Analysis of Best Practice Remote-Lab Through Network Monitoring in Teaching Vocational Practicum Courses

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Abstract*—Vocational education offers a curriculum in form of a combination of theory and practice, where the percentage of theory is smaller than the practice. This is because vocational college graduates are prepared to go directly into the world of work. In order for vocational college graduates to be quickly absorbed in the job market, they must be equipped with good skills through practicum. As usual, the implementation of practicum courses, especially at PNUP, is carried out using the hands-on laboratory method. With the Covid-19 pandemic, PNUP took a policy to be able to carry out lectures online. The implementation of practicum activities using various kinds of computer applications in the form of software can increase the flexibility of practicum. This is what underlies an alternative to the implementation of a Remote laboratory (Remote-Lab) which is very suitable for software-based practicum that has efficiency in financing which will support online lectures. The purpose of this research is to analyze several Remote-Lab applications based on remote access / desktop as best practice. This alternative method of Remote-Lab is useful in direct supervision management and control of computers connected to the network in practicum activities specifically in Code-2 and Code-3 courses. The results show that remote access/desktop allows users to connect to a machine (computer/desktop) remotely as if they were sitting in front of the machine in question. Remote-Lab is an easy and practical solution for conducting computer-based theory and practical classes. Through remote-lab lecturers and students can still interact with each other properly using existing desktop access support applications. The convenience felt by students means that this method is easily accepted and learning objectives can still be achieved.

Keywords*—Virtual Laboratory, Remote-Lab, Remote access, online

I. Introduction

Vocational education curriculum should be supported by practicum activities. In a practicum activity, several factors are needed including laboratory space in accordance with practical courses, equipment facilities, and complete practical materials. With the incessant technological innovation, it demands an adjustment of the education system that is in line with the demands of the world.

Work. Universities are obliged to prepare student graduates who are ready to enter the world of work and are able to develop a professional attitude in the vocational field, and must be able to provide competencies or skills that can improve the quality of graduates to achieve success.

The use of *hands-on* laboratory (*hands-on lab*) is a direct practice activity carried out in a special laboratory room available, where students can operate their own materials and tools as practicum activities. The implementation process is carried out by direct face-to-face between students and supervisors in a certain duration of learning time. The implementation of *hands-on lab* at Politeknik Negeri Ujung Pandang (PNUP) has been running consistently (onsite) so far. According to data from the General and Academic Section of PNUP in 2020, PNUP has a total of 58 laboratories, 14 workshops, and 4 studios spread across 6 departments.

This research was motivated by two issues. First, during the Covid-19 pandemic where teaching methods that were originally conducted face-to-face in the classroom/laboratory were transferred to online classes. At the beginning of the pandemic that occurred in 2020,

all classes and laboratories/workshops/studios were eliminated and transferred to the online method. Especially in laboratory/workshop/studio activities, this is a big obstacle because there is no readiness for these activities online, both the readiness of online laboratory media and the form of jobsheets that will be presented. In the future education system, the concept and method of teaching practicum should be carried out in the form of *Blended Learning systems* by combining *online* and *offline* classes (Abdullah, 2018). Second, there are obstacles for lecturers who carry out online practicum

teaching in Code-3 courses. Code-3 is a special code that applies at PNUP which combines theory and practicum in one face-to-face meeting. This is in accordance with the curriculum guidelines for vocational study programs based on the Indonesian National Work Competency Standards (SKKNI) in 2016 that the Course Code consists of Code-1: Theory Class, Code-2: Practicum, and Code-3: Combination of Theory and Practicum. In general, with Code-2 courses, practicum activities have been systematically arranged regarding laboratory use schedules and laboratory room locations. Whereas in Code-3 courses, lecturers are only given classrooms and not all are given a special schedule for using the laboratory for the completion of the teaching method of practicum. Whereas in terms of providing practical material, the space occupied should be in certain related laboratories.

Based on the rules of Law No. 20 of 2003 concerning the National Education System and No. 12 of 2012 concerning Higher Education, the guidelines for the realization of the Semester Credit System (SKS) for laboratory / workshop practice courses have a portion of 60-70% of the total credits in each vocational study program curriculum. Therefore, it is appropriate that the practicum mechanism can be maximally implemented both in *hands-on lab* (onsite) and online/remote (online).

