation (PWM), an ultrasonic module for remote reading, light-dependent resistor (LDR), analog to digital converter (ADC), inter-technology integrated circuit (I2C) is connected to a liquid crystal display (LCD). The board is also connected to a WiFi network, so the sensor and actuator data can be accessed by Thingsboard and Firebase. The OTA configuration is installed on the webserver so that IoT32 can be accessed remotely [29]. Firmware upload on the ESP32 is done remotely via OTA. Participants can view IoT32 using the ESP32CAM and monitor data on the Thingsboard. Picture. 3 shows the block diagram of the IoT32 environment.

The IoT32 tutorial module is used as a practical work reference for the basic competencies of the Embedded Systems and IoT courses. The tutorial module has several sections, including a cover page, introduction, table of contents, and a list of images. In addition, this training kit also consists of basic IoT theory, an explanation of the function of each component, an Arduino IDE tutorial, and 8 practical worksheets. The tutorial module is also equipped with an evaluation form and practice questions. In Fig. 4, it is explained that the development of the IoT32 training kit consists of several main stages.

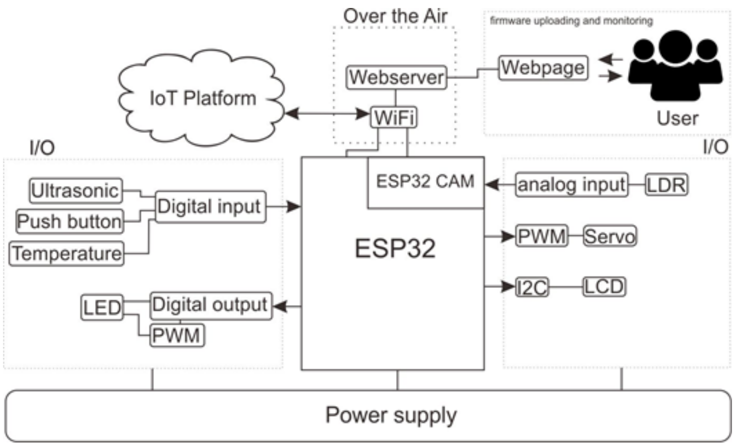

Fig. 3. The block diagram of the IoT32 environment.

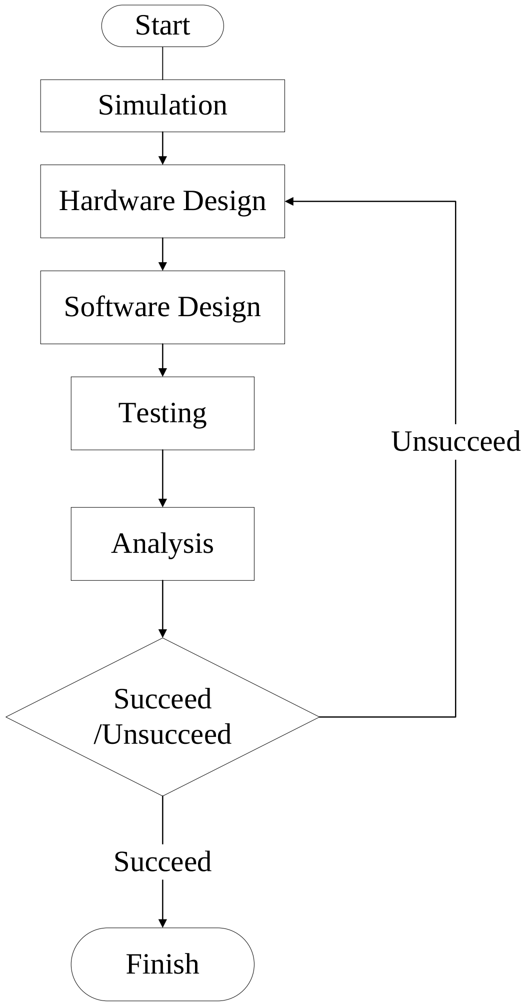

Fig. 4. Flowchart of stages.

Based on Fig. 4., the development of the IoT32 training kit consists of several main stages. These stages include simulation, hardware design, software design, testing, and analysis [51]. In the testing phase, the researcher involved prospective participants and supervisors to provide suggestions about the training kit. The advice given by the supervisor is that the IoT platform uses a things board or firebase, the training kit is made portable, and the ultrasonic sensor placement is placed in one device, while suggestions from participants are programming software using Arduino IDE. Figure 4 shows the IoT32 training kit.

