An affordable Internet of Things Training Kit for practical work of industrial automation

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Abstract. The need for practical equipment in the vocational high school (VHS) program is necessary. However, due to some difficulties such as the pricey of available training kit in the market caused that most student could not get appropriate practical work equipment. One of the important facilities is a training kit that encouraged the student to learn the Internet of Things. This study describes the design of the Internet of Thing Training Kit based on ESP-32 (IoTTK32). A set of IoT training module has been designed. Through research and development approach, the researcher has constructed a low-cost IoT trainer that can be used in industrial practical work. The results of the examination show that produced IoT kit could be used in formal practical work of industrial automation related to the industrial 4.0 evolution.

1. Introduction

In the industrial 4.0 and the digitalization era, the understanding of microcontrollers and Internet of Things (IoT) by teachers and students needs to be improved both in terms of knowledge, attitudes, or skills. In the curriculum, microcontroller material was studied at the University, Polytechnic [1], course center [2], and vocational high school (VHS), especially in the electrical engineering education field. Microcontroller and IoT applications are very broad in all fields of knowledge and technology or engineering [3]. IoT is applied in various application that is; the intelligent lighting systems on highways [4], the distribution of milk efficiently [5], the cleanliness of air around the campus [6], environmental conditions in the home intelligently [7], regulate the library system intelligently [8], distribution of systems sound classification presented by the appearance of clouds in the sky [9], irrigation systems of plants that grow indoors [10], intelligent traffic system monitoring [11], etc.

Mastering science and technology require qualified human resources to anticipate the misuse of science and technology in human life. One of the concepts of science and technology-based research is IoT. It could not be denied that by using the internet, all the activities become easier, and it is bridging between the physical world with the world of information. Some explanations regarding the development of science and technology in the field of IoT nowadays, it can be concluded that with the advancement of science and technology will require human resources who are experts in certain fields so that some industries or developments that will be done by the government need a relationship between human resources and employment, then a vocational education like VHS needs to do competence development so it can balance the needs of government. Efforts to improve competence in VHS is by improving the learning aspects with facilities and infrastructure that support the improvement of VHS.
students’ competence, by providing learning media in accordance with the needs and developments of science and technology, especially in the field of IoT research.

One of the previous studies on IoT using sensors and actuators is the development of learning media in the form of trainer’s actuator sensor kits to improve the learning outcomes of VHS students. The result of this study is to develop a sensor and actuator trainer kit that can detect changes in physical and chemical environments, as well as actuators that work according to instructions.

Based on the survey results of the researcher with teachers of mechatronics engineering skill program in several VHS, that the application of media trainer of IoT currently is not widely used, due to IoT technology is new. Looking at many advantages and potentials of the application of IoT technology research is in a form of learning trainer, the researcher takes the initiative to make one of learning media resources in the design of learning trainer module IoT with a prototype using ESP32 which is expected to provide changes for students in understanding and utilizing computers and microcontrollers in a wider application. Based on the explanation above, the research was designed and develop An Affordable Internet of Things Training Kit for Practical Work of Industrial Automation.

2. Literature review
Vocational education is part of an educational system that prepares a person to be better able to work in a single group of occupation or one occupation than any other field of work. Based on the explanation of Indonesian law, vocational education is a secondary education that prepares students to work in a particular field. VHS students’ competency standards have a purpose of filling the needs of personnel in the industrial world; automatic learning is tailored to the needs of the industry so that the delivery of learning materials should be delivered by the development of the world of industry, also accompanied by media that support the learning. Media in VHS education are not only textual media such as learning modules but also must be equipped with practicum tools in the form of learning trainers, toolkits for each student, machine tools, chemicals, computers, the internet, etc. appropriate to the area of the expertise in VHS. Educational media in the form of trainers for electronics skill programs, especially industrial automation, is designed and made to learn practicum and learn in the classroom, such as the practice of a series of control systems. At the time of the practicum, educational media in the form of job sheets and learning modules are needed to facilitate the operation of microcontroller-based hardware and software. Also, educational media in the form of electrical and mechanical measuring instruments are required for basic skills training practice. However, some supporting software such as Electronic Work Bench (EWB), Eagle, Proteus, etc., for microcontroller-based learning simulators as well as drawing electronics circuits are also necessary to support VHS education program.