Currently, various computer applications have begun to be developed to support the implementation of online laboratories such as *Virtual* Laboratories () which are believed by education experts to increase flexibility in terms of time allocation and place for practicum implementation. V-Lab activities can provide an efficient level of financing because they are based on simulators created using computer programs. V-lab is managed in the form of computer software that has the ability model computer equipment mathematically presented through a simulation. This system was created to strengthen the understanding of concepts in the learning process but it is also part of a *hands-on lab* that used to complement and improve existing weaknesses (Widodo, 2016). Of course, the disadvantages of V-lab are that it does not provide real field experience (Rohrig, 1999) and the procurement of specialized equipment implementation is quite expensive (Waldrop, 2013). The implementation of V- lab at PNUP began to be piloted in one of the study programs but still has obstacles in the procurement of mandatory devices that must be provided in large quantities according to the ratio of users (students). This is what underlies an alternative to the implementation of *Remote laboratories* (Remote-Lab) which is very suitable for software-based practicum that has efficiency in financing.

Strengthening the implementation of Remote-Lab in accordance with the Academic Regulation (PA) PNUP 2019 Article 11 concerning Forms of Learning Paragraph 4 that online learning is organized in various forms, methods, and scopes supported by learning facilities and services as well as an assessment system that ensures the quality of graduates in accordance with national standards of higher education. This research aims to analyze Remote-Lab applications based on remote access/desktop as *best practice.* This alternative method of Remote-Lab is useful in direct supervision management and control of computers connected to the network in practicum activities specifically in Code-2 and Code-3 courses. The stability of client and server- based networks available at PNUP spots is needed, where later the client is likened to a practicum student and the server (operator/host) as a supervisor. Remote access/desktop allows users to connect to a machine (computer/desktop) as if they were sitting in front of the machine in question. The steps that have been taken in this activity are to take a sample focus on several Code-3 courses in teaching Odd or Even Semester 2020/2021 in the sample study programs D4 Telecommunication Network Engineering Technology and D3 Telecommunication Engineering PNUP.

II. Literature Review

Learning models and current education policies

The existence of the Covid-19 pandemic resulted in the issuance of Circular Letter No. 4 of 2020 from the Minister of Education and Culture which recommends that all activities in educational institutions must maintain a distance and all material delivery will be delivered at their respective homes. Thus, the education system began to look for innovations for the teaching and learning process. Here are some methods that can be used, namely (Alam, 2020):

a. *Project Based Learning: Project-based learning* has the main objective of training students to be more collaborative, cooperative, and empathetic with others. This system is very effective for students by forming small study groups to work on projects, experiments, and innovations. This learning method is suitable for students who are in the yellow or green zone. By carrying out this kind of learning method, the main thing is of course to pay attention to the applicable health protocols.
b. *Online Method:* This method utilizes online networks, and can make students creative in using existing facilities, such as creating content by utilizing items around the house or doing all learning activities through the online system. This method is very suitable for students who are in the red zone area. By using this *full* online method, the learning system delivered will still take place and all students remain in their respective homes in a safe condition.
c. *Offline Method: The offline method* is a learning model that is carried out outside the network so that the teaching and learning process is carried out face-to-face with due regard to zoning and applicable health protocols. This method is very suitable for students who are in the yellow or green zone areas, especially with strict *new normal* protocols. In this method, students will be taught in *shifts (shift model*) to avoid crowds. This offline learning model was suggested by the Minister of Education and Culture to fulfill curriculum simplification during this pandemic emergency. This method is designed to get around the delivery of the curriculum so that it is not too difficult when delivered to students. addition, this one learning is also considered quite good for those who lack or do not have supporting facilities and infrastructure for online systems.
d. *Home Visit Method: Home visits* are one of the options for learning during this pandemic. This method is similar to the teaching and learning activities delivered during *home schooling*. So, the teacher organizes a *home visit* to the student's home within a certain time. Thus, the material that will be given to students can be conveyed well, because the subject matter and assignments are directly carried out properly under the guidance of the teacher. This method is more suitable for primary and secondary education levels.
e. *Integrated Curriculum:* This method will be more effective when referring to the *project base,* where each class will be given a project that is to the subject. In this method, it does not involve one subject, but also relates learning materials from other subjects. By applying this method, in addition to students who cooperate in working on projects, other lecturers are also given the opportunity to to *team teaching* with teachers in other courses. *Integrated curriculum* can be applied to all students in all regions, because this method will be applied with an online system. So the implementation of this *integrated curriculum* is considered very safe for students.

