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Development of a Smart Laboratory Iot Trainer Kit Based on Raspberry Pi with The Addition of Fire Sensor, Gas Sensor, and RFID and Monitor Screens in The Telecommunications Lab of The Faculty of Engineering Unesa

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Raspberry Pi
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ABSTRACT (9 pt)

Integrating IoT concepts into education is critical, and the creation of intelligent IoT lab trainers plays a vital role in this process. This paper outlines the creation of a sophisticated laboratory IoT Trainer kit utilizing a Raspberry Pi. The Telecommunications Lab of Surabaya State University's Faculty of Engineering has fire and gas sensors, RFID technology, and monitoring screens. This trainer facilitates remote monitoring and control of network-connected equipment. The Raspberry Pi microcontroller offers automatic tracking and fast response to potential hazards such as fire or gas leaks by combining computer vision-based sensors and gas/fire detectors. This technique uses a research and development (R&D) structure which includes planning, development, evaluation, and improvement stages. Hardware design, sensor integration, power management, and testing processes are crucial. This prototype is an interactive educational tool fostering comprehension of IoT concepts among students and consumers. Integrating with the Telegram Bot API makes it possible to actively monitor and receive real-time notifications, thereby enhancing laboratory security and efficiency. The successful development of this Trainer improves the standard of IoT teaching and practical training in the academic setting.

INTRODUCTION

One of the goals of the Internet of Things (IoT) concept is to enhance the benefits of continuously connected internet connectivity (Melor, 2018). Buildings can use computer networks to remotely control electronic equipment using the Internet of Things (IoT) (Wegner, 2016). We must be able to use, learn, and apply these technological advances daily. The development of technology that can be used is an example. Electronic equipment such as room lights can be accessed through mobile phones with an internet connection (Bassily et al., 2007). Thus, remote control technology will allow users to monitor and control the lights anytime and anywhere by keeping records in locations with adequate internet networks. Internet of Things (IoT) systems make controlling other electronic equipment easy remotely (Kumar et al., 2019). Due to its many benefits, automation systems have become more prevalent in recent times (Gréczi & Berecz, 2019). One of them is a remote controller over the network. The Raspberry Pi is a microcontroller with a Wi-Fi network chip that allows users to communicate with the system over the same or different networks, depending on the user's needs (Joshi et al., 2015). The user can communicate with the system through the web or phone applications, depending on the situation. Researchers use the idea of the Internet of Things (IoT) to make equipment in telecommunications Laboratories into automated systems (Rusimamto, et al., 2021).

They proposed a Raspberry Pi microcontroller to integrate computer vision-based sensors with gas and flame sensors for sensing and surveillance.

For example, it is used as a room detector; fire sprinkler lights and water will self-ignite without human assistance if a fire or gas leaks occur. One of the technologies that can be used to drive ICT is the innovative laboratory, where all physical devices and laboratory components will be integrated and embedded into electronic devices, making them behave like the Internet of Things (IoT) (Gavali et al., 2016). Used to help monitor and manage laboratory and classroom spaces in real-time (Boelens et al., 2017). Intelligent Laboratory Products begins by gathering information to learn more about the product to develop. Monitored conditions and electrical equipment in laboratories controlled by Smart laboratories are examples of intelligent laboratory products. After the information is collected, an analysis of the need to produce the product is carried out (Coskun & Işik, 2009). After that, system planning is required. Design software and hardware are components of this system (Spector et al., 2015). Hardware design includes applying sensors and actuators to the Raspberry Pi microcontroller using the basic rules of the microcontroller (Sugoyono, 2016). Further analysis of data pins is needed to determine whether they are analog or digital, and the process involves the entire design ecosystem. Using an intelligent digital laboratory will allow many things to be monitored and controlled (Arifianto, et al., 2018). These include air conditioning control, light control, door locks, lab door supervision, and room air temperature and humidity. In addition, the working principle of Passive infrared (PIR) sensors can be used to determine whether a laboratory is being used or not (Habibi & Agustini, 2022).

