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Design and Construction of an IoT-Based Smart Laboratory at the Information Technology Study Program Laboratory of the PSDKU Pontianak State Polytechnic in Sukamara Regency

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Abstract. The Software and Networking Laboratory of the Information Technology Study Program at the Off-Campus Program of Politeknik Negeri Pontianak in Sukamara Regency serves as a space for practical work and research for students. However, the safety and security systems in this laboratory are still very minimal, relying only on CCTV cameras. This poses risks to the safety and security of students and laboratory equipment, especially when the laboratory is not directly supervised. This study aims to design an Internet of Things (IoT)-based monitoring system that enables real-time and remote monitoring of the laboratory space by technicians, laboratory heads, and study program coordinators. The system is designed to be accessible via mobile devices and computers. The methodology used consists of eight stages: defining the project's goals and requirements, designing the system architecture, developing the User Experience (UX) interface, and assembling and integrating hardware and software components. The ESP32 microprocessor is used as the main controller, connected to the IoT platform Thingsboard to monitor temperature, humidity, and access conditions in the laboratory. The system is also equipped with automatic notifications in case of emergency situations. The IoT devices have been installed in the software laboratory, networking laboratory, and library, and they function as designed. The result of this research is a prototype of an IoT-based monitoring system ready to be tested to enhance the safety and security of the laboratory environment

Keywords: Internet of Things (IoT); Monitoring; Smart Laboratory; Microprocessor ESP32; Thingsboard, Sukamara

INTRODUCTION

The Software Laboratory and Computer Network Laboratory of the Information Technology Study Program serve as practical rooms for students under the Department of Electrical Engineering Study Program. These facilities are located outside the Main Campus of Pontianak State Polytechnic, in Sukamara Regency. Currently, the laboratories are utilized for conducting teaching and learning activities, supporting educational and teaching efforts as part of the tri dharma of higher education (Direktur Jenderal Sumber Daya IPTEK dan Perguruan Tinggi, 2019). In addition, the laboratory is used to conduct research and provide community service for lecturers and students. Therefore, it is necessary to manage it to function well and optimally through a good management system. (M. Poongothai, Subramanian, & Rajeswari, 2018).

Information Technology Study Program Laboratory Study Programs outside the Main Campus of Pontianak State Polytechnic Pontianak State Polytechnic in Sukamara Regency currently do not have adequate safety features. The laboratory room does not have a tool to detect the status of the door being open or closed and the history of the door status. There is no tool to monitor environmental parameters in the laboratory room such as temperature, humidity, and light intensity. No system automatically sends real-time notifications to the

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head of the laboratory and laboratory assistants when certain conditions occur such as smoke being detected, the door being open or closed outside of working hours, or internet connection disruptions in the laboratory room. In terms of security, the Information Technology Laboratory currently only uses surveillance cameras or Closed Circuit Television (CCTV). The problem that occurs is that in terms of safety, of course, it poses a risk of danger or damage to both someone who is in the laboratory and the equipment in the laboratory building (Firmansyah, Pendidikan, & Madura, 2024).

The purpose of this study is to provide a system based on the Internet of Things (IoT) that can be used to improve safety and security in the Information Technology Laboratory of the Off-Campus Study Program of the Pontianak State Polytechnic in Sukamara Regency. In addition, the system can also be used to detect and provide notifications via mobile devices to technicians and laboratory heads. (Pietraru, Zegrea, & Ionita, 2019) when there is a change in the status of the door in five rooms, namely the door to the dormitory building 1, the door to the software laboratory room, the door to the computer network laboratory room, the door to the library room, and the door to the information technology study program room. The system can provide notification to the head of the laboratory.

The benefits of this research are to assist the head of the laboratory, laboratory assistants, and the head of the Information Technology study program of the Study Program Outside the Main Campus of the Pontianak State Polytechnic in Sukamara Regency in supervising and managing the laboratory. As a means to introduce research products from vocational colleges, especially the Pontianak State Polytechnic to students, the community, and academics in the Polnep campus environment in Sukamara.

Several similar studies are related to the application of Internet of Things (IoT) technology in management and safety systems in laboratories, buildings, and industrial environments. Each study has its own uniqueness but focuses on the use of IoT technology for energy efficiency, security, and early warning purposes in various conditions.