III. Research Method

The research stages as shown in Figure 5 can be explained in the following description:

3.1 Observation

This activity includes observation and data collection of Code-2 and Code-3 course groups in several PNUP study program samples.

The required data variables are:

- Data on lecturers who teach Code 2 and/or Code 3 courses
- Course (Code 2 and Code-3)
- Competency grade and target
- Existing Jobsheet
- Program applications and practicum methods used

3.2 Data Analysis

This activity involves analyzing the data obtained from the observations.

The required data parameters are:

- Classification results of the percentage of Code 2 and Code 3 courses as a whole
- Appropriateness of competency targets and practicum methods Code-3
- Types of practical teaching methods as needed Existing Jobsheets (*hand-on labs* or V- labs or a combination of both).

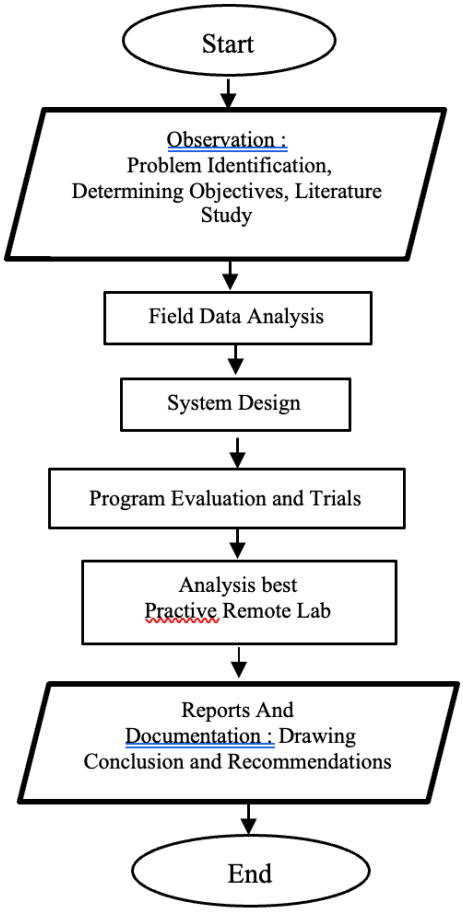

Figure 1. Flowchart of research steps.

3.3 System Design

This activity includes analyzing the design of the control application according to existing data and implementing a Remote-Lab model that is suitable users (lecturers and students).

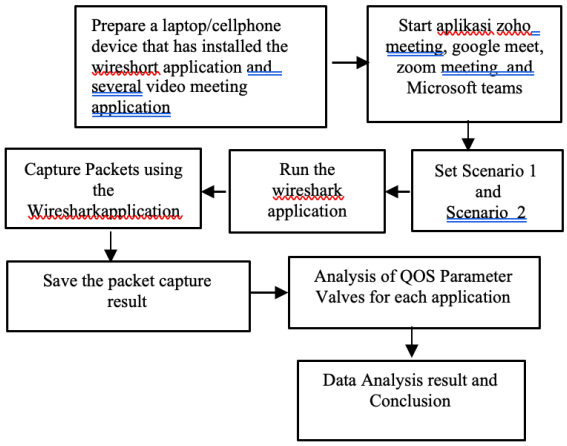

Figure 2. Systematics of System Design

This activity includes *monitoring & anagement network* Remote-Lab model with *live video conference* interaction. Systematic design as in Analysis of the quality of telecommunications networks in *video conferencing* using *wireshark software* where integration will be connected between the host (lecturer) and client (student). Each *client* will *join* using a shared *link* so that virtual meetings can be held with different locations. The test method is carried out on two conditions with different variables. Condition I some variables are not considered or randomly such as the number of participants, camera conditions, and also the microphone conditions of each *client*. Condition II has considered several variables such as the number of class participants for each application, camera and microphone in the *on condition.*

Then continuing the *capture* process on the *wireshark software* used also displays the packets sent during *live* process. *QoS* parameters such as *throughput, packet loss, delay and jitter* will be obtained in the ongoing *live* process.

3.4 Program Evaluation

These activities include modeling online-based teaching and testing all structured specifications and the application as a whole. At this stage, the application is tested and to ensure that the system that has been made already includes the achievement of the learning system. Furthermore, a *best-practice* analysis of the teaching/learning process system (PMB) through Remote Lab is made.