This Smart Laboratory system has many sensors and actuators that can be used depending on the availability of facilities in the Faculty of Engineering Surabaya State University Telecommunications Lab. They physically connect to the Raspberry Pi, but the sensors generate data that observers can trigger to perform certain actions in specific situations. The system has sensors and actuators that measure and operate in real-time. Using Computer Vision technology, the camera module is used as a human presence sensor. The PIR Sensor also detects people, temperature, and humidity with the DHT sensor, and the phone app is used to monitor the data in real-time.

To solve the problem, the system will be connected to the internet via an Android phone. The research entitled The development of Raspberry Pi-based IoT Smart Laboratory Trainer Kit with the addition of fire, gas, and RFID sensors and monitor screens in the Faculty of Engineering Surabaya State University Telecommunications Lab was appointed based on the background presented.

RESEARCH METHOD

This study employs the research and development (R&D) methodology. Research and development (R&D) is a strategic method that prioritizes creating, experimenting, and enhancing novel products, technologies, or innovations to fulfill requirements and attain targeted objectives (Nurseto, 2012).

Planning stage: During this phase, the researcher establishes the study's objectives, identifies the requirements, and defines the scope of the study. It is crucial to arrange the development steps per the study's objectives carefully.

Development stage: The researcher generates a novel product or technology following a predetermined plan during this phase. A prototype or preliminary model is constructed for testing and evaluation during this project phase.

Evaluation stage: Following the creation of the original prototype or model, the new product or technology undergoes testing to identify possible enhancements and modifications. During the improvement stage, the researcher addresses any issues or shortcomings in a new product or technology by making necessary tweaks and enhancements to enhance its quality and performance. This procedure can be iterated until the product or technology achieves the required level of excellence.

Improvement stage: If a new product or technology has deficiencies or problems, the researcher makes improvements and adjustments to improve its quality and performance. This improvement process can be repeated until the product or technology reaches the desired level of perfection.

Implementation stage: occurs following the successful evaluation and improvement of the product or technology. This stage is conducted to implement the study's findings in the appropriate setting or context. The objective of this implementation phase is to conduct a comprehensive evaluation of the product or technology and assess its reception by the environment or users.

Research Flow Chart

The research process that will be carried out is as follows in the flow chart in Figure 1. This stage of the Literature study involves collecting and analyzing literature related to the research topic to understand pre-existing theories and knowledge. The literature study also helps direct research in the right direction and find gaps in knowledge. Literature test, this stage tests and ensuresthat the literature used as a research reference is correct. The researcher verifies the veracity and relevance of the literature used in the study. Software and Hardware design, this stage involves creating a design for the software and hardware components that will be used to construct the system or tool under study. This design encompasses the technical, architectural, and design specifications of the system or tool that will be constructed.

Raspberry Pi, is a developed mini-computer that serves as the control center of the developed system. Different types of sensors used in research are shown here, such as flame sensors, gas sensors, and RFID sensors. Various actuators, such as servos, relays, and motors, drive or control the system. A breadboard is a place to assemble and connect electronic components temporarily. The GPIO Expansion section showcases the development of GPIO (General Purpose Input Output), which allows the Raspberry Pi to communicate with more devices and components. This design provides a visual overview of the layout and integration of components in the acrylic board media used in the study. The purpose of this design is to provide guidance and reference for developing the physical system. After the acrylic media is printed, the next step is to install the components according to the layout arranged on the acrylic board media Design. Where the components are all correctly and orderly assembled according to the planned design. To ensure that the components are connected and set correctly, the components are installed carefully. After the components are installed, the next step is the wiring process. This process connects electronic components to acrylic board media using cables or jumper wires. This process aims for each component to communicate and interact according to a pre-planned system design. This process must be carried out carefully and thoroughly because mistakes can lead to damage.

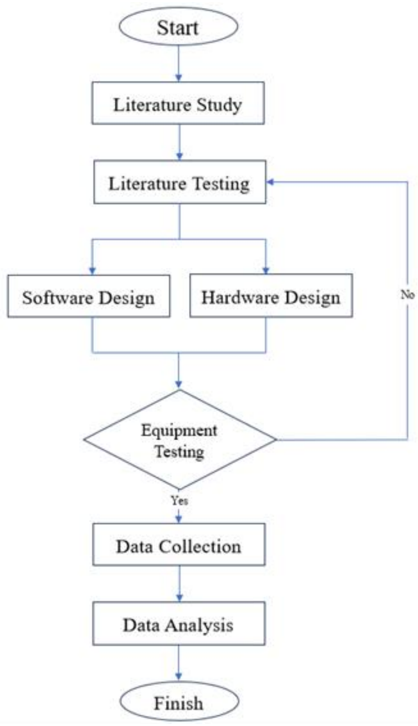

Figure 1. Research Flow Chart.