Figure 5 shows the IoT32 training kit. The development of the IoT32 tutorial module consists of designing the module framework, content, and evaluation sheets. Researchers involved supervisors and lecturers for Embedded Systems and IoT courses to provide suggestions, including adding evaluation sheets or practice questions to each worksheet, adding widget management worksheets on Thingsboard, and adding basic IoT theory.

Fig. 5. IoT32 kits.

3.3. Management

IoT32 uses the There are two main components in managing the use of remote labs, namely use and personal management. Management functions to regulate the operation of the remote lab between users and tools. In embedded systems practicum apart from hardware and systems the most important factor is the involvement of lecturers, technicians, and students, their roles include several factors.

In the case of lecturer, the roles of the lecturer in setting up the practicum using the remote laboratory among others are:

(i) Explain how to use and how access the remote laboratory

(ii) Set the schedule and Assign accounts to users

(iii) Uploading the worksheet

(iv) Uploading the module

(v) Supervise the course of the practicum

(vi) Checking student assignments uploaded through the system

In the case of technician, a technician is a person who assists the course of the practicum and has the following duties:

(i) Turn on the server computer

(ii) Check server connection

(iii) Enable public IP

(iv) Check GUI activation

Activation scheduling is built into the operating system for scheduling its start-up.

In the case of user (student), students are users who are very interested in the implementation of the practicum which has the following tasks:

(i) Download and study the modules on the website

(ii) Download and study the job sheets that are available on the website

(iii) Doing practicum according to module guide and worksheet

(iv) Record the results of the program that has been made through the camera available in the lab

(v) In addition to the main tasks above, students can also use the message sending feature if they have difficulty accessing the remote lab

(vi) Uploading assignments based on the results of the practicum that has been carried out in the form of files and videos.

3.4. Functional Test

First, the researcher tested the power supply by testing the resistance of the power bank. The results show that the endurance duration is 4 hours if the power bank is fully charged. After that, the researcher tested all available sensor and actuator modules. Tests show that all modules work well. In addition, researchers tested the internet network and servers. Researchers tested 10 times by updating firmware and monitoring data traffic. The results showed that the average delay was between 2 to 3 seconds. The last step is to test the camera quality by reading the characters on the LCD remotely via the ESP32Cam. Tests show that the ESP32Cam module can display the remote module view.

3.5. Analysis

Several analyses were done

(i) Limited Trial. A limited trial was conducted on the IoT32 training kit for participants. This stage is carried out by participants remotely with an average accessibility time of two hours for each participant and is carried out for one month. This stage aims to determine the participants' understanding of the IoT32 training kit. Researchers evaluated three aspects of learning evaluation in a limited trial, namely cognitive, affective, and psychomotor. Cognitive assessment is done by measuring the participants' understanding of the training kit. This step is done by giving 10 multiple choice questions to participants after using the IoT32 training kit. The results of the participants showed that the average score of the participants was 83.25 out of 100. The effective assessment was carried out by assessing the attitude of the participants when using the IoT32 training kit. The average score of affective participants is 3.5 and is included in the fairly good category. Psychomotor assessment is carried out by testing the motor skills of participants when using the IoT32 training kit. Participants' average score was 3.8. it belongs to the skilled category. It was seen that the participants were able to understand the IoT32 material. This also shows that they are enthusiastic about participating in practical work using IoT32.

(ii) Participant response. The participant response test involved 31 participants. Demographic data showed that 16 participants (51.6%) were male, and 15 participants (48.4%) were female. The age range of participants is between 20 to 22 years. The exam also gathers participants' experience with computer programming and embedded systems. The results showed that most of the participants had sufficient competence in C/C++ and Arduino programming. The responses of male and female participants were compared using the Mann-Whitney U Test to measure the level of significance of the differences. The results of the participants can be seen in Table 1.

Table 1. Comparison of male and female response.

Assessment Aspects	Male		Female		Mann Whitney U – Test	
	M	**SD**	**M**	**SD**	**Z**	**P**
Material Quality	4.1	0.29	4.7	0.28	-2.0688	0.03639
Media Use	4.0	0.47	4.5	0.28	-2.0688	0.03833
Learning	4.5	0.38	4.7	0.28	-1,723	0.0874

Note: **p* < 0.05, ***p* < 0.01

Based on Table 1, there are several aspects:

(i) The aspects of material quality are z = -2.0683 and p = 0.03639, indicating that there are differences in responses between male and female participants. The values are M = 4.1 and SD = 0.29 for males. The values for female are M = 4.7 and SD = 0.28.

