REKA ELKOMIKA: Jurnal Pengabdian kepada Masyarakat
ISSN(p): 2723-3235 | ISSN(e): 2723-3243 | Vol. 3 | No. 1 | Pages 20 - 29
DOI: https://doi.org/10.26760/rekaelkomika.v3i1.20-29 Januari 2022

IoT Implementation for Development of Remote Laboratory (Case Study on Microscope Practice)

JAJA KUSTIJA, NOVAL DWI JAYANTO

Departemen Pendidikan Teknik Elektro, Universitas Pendidikan Indonesia,
Email: jaja.kustija@upi.edu

Received 07 December 2021 **|** Revised 09 January 2022 **|** Accepted 09 January 2022

ABSTRACT

During the pandemic situation, laboratories with a limited number of equipment cannot be used to their full capacity to avoid over crowded. Thus, innovation is needed in the design and arrangement of laboratories so that they can be accessed remotely with flexible schedule. However, when the community service team studied cases of teaching and learning practices during the pandemic, problems were found, among others, the imbalance between the number of tools and users, as well as limited practical opportunities in online-based learning. Therefore, in this community service a remote laboratory which could be accessed from where the users were as long as they connected to the internet was designed to provide solution to the problems. The designed remote laboratory utilized the Internet of Things (IoT) to help students do practicum on the topic Microspcope by using a remote desktop employing TeamViewer technique as a tool to access the lab computers with the users' device. As expected, it is proven that remote laboratory can be used to overcome the imbalance between the number of laboratory equipment and laboratory users, and to avoid dangerous crowds during the pandemic as it can be accessed from where the users are located as long as they are connected to the internet.

Keywords: *Internet of Things, microscope practice, remote laboratory*

1. INTRODUCTION

There are many imbalances between the many of tools and users in laboratories, both in high schools and colleges. The covid-19 pandemic requires online-based learning. The use of internet of things technology has entered various sectors of human life, including in the field of education **(Silva, 2021, Ilieva, 2020, Ahmed, 2021)**. Many things from the internet of things can be applied in the world of education to support the learning process, especially practical subjects in the laboratory **(Limpraptono, 2021)**. conditions such as the above encourage the community service team to help solve the problem, one of the objects that is used as a place for community service is the high school labschool UPI in biology subjects, namely microscope reading practicum. Based on the data obtained, the number of microscopes in the service object is 5, while the number of students who will use about 60 people. So a remote practicum system is designed or in the term remote laboratory **(Taj, 2021)** that can be accessed by users at the beginning of its emergence with the internet.

The existence of laboratories in various educational institutions is needed as a means and infrastructure to support the achievement of learning activities, namely practicum **(Orduña, 2020)**. Practical activities are an inseparable part of learning science, especially biology. Practicum is intended to gain a learning experience that allows students to interact directly with learning support tools that can later affect understanding and learning outcomes **(Jaya et al., 2020).** Advances in science and technology have a huge influence on human life **(Lima et al., 2019).** The modern era provides the reality that humans now live in cyberspace so that it requires a thorough renewal, including in the field of education **(Heradio et al., 2016)**. However, in reality, both in terms of quantity and quality, there are learning media such as laboratories that are inappropriate and inadequate so that the laboratory does not fully function as intended **(Viegas et al., 2018)**. This indicates that learning media innovation is needed in the learning process as well as being a demand in the modern era **(Grodotzki et al., 2018)**. Through learning media, the concepts and theories given by educators to students can be understood optimally. Biology subject is one of the subjects that must be taken by students majoring in science **(Debacq et al., 2021)**. This subject aims to explain the principle of observation and experimentation which in its implementation uses a laboratory **(Orduña, 2020, Bisták, 2020)**. For example, in basic biology practicum, students observe plant cells and animal cells using a microscope **(Post et al., 2019)**. Based on observations in various educational institutions, information was obtained that the learning media for biology practicum is still conventional with a limited number of tools such as microscopes which are few compared to the number of students due to the expensive price of the equipment **(Fernández-Pacheco, 2019)**. In addition, time constraints affect the process of practicum in which students try, measure, observe and use tools alternately so that the understanding obtained is not comprehensive. Departing from the problems above, the solution we offer is a remote laboratory as an internet of things-based learning medium **(Yilmaz, 2020).** The internet is one of the media that can help educators and students in the learning process. The use of the Internet of Things in a remote laboratory is a medium for connecting application software to a server that allows access to lab equipment from anywhere and anytime **(Vinothkannan, 2021)**. The Internet of Things system used is a remote desktop with the TeamViewer application. The TeamViewer application can be used to access the server using a PC or mobile phone **(Pratama & Kustija, 2020)**. Students can experiment with laboratories that seem real **(Kustija et al., 2020)**. This learning media is expected to make it easier for students to carry out practicum so that there are no more limitations of tools and can be a learning media solution that follows technological developments to optimize the learning process **(Jayanto & Kustija, 2020)**.