IV. Results and Discussion

4.1. PNUP Code 3 Course Data

PNUP Code 3 Course Data is obtained from the 2017 KKNI Curriculum data reference for PNUP study programs. This study program data is composed of 13 D3 study programs and 12 D4 study programs. The grouping of data as seen in Table 1 below shows the number of Code 3 courses from each D3 study program and Table 2 for PNUP's D4 study programs.

Table 1. Number of MK Code 3 PNUP D3 Study Programs

No.	Name of D3 PNUP Study Program	Number of MK Code-3
1	D3 Civil Construction Engineering	4
2	D3 Energy Conversion Technology	8
3	D3 Accounting	27
4	D3 Chemical Engineering	22
5	D3 Building Construction Engineering	1
6	D3 Business Administration	28
7	D3 Chemical Analysis	28
8	D3 Electrical Engineering	9
9	D3 Automotive Engineering	9
10	D3 Telecommunication Engineering	6
11	D3 Electronics Engineering	10
12	D3 Mechanical Technology	7
13	D3 Heavy Equipment Engineering	6

Table 2. Number of MK Codes 3 of PNUP's D4 Study Programs

No.	Name of PNUP D4 Study Program	Number of MK Code-3
1	D4 Electrical Engineering	12
2	D4 Manufacturing Engineering	17
3	D4 Business Administration	43
4	D4 Energy Generation Engineering	9
5	D4 Construction Management	26
6	D4 Managerial Accounting	35
7	D4 Mechatronics Engineering	16
8	D4 Computer & Network Engineering	26
9	D4 Multimedia & Network Engineering	29
10	D4 Industrial Chemical Technology	28
11	D4 Building Design	1
12	D4 Telecommunication Network Engineering Technology	13

4.2. Remote-Lab MK Telecommunication Network Technology Engineering (422P1860333)

Implementation of Remote Lab in Telecommunication Network Technology Engineering, MK Code 422P1860333, in semester 6 (even). This course consists of 3 credits (1 credit of theory and 2 credits of practice). This course is also related to the Wireless Engineering Telecommunications Practicum (422P1860723) in the same semester.

According to the RPS of the Telecommunication Network Technology Engineering course, this course discusses modern Telecommunication Network Engineering Technology. The basic concept of the discussion is divided into two, namely Fiber Optic cable network engineering and wireless network engineering. Each of these telecommunications network technologies is described in the material of modern telecommunications technology that currently exists and future technology about telecommunications network systems. The purpose of this course is for students to be able to understand and observe the conceptual telecommunications network and be able to analyze network engineering in solving problems in the existing network. In this Remote-Lab trial, class implementation has been carried out in Face-to-Face OFDM Wireless Communication material. Figures 3, 4 and 5 show the process of implementing theory and practicum classes through remote classes with the Anydes application, in addition to using online meeting applications (GMeet and Zoom) in parallel.

Especially in Figure 3 and Figure 4, students can interact directly with remote access to the PC-host which is controlled or monitored by the lecturer directly (live). To facilitate communication and discussion interaction, it is connected in parallel with gMeet (Zoom) or other video conferencing applications. There is no time limit for this remote access as long as the host (lecturer) opens the access door to this application.

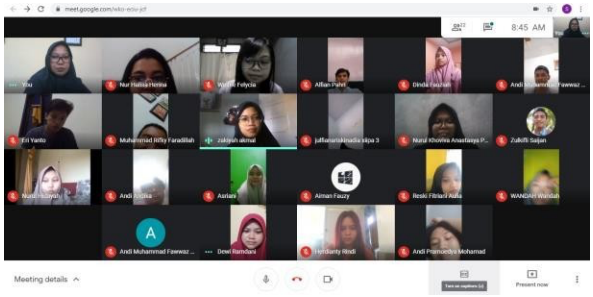

Figure 3. Theory class using GMeet. Class interaction is conducted virtually (video conference).

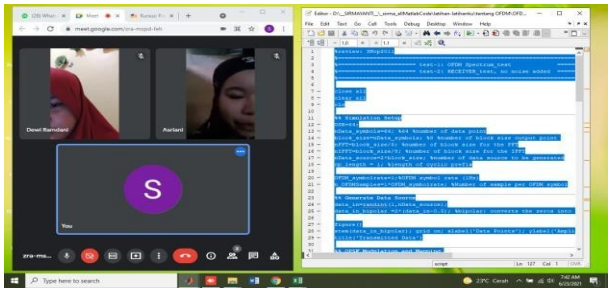

Figure 4. Theory and Practicum classes using Anydesk and GMeet applications in parallel.