(ii) The aspects of media use are z = -2.0683 and p = 0.03833, showing a difference in responses between male and female participants. The values for male are M = 4.0 and SD = 0.47, and the values for female are M = 4.5 and SD = 0.28.

(iii) The aspects of learning are z = -1.723 and p = 0.0874, showing no significant difference in responses between male and female participants. The values for male are M = 4.5 and SD = 0.38. The values for female are M = 4.7 and SD = 0.28.

Evaluating the results of distributing questionnaires to 31 respondents and inviting respondents to do practical work in remote laboratories. A self-questionnaire of eight questions measured on a scale of 1 to 5; where 5 is very good, 4 is good, 3 is moderate, 2 is bad, and 1 is very bad.

In terms of material quality, there were significant differences between male and female participants. This happens because of differences in basic knowledge about the participants' microcontrollers before doing the practicum. However, this assessment provides a good average score of 4.1 for men and 4.7 for women. It can be said that the tutorial module can be understood well.

In the aspect of media use, there are significant differences between male and female participants. This happens because of the different experiences of participants in using the microcontroller training kit before doing the practicum. However, the assessment gave a good average score of 4.0 for men and 4.5 for women. By judging from the data, the learning media products provided can be used properly by the participants.

Table 2 shows the results of data processing from a questionnaire about the use of media for a sample of male students. Based on Table 2, the results of the questionnaire processing of the use of learning media from a sample of male students have an average price of 4.0 which has a good meaning.

Table 3 shows the results of data processing from the questionnaire about the use of media for the female student sample. Based on Table 3, the results of the questionnaire processing of the use of learning media from a sample of female students have an average price of 4.5, which has a good meaning.

Table 2. Results evaluation questionnaire media use male.

#Q	Questionnaire	Score					
		1	2	3	4	5	Mean
Q1	What is the usage schedule Remote laboratory really helps you?	2	2	0	2	10	4.0
Q2	Does learning to use a remote laboratory help achieve the expected level of competence?	2	2	1	0	11	4.0
Q3	Is the use of a remote laboratory for the time provided more flexible than the real laboratory?	2	1	2	1	10	4.0
Q4	Do you think that remote laboratory can improve tool safety and work safety for practicum users?	1	2	2	2	9	4.0
Q5	Do you think that practicum evaluation based on a remote laboratory is a suitable competency?	4	0	0	0	12	4.0
	Total Mean						**4.0**

Table 3. Results evaluation questionnaire media use female.

#Q	Questionnaire	Score					
		1	2	3	4	5	Mean
Q1	What is the usage schedule Remote laboratory really helps you?	2	1	0	0	12	4.26
Q2	Does learning to use a remote laboratory help achieve the expected level of competence?	0	0	1	2	12	4.73
Q3	Is the use of a remote laboratory for the time provided more flexible than the real laboratory?	1	0	0	0	14	4.86
Q4	Do you think that remote laboratory can improve tool safety and work safety for practicum users?	2	1	0	2	10	4.13
Q5	Do you think that practicum evaluation based on a remote laboratory is a suitable competency?	1	0	0	3	11	4.53
	Total Mean						**4.502**

Figure 6 shows the average results of data processing samples of media use from men and women. Based on Fig. 6, it can be seen that the results of data processing use male and female media. In terms of learning, there was no significant difference between male and female participants. it can be said that the responses of male and female participants in this aspect are the same. The average score was 4.5 for men and 4.7 for women. So it can be said that the tutorial module can motivate and facilitate participants to learn about IoT and embedded.

Table 4 shows the results of data processing from the learning questionnaire sample of male students. Based on Table 4, the results of the questionnaire processing of the use of learning media from a sample of female students have an average value of 4.5 which has a good meaning.