This study aims to design and manufacture practical equipment for using a microscope based on the internet of things.

Various remote lab technologies have previously been created to overcome problems that occur in practical learning during the pandemic. These studies are based on remote desktop, cloud and IoT dashboards **(Indrayana & Sadikin, 2020).** In this study, the application of IoT technology is still focused on the engineering family, such as learning in electrical subjects or courses **(Salikhov, 2021).** Meanwhile, the research that we are doing is trying to create a remote lab system for the practical use of a microscope **(Škraba, 2019).**

2. METHOD

The method used is ADDIE (Analysis, Design, Development, Implementation, Evaluation), the analysis is supported by field data objects that require online laboratory innovation, literature review, the design contains the design of tools needed by laboratory users in

accordance with the object of service, development, implementation includes tools created and use, evaluation. the steps can be described in the flowchart figure number 1.

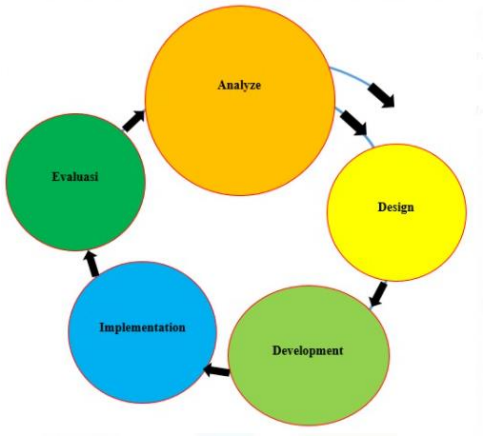


Figure 1. ADDIE Method Flowchart

2.1 Identification of Problem

This research begins by identifying problems, among others, practicum using conventional oscilloscopes, studying IoT architecture and designing Teamviewer software **(Balsamo, 2019)**. Identify the components needed for an IoT system that can interface with an oscilloscope **(Petrova, 2019).**

2.2 Study of Literature

The second step of this process is to conduct a literature study by reviewing several scientific journals that discuss remote labs and the development of the latest learning media so that the tools made can be better **(Silva, 2021).** This step is also the search for a model for the remote lab system that will be made.

2.3 Making Tools

After getting the model needed through literature study, the next step is making tools. The process of making tools is divided into several stages, namely:

1. Hardware design
2. Software design
3. Conection design

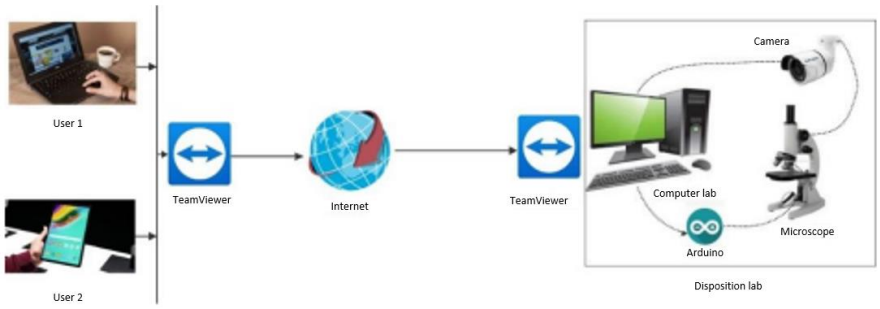
2.4 Experiment and Data Collection

After the tool-making process is complete, it is followed by a trial process to find out whether the system works in accordance with the expected job description, based on the test results data can be used to draw conclusions whether the tools designed and made have met the criteria described or still require improvement.