Research by M. Poongothai et al. (2018), in this study, the challenge faced is the difficulty of managing electronic devices in the laboratory of the Coimbatore Institute and Technology (CIT) campus in India. The solution offered involves an IoT system to automatically monitor the use of lights, projectors, and air conditioners, to increase energy efficiency. This system uses hardware such as ESP8266, Arduino UNO, and Raspberry Pi3, while on the software side, Node-RED is used as a dashboard and an Android application as a user interface. This implementation has succeeded in reducing energy consumption by 30% per year.

Research by Radu Nicolae Petraru et al. (2019). This study developed an early warning system for fire hazards using the MQTT protocol with a publish-subscribe mechanism. This system is equipped with several nodes to detect smoke, monitor environmental variables such as temperature and humidity, and sound an alarm. Using ESP8266 and Orange Pi One, as well as software such as HiveMQ and OpenHAB, this study shows that the system provides sufficient time for building occupants to evacuate when danger occurs.

Research by Sunu Dias et al. This study aims to detect hazardous gases in industrial environments using the MQTT communication protocol and MQTT broker on Thingsboard. The gas sensors used are MQ7 and MQ135, which are focused on monitoring gas conditions in industrial environments to detect hazardous gases in real time.

Research by Fitri Wibowo et al., in this study, an IoT system was developed for early warning of smoke or fire inside buildings using hardware such as ESP8266, Arduino UNO, and Raspberry Pi3, as well as Node-RED for the dashboard. This system successfully

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provides real-time information when a fire threat occurs (Wibowo, Suheri, Diponegoro, & Hermanto, 2022).

From several studies, it can be seen that the use of ESP8266 as a microprocessor is a popular choice in the development of IoT devices because it is easily accessible and economical. In terms of software, the MQTT protocol is more widely adopted compared to other protocols because of its ability to efficiently publish-subscribe communication. In addition, Thingsboard has proven to be reliable as an IoT platform for monitoring and managing the data generated.

The tools used in this study are Door Sensor, Set Top Box (STB), Router, Wall Switch, Temperature Monitor, CCTV, and IR Blaster.

1. Door Sensor

A door sensor is an electronic device that detects the status of a door or window, whether open or closed, using magnetic or infrared technology. A magnetic sensor consists of two parts—a magnet and a reed switch—that trigger a detection when the two are separated. In smart home applications, these devices are often integrated with applications such as Smart Life via the ZigBee or Wi-Fi protocol to send notifications directly to the user. These sensors are used for home security by alerting unauthorized access, automation such as sliding door operation, and energy efficiency by controlling electronic devices based on the door status. Some ZigBee models require a gateway for integration into the IoT ecosystem. With low power consumption and easy installation, door sensors are popular for improving security and comfort in homes or commercial environments.

2. Set Top Box (STB)

This tool functions to convert digital signals into images and sound so that they can be displayed on analog television. STB can be used to support digital signal transmission from various broadcast services, such as cable or satellite. In addition to its main function as a signal decoder, STB allows users to access various digital content on TVs that do not yet support digital broadcasts directly. (Ariyani, Sarwandianto, Suaedah, & Fitriansyah, 2023).

3. Router

A router is a networking device that connects two or more computer networks and manages the flow of data between them. In an IoT system, a router allows various IoT devices to communicate and connect to the main network. This router is especially important when the IoT device installation spans separate buildings, as it ensures that data sent from IoT devices can reach the central server or system safely and smoothly.

4. Wall Switch

A wall switch or smart wall switch is a device that can turn on or off electrical appliances such as lights or fans. In IoT, wall switches are often equipped with touch sensors or voice commands and can be integrated into smart home systems. With IoT connectivity, wall switches allow users to control appliances from an app on their smartphone, and can connect to voice assistants such as Google Home or Alexa (Suryono, 2017).

5. Temperature Monitor

Temperature monitors are used to measure, record, and analyze temperature data in a room or specific environment (Naufal, Pratama, Eko, Widagda, & Hadiyanto, 2024). In IoT systems, temperature monitors can be connected to a network and provide real-time data to a central system or user application. This tool is useful for automatically controlling temperatures in laboratories or other sensitive rooms, helping to maintain ideal conditions and protecting equipment or materials that may be affected by extreme temperatures.

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6. CCTV (Closed Circuit Television)

CCTV is a surveillance device consisting of cameras and monitors connected in a closed network. CCTV cameras can record and display real-time video to monitor and secure certain areas from suspicious activity. In an IoT environment, CCTV can be integrated with monitoring applications or security systems that can be accessed remotely, providing the ability to monitor important areas from anywhere.