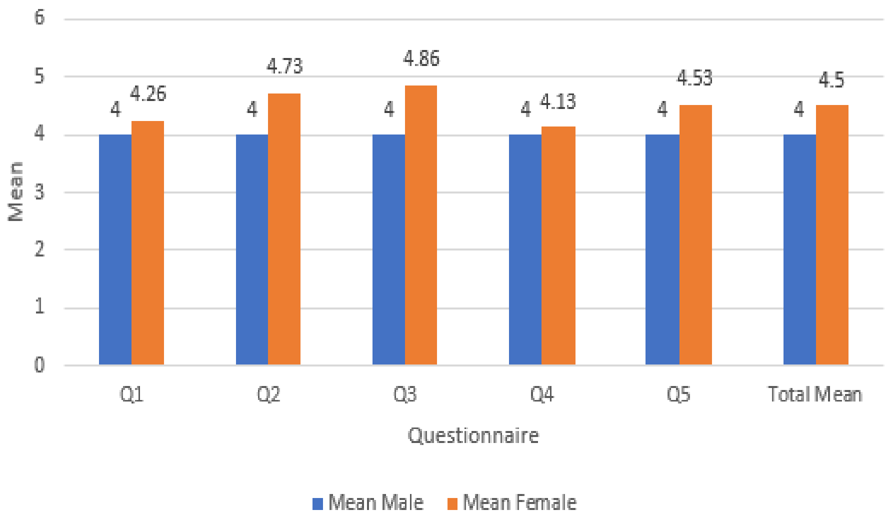

Fig. 6. Evaluation media use.

Table 4. Results evaluation questionnaire learning male.

#Q	Questionnaire	Score					
		1	2	3	4	5	Mean
Q1	Has the Remote laboratory schedule helped you?	0	2	0	2	12	4.50
Q2	Does learning to use a remote laboratory help achieve the expected level of competence?	0	0	0	8	8	4.50
Q3	Is the use of a remote laboratory for the time provided more flexible than the real laboratory?	2	1	2	7	7	4.50
Q4	Do you think that remote laboratory can improve tool safety and work safety for practicum users?	0	1	2	1	12	4.50
Q5	Do you think that practicum evaluation based on a remote laboratory is a suitable competency?	2	0	0	0	14	4.50
	Total Mean						**4.5**

Table 5 shows the results of data processing from the learning questionnaire for the female student sample. Based on Table 5, the results of the questionnaire processing using learning media from a sample of female students have an average price of 4.7 which has a good meaning.

Figure 7 shows the results of the average learning outcomes of male and female data processing samples. Based on Fig. 7, it can be seen that the results of data processing learned from men and women.

Table 5. Results evaluation questionnaire learning female.

#Q	Questionnaire	Score					
		1	2	3	4	5	Mean
Q1	Has the Remote laboratory schedule really helped you?	0	0	1	0	14	4.86
Q2	Does learning to use a remote laboratory help achieve the expected level of competence?	0	1	1	0	13	4.66
Q3	Is the use of a remote laboratory for the time provided more flexible than the real laboratory?	0	1	0	2	12	4.73
Q4	Do you think that remote laboratory can improve tool safety and work safety for practicum users?	0	2	0	1	12	4.53
Q5	Do you think that practicum evaluation based on a remote laboratory is a suitable competency?	1	0	0	0	14	4.73
	Total Mean						**4.702**

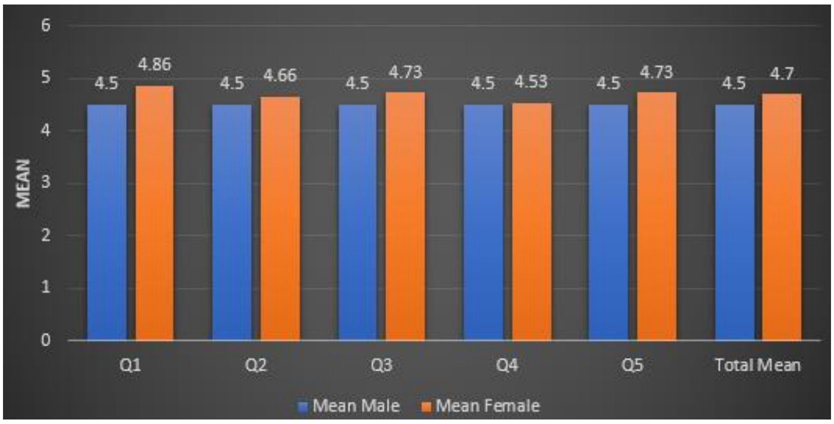

Fig. 7. Evaluation learning.

Based on the results of data processing, the two positive responses from female participants were always higher than the responses from male participants. This means that the remote laboratory is more fun for the female participants.