For the Raspberry Pi model 3B+, the recommended power source is 5V 2.5 A. However, in certain situations, such as when multiple loads require more power, the author uses a power source with 5V 3A. We do this to ensure that the Raspberry Pi has enough power to handle the additional load the other connected components require. In addition, the Raspberry Pi has a cooling fan and heatsink to improve performance and prevent its temperature from being too high when used with high loads. This Trainer uses two types of power—AC power as the main plug and DC power for the Raspberry Pi. AC power is equipped with a switch so that users can adjust the power that goes to the Trainer, and DC power is equipped with a switch that can adjust the power that goes directly to the Raspberry Pi.

All power sensors (VCC and GND) are connected directly to the power during wiring to avoid excessive use of jumper cables during learning. With a direct connection, the wiring

process becomes faster and more orderly, and the problem of unstable connection is minimized. All steps taken to regulate the power supply on this instructor are aimed at ensuring that the Raspberry Pi and other components get enough stable power supply to work correctly and efficiently in any learning or testing. After connecting and setting up the power supply is completed, the next step is to test the tool to ensure that the entire system and components on the instructor are working correctly.
At the equipment testing stage, the system or tool ensures its performance meets expectations and specifications. If there is a problem or discrepancy, the problem will be addressed at the design stage. The tool can be tested in several stages. This includes functionality testing. At this stage, each component is tested individually to ensure the tool works correctly. After components are tested individually, integration testing is performed to ensure that all components can interact with each other and work together in a single system. For example, test how the Raspberry Pi interacts with sensors and actuators and how data from the sensors can be displayed on the LCD monitor screen. After all the tests are completed, the test results should be recorded and analyzed to evaluate the performance of the Internet of Things Smart Laboratory instructor. If a problem or repair is needed, repairs or adjustments are made to ensure the system operates correctly and meets the study's objectives. The data collection stage involves collecting data from testing tools or systems that have been built. The results of tests and observations about the performance of the appliance or system are included in this data collection. Data analysis encompasses qualitative and quantitative methods, helps interpret research results, and draws conclusions.

RESULTS AND DISCUSSION

Raspberry Pi, is a developed mini-computer that serves as the control center of the developed system. Different types of sensors used in research are shown here, such as flame sensors, gas sensors, and RFID sensors. Various actuators, such as servos, relays, and motors, drive or control the system. A breadboard is a place to assemble and connect electronic components temporarily. The GPIO Expansion section showcases the development of GPIO (General Purpose Input Output), which allows the Raspberry Pi to communicate with more devices and components. This design provides a visual overview of the layout and integration of components in the acrylic board media used in the study. The purpose of this design is to provide guidance and reference for developing the physical system. After the acrylic media is printed, the next step is to install the components according to the layout arranged on the acrylic board media Design. Where the components are all correctly and orderly assembled according to the planned design. To ensure that the components are connected and set correctly, the components are installed carefully. After the components are installed, the next step is the wiring process. This process connects electronic components to acrylic board media using cables or jumper wires. This process aims for each component to communicate and interact according to a pre-planned system design. This process must be carried out carefully and thoroughly because mistakes can lead to damage.