7. IR (Infrared) Blaster

IR Blaster is a device that allows electronic devices, such as TVs or set-top boxes, to be operated via infrared remote control. In an IoT system, IR Blaster can be connected to the main control platform, so users can control electronic devices that do not have IoT connectivity directly, simply by using IoT applications or voice commands, providing more flexibility in controlling devices at home or in the office. (Ali & Bao, 2021).

METHOD

This research uses a product development methodology that includes software and hardware in a project. The stages of this methodology, the stages carried out include: (1) Determining project objectives; (2) Compiling project requirements based on these objectives; (3) Designing system architecture; (4) Compiling User Experience (UX) flow; (5) Identifying components or stages of development; (6) Assembling hardware and developing code for each stage; (7) Integrating all components or stages; and (8) Conducting trials and troubleshooting (Wibowo et al., 2022). In addition, there is an iterative process that connects UX design with system architecture and testing with code development at certain stages. These research stages can be seen in Figure 1.

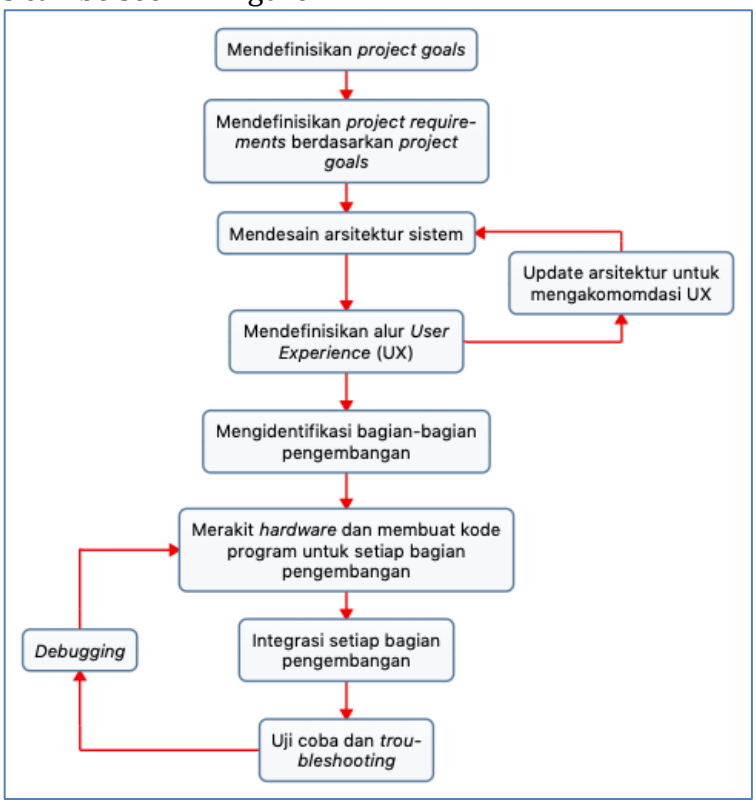

Figure 1: IoT Smart Lab Project Creation Stages

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RESULTS AND DISCUSSION

IoT devices were successfully installed in five locations, namely dormitory building 1, D3 Information Technology Study Program Room PSDKU Polnep Sukamara, Sukamra campus library room, software laboratory room, and computer network laboratory room. The following are the results of the IoT device installation that has been carried out..

1. Dormitory Building 1

In dormitory building 1, there are 3 rooms with IoT devices installed, namely the software laboratory room, library room, and study program room. In this building, there is a main door accent to enter the building. At the entrance, there is a device called the Door Sensor. The device is installed at the entrance of Dormitory Building 1. The function of this sensor is to detect the presence of someone approaching the door. By utilizing interference in the infrared field, the sensor sends a signal to operate the sliding and pulley system that opens the door automatically. The results of installing the Door Sensor device at the entrance of Dormitory 1 can be seen in Figure 2.

Figure 2: Door Sensor Device at the Entrance of Dormitory 1

2. Information Technology Study Program Room PSDKU Polnep Sukamara

The study program room is equipped with a Door Sensor device and a Set Top Box (STB) device.

a. Door Sensor device is installed at the entrance, this device is used to detect open or closed door activity. This sensor is also known as a door contact, which supports security functions and access management. In this case, as security to monitor the condition of the room door in an open or closed state. Devices a and b have magnetic sensors, if the door leaf is open then the sensor and magnet are separated, which triggers a smart alarm or provides notification of the door condition in an open state. The results of installing the Door Sensor are as in Figure 3.