Based on the participants' responses, this research has a good impact on completing the final project in this course. In addition, IoT32 can help students to practice in pandemic situations. It is in a good line with previous studies that IoT is one of the excellent problem solvers for taking care current problems [3, 45, 57-59]. Compared with the previous research, this research successfully uses OTA on ESP32 remotely. This is different from previous studies that used remote desktop technology for remote laboratories. This research has a weakness in the server delay which is too long when it is first activated. For further research, it is expected to use a faster server to speed up the firmware update process remotely. Previous research [29] still has shortcomings and it is different from our study. The Training Kit is made to measure electronic components but cannot be used for remote laboratories or cannot be accessed via the internet, in this study it can be accessed via the internet. In the previous study [60], a virtual laboratory was also created to train science skills in formulating and analysing junior high school science using phET software which can only be accessed via android. Thus, in this study, it can be accessed via laptops, androids, computers, and tablets. In previous research [4], the remote laboratory can be used properly and can be accessed via the internet, but the specific content is about PLC only, while in this study it can be applied to a wider range of content. In previous research [5], remote laboratory can be used for distance learning but only on electro-pneumatic mechatronic content, while in this study it can be applied to a wider range of content

4. Conclusion

Based on the analysis of data processing, the remote laboratory designed, built, and tested meets the criteria for this study, namely the performance of the remote laboratory (delay, server response, GUI display) is quite good, participant responses to ease of use are between good and very good, the ease of achieving competence between good and very good, and time flexibility are close to very good. Another finding in this study is that the remote laboratory is preferred by female participants compared to male participants. The results of participant responses showed that all participants gave positive opinions on the training kit. The results of the limited trial also showed that all participants gave a positive response to the IoT32 modules and tutorials. This IoT32 training kit can overcome the gap between the number of tools and the number of participants by setting the schedule flexibly. The researcher provides recommendations for further research, namely testing the tutorial module by measuring the effectiveness of the practicum based on the learning outcomes of participants. In addition, further researchers can modify IoT32, especially on the server-side, so that remote firmware uploads will be faster.

References

1. Hasanah, L.; Hakim, W.L.; Aminudin, A.; Sahari, S.K.; and Mulyanti, B. (2020). A design and performance analysis of a telemetry system for remote monitoring of turbidity of water during the covid-19 pandemic. *Indonesian Journal of Science & Technology*, 5(2), 299-307.
2. Shweta, N.M.; Dwarakanath, V.T.; Nanda, K.; Saha, S.; Singh, V.P.; Hari Babu, P.; and Prasad, G.L.G. (2019). Applications of IoT Lab Kit in Educational Sector. *IETE Journal of Education*, 60(1), 24-32.
3. Thapwiroch, K.; Kumlue, A.; Saoyong, N.; Taprasan, P.; and Puengsungewan, S. (2021). Easy-mushroom mobile application using the Internet of Things (IoT). *Indonesian Journal of Educational Research and Technology*, 1(2), 1-6.
4. Purnomo, R.D.; Mulyanti, B.; and Kustija, J. (2021). PLC (Programmable Logic Controller) distance learning using remote lab system. In *IOP Conference Series: Materials Science and Engineering*, 1098(4), 042014.
5. Kustija, J.; Ana, A.; and Jayanto, N.D. (2021). Web-based and thinvnc remote laboratory implementation to support students skills in mechatronics course to face the industrial revolution 4.0. *Journal of Engineering Science and Technology* (*JESTEC*), 16(2), 1800-1813.
6. Jaya, H. (2012). Pengembangan laboratorium virtual untuk kegiatan paraktikum dan memfasilitasi pendidikan karakter di SMK. *Jurnal Pendidikan Vokasi*, 2(1), 81-90.