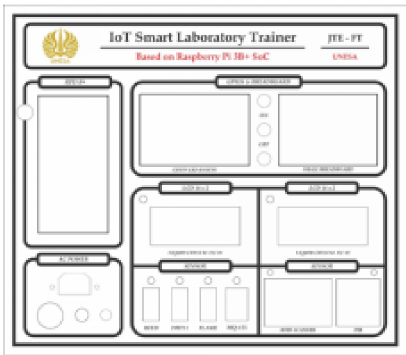

Figure 2. Acrylic Board Design

For the Raspberry Pi model 3B+, the recommended power source is 5V 2.5 A. However, in certain situations, such as when multiple loads require more power, the author uses a power source with 5V 3A. We do this to ensure that the Raspberry Pi has enough power to handle the additional load the other connected components require. In addition, the Raspberry Pi has a cooling fan and heatsink to improve performance and prevent its temperature from being too high when used with high loads. This Trainer uses two types of power—AC power as the main plug and DC power for the Raspberry Pi. AC power is equipped with a switch so that users can adjust the power that goes to the Trainer, and DC power is equipped with a switch that can adjust the power that goes directly to the Raspberry Pi.

Figure 3. Prototype Trainer

All power sensors (VCC and GND) are connected directly to the power during wiring to avoid excessive use of jumper cables during learning. With a direct connection, the wiring process becomes faster and more orderly, and the problem of unstable connection is minimized. All steps taken to regulate the power supply on this instructor are aimed at ensuring that the Raspberry Pi and other components get enough stable power supply to work correctly and efficiently in any learning or testing. After connecting and setting up the power supply is completed, the next step is to test the tool to ensure that the entire system and components on the instructor are working correctly.

At the equipment testing stage, the system or tool ensures its performance meets expectations and specifications. If there is a problem or discrepancy, the problem will be addressed at the design stage. The tool can be tested in several stages. This includes functionality testing. At this stage, each component is tested individually to ensure the tool works correctly. After components are tested individually, integration testing is performed to ensure that all components can interact with each other and work together in a single system. For example, test how the Raspberry Pi interacts with sensors and actuators and how data from the sensors can be displayed on the LCD monitor screen. After all the tests are completed, the test results should be recorded and analyzed to evaluate the performance of the Internet of Things Smart Laboratory instructor. If a problem or repair is needed, repairs or adjustments are made to ensure the system operates correctly and meets the study's objectives. The data collection stage involves collecting data from testing tools or systems that have been built. The results of tests and observations about the performance of the appliance or system are included in this data collection. Data analysis encompasses qualitative and quantitative methods, helps interpret research results, and draws conclusions.

This Trainer method has been used and tested to ensure it works well. These instructors can help students understand basic and advanced concepts about the Internet of Things (IoT) through various application examples and experiments. In addition, the instructor is wrapped in a special suitcase designed to be easy to carry and use. The suitcase is designed to store the instructor safely and neatly. The Smart Laboratory IoT Trainer is small and portable, allowing users to perform IoT learning and experiments in various locations. At the Telecommunications Systems Laboratory of the Surabaya State University, the findings of this study help improve education and understanding of Internet of Things (IoT) technologies. This Trainer can be an effective and interactive learning tool to help students and other users understand and grasp more IoT concepts.

Integration with Telegram Bot API

Figure 4 shows the result of integrating the tool with the Telegram Bot API. Telegram bots provide relevant information from sensors that have been installed, even when they are not on the internet. The Sensor also alerts a group of Telkom lab members if a hazard, such as a gas leak or fire, is detected. In conclusion, by integrating the Telegram Bot with sensor data, Telkom lab members can be monitored and alerted in real-time to quickly respond to dangerous situations remotely. This improves the safety and efficiency of using equipment in the telecommunication laboratory.