Students can access/remote the Matlab software application from the lecturer (host PC) and can do coding exercises directly and monitored properly.

4.3. Remote-Lab MK Practicum Digital Communication System (422P1840822)

The remote-class concept was also tested in the Digital Communication System Practicum course (422P1840822). This activity is also related to the remote-lab-based online module concept. This online module is designed in order to realize a comprehensive digital communication system on the concept of *analog-to-digital* (A/D) and *digital-to-analog* (D/A) conversion theory. The purpose of this online module is so that students can find out about the formation of digital pulse stream levels, namely through a digital modulation system with a relatively fast and reliable bit rate.

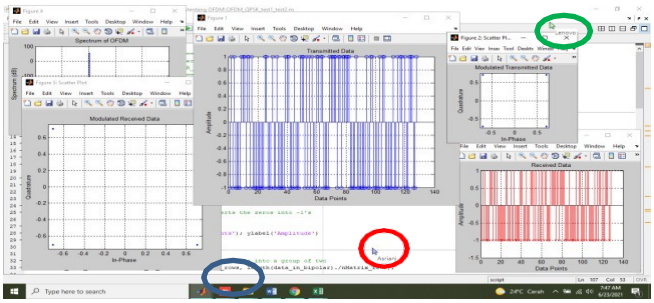

Figure 5. Remote access by 2 students (red and green circles) on the host PC (blue circle) using Matlab application software on the host PC.

The best-practice method carried out is the independent activities of students in conducting practicum following the practicum guidelines provided. One of the skills needed by students is in the implementation of data analysis. Through this tool, students will more easily understand and analyze the basic theory already know through simulation and parameter engineering.

During this time, students only use the old Delta Modulation module equipment and some measurement pins cannot be obtained properly. So that to continue to the material

The changes in the Sigma-Delta Modulation module are also increasingly difficult. With the use of existing software tools, this Online Module is prepared by providing instructional practicum steps that are easily implemented by students. The arrangement of instructional instructions in the Online Module is made with four main steps, namely:

a) Perform Remote-Lab access through direct practicum interaction. The practical concept of Remote Lab is Remote Desktop access through a special program application that functions as a provider of access to computers via the network. In general, Microsoft provides this program to manage Microsoft Windows-based computer management systems that are easily set up in online classes.
b) The combination of online classes through class interaction (live) with the help of online meeting applications such as Zoom and Google Meet. This method is used to facilitate direct interaction between supervisors (lecturers) and students during the remote-lab.

c) Preparation of Online Modules on the job of Delta Modulation and Delta-Sigma Modulation Order 1&2 based on MATLAB. To facilitate students in carrying out their practicum, the module also contains instructions for opening Matlab and how to operate Matlab and the basics of the Matlab operating system.
d) Create sequential practicum procedures to make it easier for students to practice independently, without or with Remote-Lab.

In this trial, the Remote-Lab structure consists of Remote Lab and User Domain as in Figure 8. In the online module content, information on the introduction of Matlab or the software tool to be used is given. Then provide instructional steps in a simple or easy to follow by students independently. In general, the modeling trap that students try is to rewrite the Matlab *coding script* on their work page and observe the cold results according to the instructions on the jobshet (experiment guide).

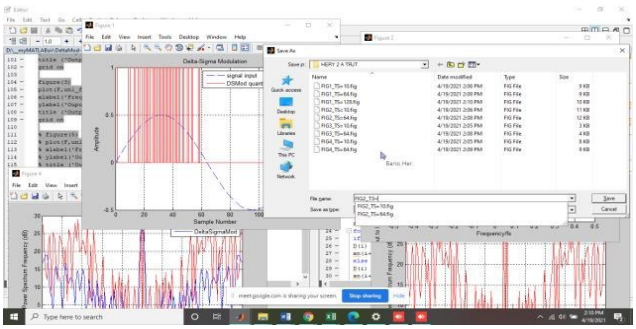

Figure 6. Practical activities of Digital Communication System Practicum with remote-lab.

Figures 6, 7 and 8 show the activities of the practicum implementation of the System Practicum course.

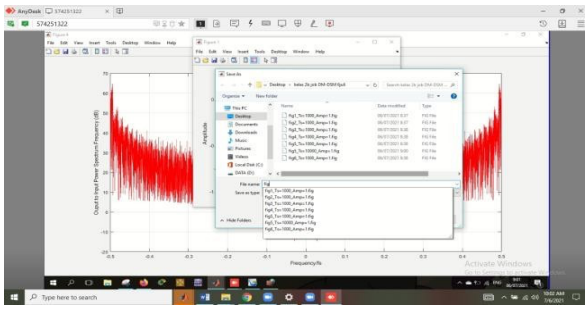

Figure 7. Desktop display of the client (student) when performing remote-lab practicum activities to the host (lecturer).