7. Hendrayanto, A.R.; Muktiarni, M.; and Mupita, J. (2022). Perception of junior high school students in using iPusnas App as medium for increase literacy social studies subject. *Indonesian Journal of Educational Research and Technology*, 2(3), 149-154.
8. Dewi, F.A.; Muktiarni, M.; and Mupita, J. (2021). Improving knowledge of chicken nugget processing using animated videos for junior high school students. *ASEAN Journal of Science and Engineering Education*, 2(1), 193-198.
9. Azizah, E.V.; Nandiyanto, A.B.D.; Kurniawan, T.; and Bilad, M.R. (2022). The effectiveness of using a virtual laboratory in distance learning on the measurement materials of the natural sciences of physics for junior high school students. *ASEAN Journal of Science and Engineering Education*, 2(3), 207-214.
10. Haristiani, N.; and Rifa'i, M.M. (2020). Combining chatbot and social media: Enhancing personal learning environment (PLE) in Language Learning. *Indonesian Journal of Science & Technology*, 5(3), 487-506.
11. Haristiani, N.; and Rifai, M.M. (2021). Chatbot-based application development and implementation as an autonomous language learning medium. *Indonesian Journal of Science & Technology*, 6(3), 561-576.
12. Firmansyah, D.B.; and Rahmawati, R.S. (2018). Penggunaan media ajar berbasis multimedia dalam pembelajaran kanji. *Japanedu: Jurnal Pendidikan dan Pengajaran Bahasa Jepang*, 3(1), 1-10.
13. Maryunita, R. (2017). Pemanfaatan aplikasi google japanese input dalam meningkatkan minat dan kemampuan membaca teks bahasa jepang. *Japanedu: Jurnal Pendidikan dan Pengajaran Bahasa Jepang*, 2(1), 20-28.
14. Samsudin, A.; Suhandi, A.; Rusdiana, D.; and Kaniawati, I. (2016). Preliminary design of ICI-based multimedia for reconceptualizing electric conceptions at universitas pendidikan indonesia. *Journal of Physics: Conference Series*, 739(1), 012006.
15. Riyanto, Y.; Nandiyanto, A.B.D.; and Muhammad, N. (2021). The effectiveness of distance teaching and learning activities in primary schools. *Indonesian Journal of Multidiciplinary Research*, 1(1), 1-6.
16. Agustina, S.; and Nandiyanto, A.B.D. (2021). The effectiveness of distance learning using learning management system media and whatsapp groups at senior high school. *Indonesian Journal of Multidiciplinary Research*, 1(1), 89-98.
17. Andhini, A.B.; and Sakti, A.W. (2021). Impact of distance learning on reading and writing ability in elementary school students. *Indonesian Journal of Multidiciplinary Research*, 1(2), 393-398.
18. Sabila, L.; Nandiyanto, A.B.D.; Kurniawan, T.; and Bilad, M.R. (2021). Improved rhythm pattern reading skills using the eurythmics dalcroze method on distance learning for junior high school. *Indonesian Journal of Multidiciplinary Research*, 1(2), 413-418.
19. Riyanto, M.; Nandiyanto, A.B.D.; Kurniawan, T.; and Bilad, M.R. (2022). Management of character education in the scope of elementary school students in the distance learning period, *Indonesian Journal of Multidiciplinary Research*, 2(1), 1-8.
20. Escomes, E.L.; and Morbo, E.A. (2021). Factors affecting distance learning of the physical education students of Sultan Kudarat State University, Mindanao,

Philippines. *Indonesian Journal of Educational Research and Technology*, 1(3), 87-94.

21. Ajijola, E.M.; Ogunlade, O.O.; and Aladesusi, G.A. (2021). The attitude of distance learners towards the utilization of learning management system (A case study of National Open University of Nigeria). *Indonesian Journal of Teaching in Scienc*e, 1(1), 53-62.
22. Mulyanti, B.; Purnama, W.; and Pawinanto, R.E. (2020). Distance learning in vocational high schools during the covid-19 pandemic in West Java province, Indonesia. *Indonesian Journal of Science & Technology*, 5(2), 271-282.
23. Nafsi, N.R.R.; and Maryanti, M. (2022). Analysis of teacher skills in e-learning content development during distance learning during the Covid-19 pandemic. *ASEAN Journal of Science Education*, 1(1), 23-32.
24. Reskianissa, A.; Sakti, A.W.; and Azizah, N.N. (2022). TikTok platform to train middle school students' computational thinking skills in distance learning. *ASEAN Journal of Educational Research and Technology*, 1(1), 79-86.
25. Ariyanti, L.S.; and Nandiyanto, A.B.D. (2022). Distance teaching of stress materials to junior high school students using digital media. *ASEAN Journal of Community Service and Education*, 1(1), 7-14.
26. Nasution, A.R.; and Nandiyanto, A.B.D. (2021). Utilization of the google meet and quiziz applications in the assistance and strengthening process of online learning during the Covid-19 pandemic. *Indonesian Journal of Educational Research and Technology*, 1(2), 31-34.
27. Cabrillos, L.E.; Gapasin, J.D.; Marfil, J.A.; and Calixtro Jr.V.L. (2023). Examining the effects of online games on the academic performance of BPEd students of Sultan Kudarat State University, Philippines. *Indonesian Journal of Educational Research and Technology*, 3(1), 13-18.
28. Palma, M.C.; Escucha, T.N.V.; Distor, Z.B.; Tuyao, B.V.; Malaco, A.; and Estrellan, J. (2021). Parental academic support in online and modular learners amidst pandemic: a comparative study. *Indonesian Journal of Community and Special Needs Education*, 1(1), 31-36.
29. Alfasimi, D.; Krismadinata, K.; Sukardi, S.; and Syukhri, S. (2018). Development of electrical measurement training kits as learning media in the subject of understanding measurement of electronic components at SMK Muhammadiyah 1 Padang. *Invotek Journal of Innovation Vocational and Technology*, 18(1), 91-98.
30. Ochayi, O.A.; Olabo, O.O.; Aderogba, O.A.; Musiliu, A.A.; and Joshua, A.B. (2021). For what purpose do undergraduates utilize google classroom?. *Indonesian Journal of Multidiciplinary Research*, 1(2), 313-324.
31. Olumorin, C.O.; Babalola, E.O.; Ashaolu, S.; and Omolafe, E.V. Students 'attitude towards the utilization of google classroom for learning. *Indonesian Journal of Educational Research and Technology*, 2(3), 213-222.
32. Aderogba, O.A.; Shittu, A.; Afolake, N.; Ochayi, O.A.; and Musiliu, A.A. (2021). Accessibility of google classroom by undergraduates for learning. *Indonesian Journal of Teaching in Scienc*e, 1(2), 69-78.
33. Ochayi, O.A.; Olabo, O.O.; Aderogba, O.A.; Rabiu, A.M.; and Peace. A. (2021). Science lecturers' seeming use of google classroom for instruction. *ASEAN Journal of Science and Engineering Education*, 2(1), 141-150.