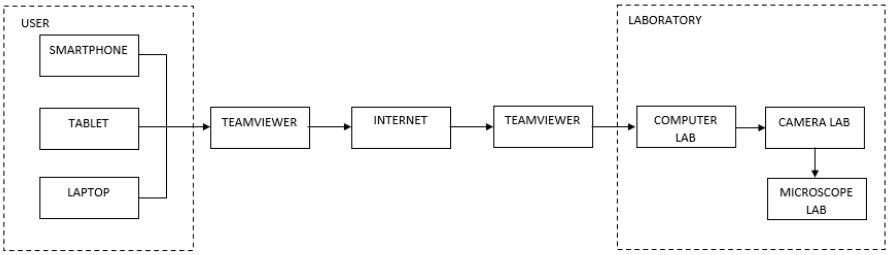
3. RESULTS DAN DISCUSSION

3.1 The Concept of a Remote Laboratory as a Medium for Learning the Use of a Microscope

Remote desktop systems are the basis of the remote laboratory concept. Various techniques for performing remote desktops include Virtual Network Computing (VNC), the default operating system, and TeamViewer **(Jayanto & Kustija, 2020)**. In this tool, we use a remote desktop with the TeamViewer technique as a tool to access the lab computer with the user's device **(Campisano, 2020).** Users can access the microscope from anywhere with an agreed time as long as they are connected to the internet. Besides being able to access the microscope and adjust the lens remotely, users can also view images from the camera provided in the lab **(Kustija et al., 2020)**.



a. Fig System



b. Fig Block Diagram System

Figure 2. a). Fig System b). Fig Block Diagram System

Figure 2 shows system scheme and block diagram. Hardware design begins with determining the connection between the server computer and Arduino. This process uses serial communication between the computer and the Arduino **(Kitishat, 2020)**. Arduino is directly connected to the microscope and camera which will be used for monitoring the practicum process. The second process is software design, in software design TeamViewer software is used as a communication medium between users and the computer lab **(Garcia-Loro, 2019).** This step begins by making settings on TeamViewer, namely setting the user id and password according to the practicum hours **(Jaya, 2013).** The next step is to design the Graphical User Interface (GUI) software on the server computer. The GUI functions as a medium that makes it easier for users to do practicum on the server computer, set the practicum schedule and calculate the practicum time. In addition to being an interface between the server computer and Arduino, the GUI provided can also directly access the remote microscope site. This allows the occurrence of digital observations in the microscope practicum. The third process is internet connection design, in this process a LAN network

connection is used in the lab to the server computer using RJ45. The use of this technique aims to minimize connection disruptions that occur. After connecting to the lab computer which acts as a server, the user can access the microscope which is connected to the lab computer to conduct practical observations and use the camera as a monitoring tool that is practiced **(Efendi & Sartika, 2021)**. Users can see the suitability of the program made by looking at the camera features as a media monitoring tool that is being run **(Jayanto, 2020)**. This tool is also equipped with an organized scheduling system and the settings are located in the graphical user interface (GUI) on the server computer **(Viegas et al., 2018)**.

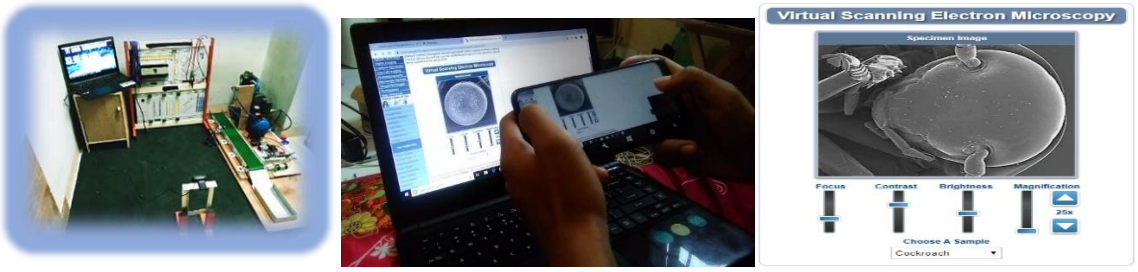


Figure 3. Experiment for Access Remote Lab

Figure 3 shows experiment for access remote lab. Remote laboratories can be applied to practicum using a microscope because the practicum does not require hands-on skills, but only observes objects on a microscope. As described above, the existence of a remote lab can overcome the imbalance in the number of students with the amount of equipment available. This allows for alternate access to lab equipment with a relatively longer time **(Viegas et al., 2018)**.