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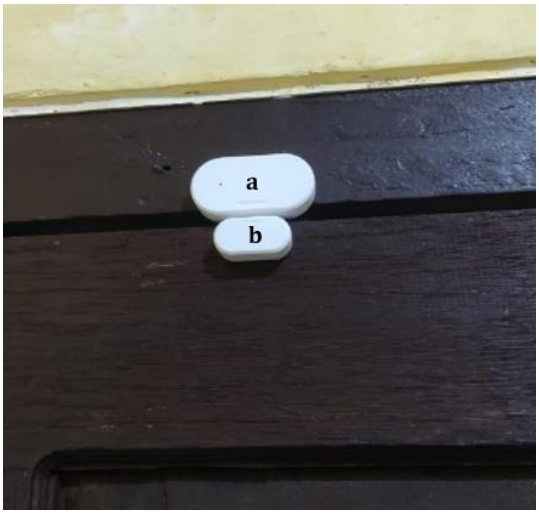

Figure 3: Door Sensor Device on the Study Program Room Door

b. b. Set Top Box (STB) devices are installed in the study program room. The function of this device is to convert digital signals into images and sound so that they can be displayed on analog TV. STB can also be used to strengthen entertainment and information functions. STB makes it easy to monitor the results of installing IoT devices via computer devices or mobile devices so that they can monitor the room where the IoT device is installed. The results of the STB installation can be seen in Figure 4.

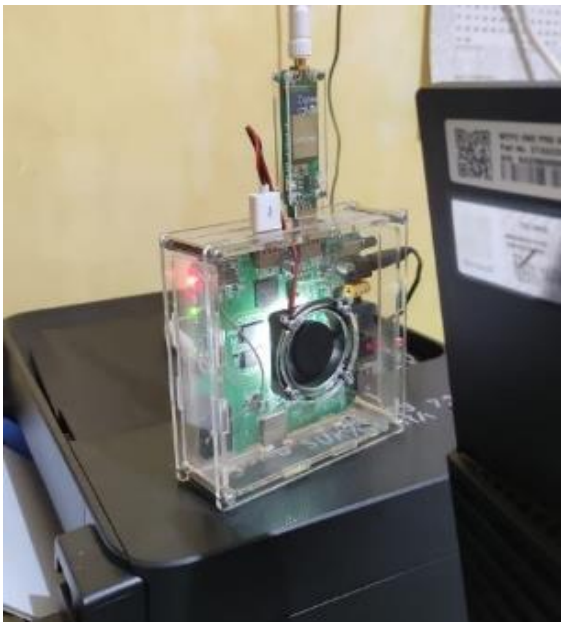

Figure 4: STB Device in the Study Program Room

3. Sukamara Campus Library has a Door Sensor device, Router device and Wall Switch.
   a. Door Sensor device is installed at the entrance to the library room. The function of this device is the same as in other rooms, this device detects the status of the door open or closed for security and efficiency of access. The Door Sensor device in the library room of the Sukamara campus can be seen in Figure 5..

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Figure 5: Door Sensor Device in the Sukamara Campus Library Room

b. Router devices are installed to connect IoT networks between buildings, these routers manage data traffic and support the connectivity of installed IoT devices. The router in this room aims to connect IoT devices located in the dormitory building 1 with the computer network laboratory room located in a different location. The installation of the Router device can be seen in Figure 6.

Gambar 6: Prangkat Router

c. Wall Switch device is installed on the wall as a controller to turn the library room lights on and off. Smart switch function that can be operated by touch or voice command (Gregorius Radithya, Saputri, & Hadi Prasetya, 2023). Its function is to control electronic devices such as lights automatically. The results of installing the Wall Switch device can be seen in Figure 7.

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Figure 7: Wall Switch Device in Library Room

4. The Software Laboratory is located in dormitory building 1 which is equipped with devices such as: Door Sensor, Temperature Monitor, Wall Switch, CCTV, and IR Blaster.

a. The Door Sensor device is displayed at the entrance to support door access detectionand management. So that the condition of the room door can be monitored in an open or closed state. The results of the Door Sensor installation can be seen in Figure 8.

Figure 8: Door Sensor on the Door of the Software Laboratory Room

b. The Temperature Monitor device is installed to control the room temperature in normal or abnormal conditions so that it can be detected if there is an anomaly in the room temperature. The function of this device is to monitor, record, and analyze temperature data in a certain environment to ensure optimal conditions. The results of the Temperature Monitor installation can be seen in Figure 9.