34. Joshua, A.B.; Olabo, O.O.; Ochayi, O.A.; Musiliu, A.A.; and Aderogba, O.A. (2022). Barriers limiting the use of google classroom for learning vocational and entrepreneurship courses. *ASEAN Journal of Science and Engineering Education*, 2(1), 61-74.
35. Zuyyinasyam, S.; Nandiyanto, A.B.D.; Kurniawan, T.; and Al Husaeni, D.F. (2023). Implementation of the educational personnel program for elementary school students in the digital age using google classroom. *ASEAN Journal of Educational Research and Technology*, 2(1), 29-34.
36. Ganesha, P.; Nandiyanto, A.B.D.; and Razon, B.C. (2021). Application of online learning during the covid-19 pandemic through zoom meeting at elementary school. *Indonesian Journal of Teaching in Scienc*e, 1(1), 1-8.
37. Suroto, S.; and Nandiyanto, A.B.D. (2021). The effectiveness of using whatsapp social media as learning media at elementary school. *Indonesian Journal of Multidiciplinary Research*, 1(1), 79-84.
38. Ramdhani, T.; and Nandiyanto, A.B.D. (2021). The use of whatsapp social media as reinforcement online learning during the Covid-19 pandemic. *Indonesian Journal of Multidiciplinary Research*, 1(1), 107-112.
39. Maulidayani, T.; Muktiarni, M.; and Mupita, J. (2022). Strengthening the value of pancasila in elementary schools in online learning through whatsapp group media, *Indonesian Journal of Multidiciplinary Research*, 2(1), 117-124.
40. Risnandar, R.; and Sakti, A.W. (2022). Optimizing instagram in sociology materials to improve digital literacy for junior high school students. *ASEAN Journal of Educational Research and Technology*, 1(1), 39-46.
41. Fadillah, I.N.; and Maryanti, R. (2021). Application of learning videos and quizizz in increasing students interest in learning English in middle schools. *Indonesian Journal of Multidiciplinary Research*, 1(2), 329-336.
42. Saefurohman, S.; Maryanti, R.; Azizah, N.N.; Al Husaeni, D.F.; Wulandary, V.; and Irawan, A.R. (2021). Efforts to increasing numeracy literacy of elementary school students through Quiziz learning media. *ASEAN Journal of Science and Engineering Education*, 3(1), 11-18.
43. Gajo, A.G.E.; Gaisen, E.M.P.; Lino, F.V.K.R.; Edaṅo, L.B.; and Calixtro Jr, V.L. (2023). Sustaining students' mental health through the use of Tiktok application. *Indonesian Journal of Community and Special Needs Education*, 3(1), 11-20.
44. Bidarra, J.; and Rusman, E. (2017). Towards a pedagogical model for science education: bridging educational contexts through a blended learning approach. *Open Learning: The Journal of Open, Distance and e-learning*, 32(1), 6-20.
45. Anh, D.H.M. (2022). Mesh network based on MQTT broker for smart home and IIoT factory. *ASEAN Journal of Science and Engineering*, 2(2), 173-180.
46. Ana, A. (2020). Trends in expert system development: A practicum content analysis in vocational education for over grow pandemic learning problems. *Indonesian Journal of Science & Technology*, 5(2), 246-260.
47. Veronica, J.; Intan Febriani, L.; Nurhashiva, C.; Ragadhita, R.; Nandiyanto, A.B.D.; and Kurniawan, T. (2021). Practical computation in the techno-economic analysis of the production of magnesium oxide nanoparticles using sol-gel method. *International Journal of Informatics, Information System and Computer Engineering* (*INJIISCOM*), 2(2), 1-12.