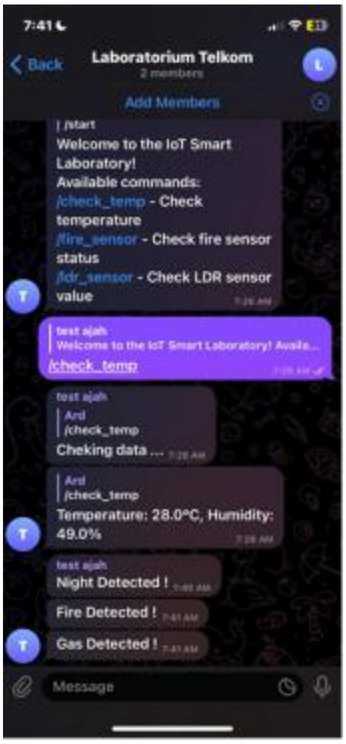

Figure 4. Integration Result of IoT

CONCLUSION

Studies show that developing Raspberry Pi-based Smart IoT laboratory instructors in the Telecommunications Systems Laboratory of the Surabaya State University was successful. The previous Smart Laboratory IoT Trainer, created in 2023, was well-developed and used. Users can learn Internet of Things (IoT) concepts and applications effectively and interactively with these instructors. The test showed that the Trainer system works well and gives the best results. Using a 5V 3A power supply along with a heatsink and cooling fan on the Raspberry Pi helps system stability and prevents overheating when the system works with high loads. Because it is packed in a special suitcase, this Trainer is also easier to use and carry anywhere. This makes it easy for users to explore and learn about IoT in various places.

REFERENCES

Arifianto, H., Adi, K., & Widodo, C. E. (2018). Design of automatic bottle filling using Raspberry Pi. *Jurnal Fisika: Uji Coba dan Aplikasi*, 1(1), 10. https://doi.org/10.14710/jpa.v1i1.3910

Bassily, H., Sekhon, R., Butts, D. E., & Wagner, J. (2007). A mechatronics educational laboratory – Programmable logic controllers and material handling experiments. *Mechatronics*, 17(9), 480–488. https://doi.org/10.1016/j.mechatronics.2007.06.004

Boelens, R., De Wever, B., & Voet, M. (2017). Four key challenges to the design of blended learning: A systematic literature review. *Educational Research Review*, 22, 1–18. https://doi.org/10.1016/j.edurev.2017.06.001

Coskun, I., & Işik, M. F. (2009). Design and application of the technical training set for PLC-based power supply unit developed for industrial applications. *Procedia - Social and Behavioral Sciences*, 1(1), 1658–1662. https://doi.org/10.1016/j.sbspro.2009.01.293

Gavali, A. B., Patil, S. A., & Koli, A. R. (2017). Technology-based learning system in programmable logic controller education. In *Proceedings of the IEEE 8th International Conference on Technology for Education (T4E 2016)* (pp. 264–265). https://doi.org/10.1109/T4E.2016.071

Gréczi, P., & Berecz, A. (2019). Opportunities of Raspberry Pi's use in education. *Journal of Applied Multimedia*, 13(3), 73–79. https://doi.org/10.26648/jam.2018.3.001

Joshi, A., Kale, S., Chandel, S., & Pal, D. (2015). Likert scale: Explored and explained. *British Journal of Applied Science & Technology*, 7(4), 396–403. https://doi.org/10.9734/bjast/2015/14975

Kumar, S., Tiwari, P., & Zymbler, M. (2019). Internet of Things is a revolutionary approach for future technology enhancement: A review. *Journal of Big Data*, 6(1). https://doi.org/10.1186/s40537-019-0268-2

Melor Md Yunus. (2018). Digital platforms, online corpora, mobile learning and BYOD (bring your own device), online CPD (continuous professional development) and the global staffroom. *2(1)*, 33–34.

Nurseto, T. (2012). Membuat media pembelajaran yang menarik. *Jurnal Ekonomi dan Pendidikan*, 8(1), 19–35. https://doi.org/10.21831/jep.v8i1.706

Rusimamto, P. W., Wijayanto, E., & Fadhilah, D. M. (2021). Fluid mixing process based on programmable logic controller as training kit for electrical engineering education students. *International Journal of Integrated Engineering*, 13(4), 104–111. https://doi.org/10.30880/ijie.2021.13.04.009

Spector, J. M., Merrill, M. D., Elen, J., & Bishop, M. J. (2014). *Handbook of research on educational communications and technology: Fourth edition* (4th ed.). Springer. https://doi.org/10.1007/978-1-4614-3185-5

Sugyono. (2016). *Metode penelitian kuantitatif, kualitatif, dan R&D* (1st ed.). Alfabeta.

Wagner, J. (2016). Meet the Raspberry Pi. In *Raspberry Pi® User Guide* (pp. 11–22).

Yunus, M. M. (2018). Digital platforms, online corpora, mobile learning, and BYOD (bring your own device), online CPD (continuous professional development), and the global staffroom. *Journal of Digital Learning and Education*, 2(1), 33–34.