Digital Communication with Remote-lab method. Figure 13 shows the activity of students (green circle) who are doing remote desk to the host of Matlab software provider. It appears that all student activities are monitored by the lecturer directly.

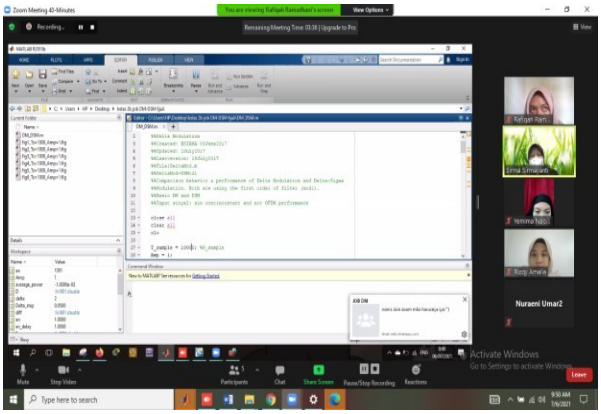

Figure 8. Desktop view of the client (student) in a parallel remote-desk activity with the gmeet application for live class interaction.

Figure 8 shows the activities of students doing practicum. This image captures the desktop client (student) when doing remote-lab practicum activities to the host (lecturer). Client must login and access permission to the host desktop. Thus, if the access permission is approved, all access to the host desktop can be used and use the tools needed. The blue circle is anydesk monitoring on the host and the green circle is anydesk monitoring on the client. Meanwhile, Figure 7 shows the appearance of the desktop on the client (student) in parallel remote-desk activities with the gmeet application for live class interaction. To find out the evaluation of online module testing conducted to students who take the Digital Communication System Practicum course, students are asked to fill out a user satisfaction survey on the online module used.

Questionnaire This questionnaire based on standard questions for using online modules from the PNUP Center for

Development and Quality Assurance of Education (P3MP). Survey results have been carried out on end of class meeting (semester) with results as in Table 3.

Table 3. Results of Online Module Assessment Score

No.	Assessment Aspect	SCORE	Description
1	Aspects of Content Appropriateness	82,91 %	Good
2	Languag e Aspects	87,13 %	Good
3	Expedien cy Aspect	82,19 %	Good
4	Graphic aspect/layout	81,32 %	Good

The first aspect is related to the *suitability of the* module *content* with learning objectives and the availability of practicum explanations. The assessment result obtained is 82.91%. The suitability of the module content with learning objectives and practicum explanations has been carried out well, both presentations in the form of remote-lab and live-class, as well as in the form of text. The second aspect is the *linguistic aspect* in the description and explanation of the practicum that the module or experiment guide provides. The assessment result for this aspect is 87.13%. In this aspect, the assessment is carried out related to the understanding of the writing system and the language used. With the assessment results being **GOOD**, and students argue that the language of delivery for practicum steps can be understood by students. The third aspect is the *Expediency Aspect*. The assessment for this aspect is based on the ease of use of the technology used in the practicum so that it can help students do the practicum independently. This aspect was rated **GOOD** by students with a score of 82.19%. This aspect is also related to the bandwidth and speed of access to the Remote-Lab system for Internet access by both Host (Lab operator) and User (Student). The fourth aspect is the *Graphic / layout aspect*, with an assessment result of 81.32%.

% **GOOD** category. In this aspect, the assessment is carried out on the size and type of font and video used.

Overall, the assessment of the online module for this course is classified as **GOOD** and the online module provided can be used by students in doing the practicum independently and the interactive class is very well organized.

V. Conclusion

The long-distance lecture system, not just theoretical classes, allows it to be carried out well and smoothly with several appropriate teaching methods. This pandemic period does not mean that lectures are stopped because onsite classes are not held to avoid the spread of the virus. Alternative online classes can be carried out both theory and practicum classes. Remote-Lab implementation is an easy and practical solution for implementing computer-based theory and practice classes. Through remote-lab lecturers and students can still interact with each other well using existing desktop access support applications. The convenience felt by students means that this method is easily accepted and learning objectives can still be achieved.

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