48. Abdussemiu, A. (2022). Problems of Teaching Practical Biology in Senior Secondary Schools. *ASEAN Journal of Science and Engineering Education*, 2(3), 199-206.
49. Indrayana, B.; and Sadikin, A. (2020). Penerapan e-learning di era revolusi industri 4.0 untuk menekan penyebaran COVID-19. *Indonesian Journal of Sport Science and Coaching*, 2(1), 46-55.
50. Haritman, E.; Somantri, Y.; Wahyudin, D.; and Mulyana, E. (2018). A remote PLC laboratory (RLab) for distance practical work of industrial automation. *IOP Conference Series: Materials Science and Engineering*, 306(1), 012034.
51. Maryanti, R.; Hufad, A.; Sunardi, S.; Nandiyanto, A.B.D.; and Al-Obaidi, A.S.M. (2020). Understanding covid-19 particle contagion through aerosol droplets for students with special needs. *Journal of Engineering Science and Technology* (*JESTEC*), 15(3), 1909-1920.
52. Maryanti, R.; Hufad, A.; Nandiyanto, A.B.D.; and Tukimin, S. (2021). Teaching the corrosion of iron particles in saline water to students with special needs. *Journal of Engineering Science and Technology* (*JESTEC*), 16(1), 601-611.
53. Rusyani, E.; Maryanti, R.; Muktiarni, M.; and Nandiyanto, A.B.D. (2021). Teaching on the concept of energy to students with hearing impairment: changes of electrical energy to light and heat. *Journal of Engineering Science and Technology* (*JESTEC*), 16(3), 2502-2517.
54. Maryanti, R.; Hufad, A.; Nandiyanto, A.B.D.; and Tukimin, S. (2021). Teaching heat transfer on solid-to-liquid phase transition phenomena to students with intellectual disabilities. *Journal of Engineering Science and Technology* (*JESTEC*), 16(3), 2245-2259.
55. Maryanti, R.; Hufad, A.; Tukimin, S.; Nandiyanto, A.B.D.; and Manullang, T.I.B. (2020). The importance of teaching viscosity using experimental demonstration from daily products on learning process especially for students with special needs. *Journal of Engineering Science and Technology* (*JESTEC*), 15, 19-29.
56. Maryanti, R.; Hufad, A.; Sunardi, S.; and Nandiyanto, A.B.D. (2022). Teaching high school students with/without special needs and their misconception on corrosion. *Journal of Engineering Science and Technology* (*JESTEC*), 17(1), 0225-0238.
57. Ng, C.K.; and Zanil, M.F. (2019). Development of IoT based heat exchanger control trainer for undergraduate process control programme. *Research Communication in Engineering Science and Technology*, 2(2019), 6-16.
58. Pantjawati, A.B.; Purnomo, R.D.; Mulyanti, B.; Fenjano, L.; Pawinanto, R.E.; and Nandiyanto, A.B.D. (2020). Water quality monitoring in Citarum river (Indonesia) using IOT (internet of thing). *Journal of Engineering Science and Technology* (*JESTEC*), 15(6), 3661-3672.
59. Budi, A.H.S.; Juanda, E.A.; Kustiawan, I.; Kurniadi, N.N.N.; and Henny, H. (2021). River water monitoring system using internet of things to determine the location of river pollution. *Journal of Engineering Science and Technology* (*JESTEC*), 16(4), 3222-3233.
60. Efendi, N.; and Sartika, S.B. (2021). The effect of distance learning practicum based on phet interactive simulations on science process skills of secondary school students. *Jurnal Pendidikan Sains* (*JPS*), 9(1), 91-96.