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Figure 9: Temperature Monitoring Device.

c. The Wall Switch device in the software laboratory room functions as a smart switch that can be integrated with other smart systems, supporting control via applications or voice commands. A Wall Switch or smart switch can be integrated with other smart systems (smart home) in the house. With this integration, users can access all devices simultaneously on the same application. The smart wall switch can be turned on or off via the application. This device can also be controlled via voice commands, as long as Google Home and Alexa support it. The Wall Switch device in the software laboratory room can be seen in Figure 10.

Figure 10: Wall Switch Device

d. CCTV devices are installed on one side of the Software Laboratory room. The function of this device is to monitor and record activities in the laboratory, providing visual security through a network of cameras connected to the monitor. The results of the CCTV installation can be seen in Figure 11.

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Figure 11: CCTV Device in the Software Laboratory Room

e. The IR Blaster device is installed in the Software Laboratory room which functions to receive input from the TV remote or other analog devices, controlling devices such as STB and connected televisions. The results of the IP Blaster installation can be seen in Figure 12.

Figure 12: IR Blaster Device in the Software Laboratory Room

5. The Computer Network Laboratory is equipped with three temperature monitoring devices, CCTV, and IR Blaster.

a. Temperature Monitor Device installed in the laboratory room is used to monitor the environmental temperature to maintain system stability and room conditions. The device is installed on one side of the room wall. The installation results are shown in Figure 13.

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Figure 13: Temperature Monitoring Device in the Computer Network Laboratory Room

b. CCTV devices are installed in one corner of the computer network laboratory room with the aim of monitoring and providing security in the laboratory area through remote visual monitoring. The results of the CCTV installation are shown in Figure 14.

Figure 14: CCTV Device in the Computer Network Laboratory Room

c. The IR Blaster device functions to control devices such as STB or connected television, helping to manage devices remotely. The results of installing the IR Blaster device in the Computer Network Laboratory room are shown in Figure 15.

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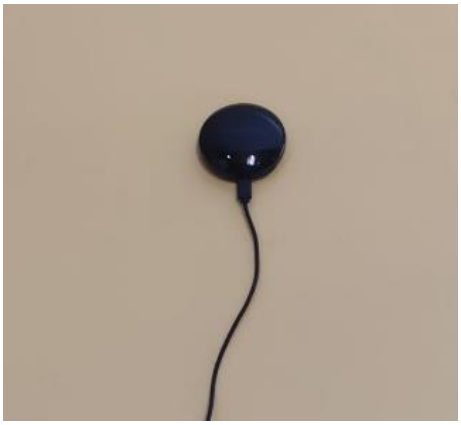

Figure 15: IR Blaster Device in the Computer Network Laboratory Room

The installed IoT devices can be accessed through the smart laboratory monitoring and control dashboard of the D3 Information Technology Study Program Outside the Main Campus of Pontianak State Polytechnic in Sukamara Regency. The display of the smart laboratory monitoring dashboard can be seen in Figure 16.

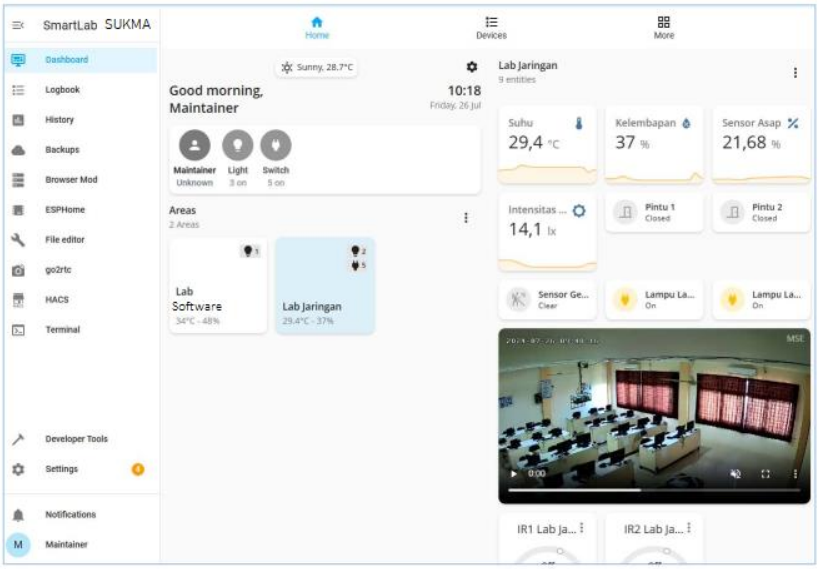

Figure 16: Smart Laboratory Monitoring and Control Dashboard

The test results show that the IoT devices that have been installed in the laboratory room have worked properly. At the time, CCTV can visually show recordings of the room's atmosphere. Other devices such as temperature monitors provide room temperature information and Door sensors successfully send information on the condition of the room in an open or closed state.