3. Hardware design
The IoTTK32 is designed to provide flexible IoT training kit. The IoTTK32 utilized the powerful of ESP-32 with some additional components. The description of IoTTK32 is as follows.

- **Power Supply**, which is the part that provides power for the entire system with a voltage of 5 V. It can use as an adapter from AC to DC voltage using 6 Vdc battery.
- **Processor**, the processor part is used ESP32 MCU. Which is the brain of the system functions to process data from input or as output? Equipped with a Wi-Fi network with a frequency of 2.4 GHz, the distance data transfer is around 165.47 meters. The processor has 15 general purpose input-output (GPIO) that are 15 channels of analog to digital converter (ADC).
- **Input devices**, which are an input of switch, potentiometer, a sensor for a various parameter such as temperature, distance, light intensity, biometric, etc.
- **Output devices**, which are light emitting diode (LED), RGB, liquid crystal display (LCD) of text and graphic, DC motor, servo motor, and Relay.
- **Communication**, it consists of a communication module of Lora, NRF-241, and RS-232.
The ESP 32 MCU node was chosen as a processor with complete consideration of its features compared to ESP 8266. The MCU equipped with a Wi-Fi network with a frequency of 2.4 GHz. It can be used to transfer data at a distance of around 165.47 meters. The ESP-32 is equipped with Bluetooth low energy (BLE) 4.0. By using the concept of very low power devices, ESP-32 could connect to other Bluetooth devices without pairing. The PCB design of IoTTK32 is shown in Figure 1. It designed using EasyEDA, which is online software for schematic and printed circuit board (PCB).

Figure 1. PCB design of IoTTK32.

ESP-32 is connected with several micro switches to regulate connections with other components when the component is connected (addressed) by ESP-32. ESP 32 pin connection with other components that are by its function. The blink led is connected with pin 33, and light dependent resistor (LDR) is connected to pin 27. The infra-red receiver is connected to pin 17; the push button is connected to pin 15. However, the other pin is connected according to its function.

4. IoTTK32 evaluation
IoTTK32 final device is shown in Figure 2. IoTTK32 equipped with several inputs and outputs as a modular interface that could be connected with regard to practical work theme. However, all of the IoTTK32 testing’s was done through transfer the data into the cloud system provided by three partite cloud provider called Antares. Antares is an IoT cloud platform that can store the IoT data in the cloud. Antares support several protocols such as Hypertext Transfer Protocol (HTTP), Message Queuing Telemetry Transport (MQTT), and The Constrained Application Protocol (CoAP). HTTP underlying protocol used by the World Wide Web. The protocol defines how messages are formatted and transmitted, whereas MQTT is a lightweight messaging protocol for small sensors and mobile devices, optimized for high-latency or unreliable networks. This protocol is very suitable for remote locations and limited bandwidth. Like MQTT, CoAP is specifically intended for exchanges between nodes that have limited resources and networks. The following explanation is examples of IoTTK32 implementation in Antares.
This is to show the results of testing the Internet of Thing (IoT) application with a random Dummy, Potentiometer, and LDR via Antares website. The first step is to create programs using the Antares library. The Antares library requires an access key obtained from the Antares account. In addition to the access key, the Wi-Fi SSID and password are needed to connect to the internet. To enter data into Antares, it requires data name and data value. In this experiment, the data value is in the form of random dummy data from 50 to 100. In the serial terminal, when the program is uploaded into ESP-32, there is a status value that is uploaded to Antares, as shown in Figure 3. On the Antares website, the data entered is based on the upload time. The incoming data can be displayed with a graph using a widget found in Antares to see the value changes that occur in ESP-32.

5. Conclusion and future work
Based on hardware design, software, input-output testing, and remote testing experiments using IoTTK32, the device is working properly to support the practical work in industrial automation. It satisfied the design specification that users could use IoTTK32 as a learning platform for supporting the
Industrial era 4.0. However, the development of IoTTK32 should be continued to expand its ability. Hence, in the future work, IoTTK32 will be equipped by wireless transmission such as LoRa (Long Range). LoRa is a spread spectrum modulation technique derived from chirp spread spectrum (CSS). With LoRa, data from IoTTK32 could be transferred into long distance using low power transmission devices.

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