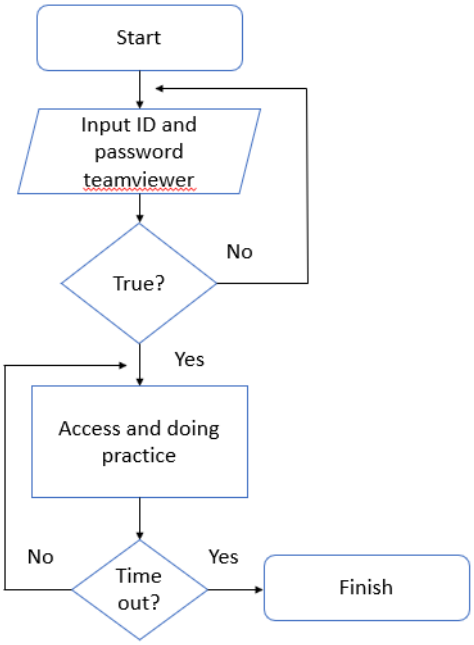


Figure 4. Access Flowchart

The design of the tool begins with making a flowchart as shown in figure 4. Making a flowchart aims to provide an overview of the working principle of the tool **(Stone, 2019)**. The flowchart above covers the start of the practicum process by entering the ID and password on each device. The device in question can be a smartphone, laptop or tablet

(González-Murillo, 2021). After entering the ID and password then proceed with checking the suitability of the ID and password **(Shamrat, 2020)**. If the password and ID match, then you can directly access the lab computer that is already connected to the lab equipment **(Purnomo et al., 2021).** The next process is a practicum according to the specified time, if the practicum time is up, the connection will be disconnected by itself and the practicum is considered complete **(Lima et al., 2019)**.

3.2 Experiment of Remote Laboratory for Microscope Practicum

The eksperiment was carried out on class XII students of SMA Labschool UPI. Currently there are only a few microscopes available, namely 5 (five) units. The microscopes are used alternately during the practicum or only 1 (one) is provided for each group **(Loco, 2019).** This sometimes becomes an obstacle in implementing the practicum because it is ineffective, inefficient and students cannot understand learning activities optimally **(Kam, 2021, Harfouche, 2020).** Therefore, teachers should use the available facilities as much as possible to support practicum activities **(Jayanto, 2020).** The solution to the lack of facilities can be anticipated by developing learning media, namely a remote laboratory based on the Internet of Things in the practice of using a microscope **(Fujii & Koike, 2017).** After testing the tool, then conducted an interview process with several class XII students of SMA Labschool UPI by taking random samples based on the following question indicators:

1. Are the practicum activities in the laboratory in accordance with the procedures?
2. Are the number of microscopes and the number of students in balance?
3. Do you fully understand how tools, especially microscopes work?
4. Is the time allocated for practicum sufficient?
5. Do you agree with the existence of an IoT-based remote lab as a solution to the lack of a microscope?

Based on the participants as many as 62 people who were willing to be interviewed or fill out a questionnaire as many as 33 people, the answers from each respondent stated that the practicum was carried out not according to the procedure, the number of practicum tools available was only a little so that students could not hold the tools for everyone **(Efendi & Sartika, 2021)**. The alternating use system cannot make time effective because there are only 90 minutes available for each meeting, including practicum **(Kustija et al., 2021).** The existence of a remote laboratory is very much needed as the development of learning media. This is influenced by technological developments that facilitate laboratory access and more flexible times **(Post et al., 2019).** Based on the data obtained from the results of trials and interviews with 33 people and 27 of them stated that the remote laboratory can be used as an innovative learning media to overcome existing problems **(Jiyanto & Kustija, 2020)**.

4. CONCLUSION

The dedication team has succeeded in designing a remote laboratory system, the development of a remote laboratory as an Internet of Things (IoT) based learning medium in the use of a microscope is a suitable medium for biology practicum. This can be seen from overcoming the imbalance between 62 students and tools available. Users can access the lab from anywhere with the agreed time. In addition, the implementation of the media was also quite successful considering the responses from several respondents who stated that they were helped by the existence of the media. It is hoped that this media can improve the quality of practice.

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