CONCLUSION

Based on the results of this research test, it has succeeded in building and implementing an IoT-based security system for the Smart Laboratory in the Information Technology Study Program, Study Program Outside the Main Campus of the Pontianak State Polytechnic in Sukamara Regency. This system can work as a security system such as a door sensor for status monitoring, a temperature sensor for environmental control, and an IR blaster for the integration of old devices. In addition, this system is also able to provide real-

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time notifications for abnormal or dangerous events such as above-normal temperatures and open spaces outside of working hours, ensuring faster responses and operational efficiency. By utilizing the ESP8266 and efficient communication protocols such as MQTT, this study contributes to the implementation of practical IoT in the study program environment, providing students with an overview of implementing IoT in real terms.

Devices such as routers, wall switches, and integrated CCTV can support devices that can be accessed through a comprehensive monitoring dashboard. This dashboard page can help laboratory heads, laboratory assistants, and study program coordinators in carrying out supervision and safety in the laboratory room. The results of the study show that this system can be developed by adding fire sensors and installing CCTV in other rooms such as classrooms, and library rooms. Further research can also use AI-based anomaly detection, and expand the application of this system to other laboratories or campus facilities. In the long term, it can be developed into a smart campus in Sukamara. Further experiments can be studied related to energy efficiency and predictive maintenance will strengthen the utility of IoT in managing laboratories and standards for innovative IoT applications in academic and industrial environments.

REFERENCES

Ali, A.-S. A., & Bao, X. (2021). Design and research of infrared remote control based on ESP8266. *OALib, 8*(4), 1–14. https://doi.org/10.4236/oalib.1107314

Ariyani, L., Sarwandianto, A., Suaedah, S., & Fitriansyah, A. (2023). Penerapan penggunaan set top box TV sebagai perangkat hiburan. *Kapas: Kumpulan Artikel Pengabdian Masyarakat, 2*(1), 8–14. https://doi.org/10.30998/ks.v2i1.1934

Direktur Jenderal Sumber Daya IPTEK dan Perguruan Tinggi. (2019). *Pedoman pemilihan laboran*. Jakarta: Kementerian Riset, Teknologi dan Pendidikan Tinggi.

Firmansyah, I. F., Pendidikan, F. I., & Madura, U. T. (2024). Implementasi sistem RFID RC522 untuk pemantauan inventaris lab komputer. *(September)*, 202–213.

Gregorius Radithya, L., Saputri, F. R., & Hadi Prasetya, I. (2023). Design of an IoT-based automatic switching system using Blynk software. *Journal of Applied Research in Computer Science and Information Systems, 1*(2), 80–85. https://doi.org/10.61098/jarcis.v1i2.59

Poongothai, M., Subramanian, P. M., & Rajeswari, A. (2018). Design and implementation of IoT-based smart laboratory. In *Proceedings of the 5th International Conference on Industrial Engineering and Applications (ICIEA)*, 169–173. Singapore.

Naufal, R., Pratama, W., Eko, M., Widagda, P., & Hadiyanto, H. (2024). Sistem monitoring cerdas ruang kelas berbasis Internet of Things (IoT) dengan menggunakan Flutter.

Pietraru, R. N., Zegrea, L. G., & Ionita, A. D. (2019). Publish-subscribe deployment alternatives for scenarios related to university laboratory safety. In *Proceedings of the 11th International Symposium on Advanced Topics in Electrical Engineering (ATEE)*, 1–6. Bucharest, Romania. https://doi.org/10.1109/ATEE.2019.8724923

Suryono. (2017). Rancang bangun pengontrol lampu listrik menggunakan Android dilengkapi dengan saklar manual. *Orbith, 13*(2), 74–80.

Wibowo, F., Suheri, Diponegoro, M., & Hermanto, B. (2022). Desain dan implementasi smart laboratory berbasis IoT menggunakan ESP32 dan Thingsboard untuk meningkatkan keamanan dan keselamatan di laboratorium teknik informatika POLNEP. *ELIT Journal Electrotechnics and Information Technology, 3*(2), 13–21.