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Making the Internet of Things Trainer Based on ESP-32 Microcontroller

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ABSTRACT

The absence of teaching aids is still an obstacle in the learning process of Internet of Things (IoT)-based interfacing subjects where students have difficulty understanding the material obtained other than because of the lack of microcontroller practice experience that makes students less understanding how to operate a microcontroller and also because of a lack of basic knowledge about IoT. The design of the ESP-32 microcontroller-based IoT interface trainer is intended as a teaching aid to help understand the interfacing of microcontrollers using several protocols and can be used as an Internet of Things teaching aid to help students practice monitoring and controlling input-output on a microcontroller using a smartphone via the internet network. In designing this trainer, direct observations were made on learning activities for IoT and interfacing subjects as well as conducting questions and answers with several students. This trainer uses RFID, RTC and LCD modules as interfacing teaching aids that are connected to the ESP-32 microcontroller, and there are components in the form of LEDs and potentiometers to practice the concept of the Internet of Things. Pin headers for microcontroller interface pin expansion are also available on this trainer which can be connected to more modules and other components. The modules and components in this trainer design are connected to the ESP32 microcontroller in one integrated circuit board so as to provide practicality in using it.

Keywords: Modul trainer, IoT, ESP-32, microcontroller

Introduction

The Industrial Revolution 4.0 is a phenomenon of rapid change, where the industrial world is now starting to move towards automation assisted by information technology to pursue effectiveness and efficiency. This will affect the map of labor needs in Indonesia, where in the future many Indonesian workers are required to master special skills, especially new skills, such as (Rezky et al., 2019; Supandi et al., 2019):

- media, technology, and information skills (media literacy, visual literacy, multicultural literacy, global awareness, and technological literacy)
- abilities to learn and innovate (creativity and curiosity, problem-solving, and taking risks)
- skills in life and career (having a leadership spirit, having high responsibility, having ethical and moral values, being able to adapt, socially and cross-culturally, being able to take initiative and being able to direct oneself)

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- effective communication skills (capable of working in a team and collaborating, having personal and social responsibility, able to communicate interactively, and having national and global orientation).

The unpreparedness of a country to face the Industrial Revolution 4.0 will result in the country having the potential to experience an increase in the unemployment rate(Rozaki et al., 2019). According to the predictions of Wicaksana et al. (2020), generation Y or millennial generation will dominate 46% of the world of work in Indonesia and by 2045 it is estimated that Indonesia will benefit from a demographic bonus, in which 70% of the population will be of productive age. Although it has enormous potential, it should be underlined that preparing Generation Y and Generation Z for the workforce in the future is not an easy challenge. Generation Y or millennials, for example, are a technology literate generation, skilled in multitasking but lacking ineffective communication and skills in life and career (Rezky et al., 2019; Velasco & de Chavez, 2018) As for Generation Z, according to Talmon (2019), in the future, they will tend to be more creative individuals than Generation Y but will have difficulty digesting material in the form of thick and long texts such as textbooks.

To overcome all the challenges of Industrial Revolution 4.0, digital technology should be utilized in the learning process. Indonesia's response to the Industrial Revolution 4.0 itself can be said to be late when compared to neighboring countries such as Malaysia and Singapore (Supandi et al., 2019). So, the competence of teachers and lecturers as educators who educate them needs to be improved. This competency improvement can be in the form of education and training (Rezky et al., 2019). Most of the educators in Indonesia have not mastered digital technology, therefore their adaptation process to use digital technology does take time (Nasititi & Ni'mal 'Abdu, 2020; Saefulmilah & Saway, 2020).

Vocational High School (SMK) as one of the educational institutions that are expected to produce graduates who are ready to work, of course, faces more severe pressure. The demands for high graduate competence are sometimes not proportional to the ability of educators or the learning motivation of their students. One effort to accelerate the adaptation of educators and students to Industrial Revolution 4.0 is to conduct a workshop. Because in the workshop both educators and students can practice freely. The workshop also allows participants to consult their difficulties with the presenters. This kind of workshop was also held by Sasmito et al. (2020) on SMK Bina Nusa Slawi and Hirzan et al. (2021) on SMK Walisongo Semarang and they successfully bring new insight into new technology to those two vocational schools, especially on the Internet of Things (IoT).

On this community service, our partner is SMK Negeri 1 Dlanggu, Mojokerto Regency. Like another vocational school in Indonesia's rural area, SMK Negeri 1 Dlanggu had common problems in their education process such as:

- Lack of variety of material taught in the Computer and Network Engineering (TKJ) major because almost all schools provide the same learnings about computer networks.
- Lack of knowledge in the internet of things (IoT) technology makes teaching and learning activities sometimes cannot keeping up with global scientific developments.
- The monotonous learning process, thus making students less creative in accepting knowledge, especially about IoT.

Material and Methods

Training module

The training module for this community service will be using ESP32 Microcontroller Module. The ESP32 Microcontroller module is a board used to develop Internet of Things applications. This module consists of a 32-bit LX6 Tensilica Xtensa® Dual-Core microprocessor. This processor is similar to the ESP8266 but has two CPU cores (individually controllable), operating at a clock frequency of 80 to 240 MHz which can be maximized to 600 DMIPS (Dhrystone Million

Instructions Per Second). And it also consists of 448 KB ROM, 520 KB SRAM and 4MB Flash memory (for program and data storage) which is enough to handle the large strings that makeup web pages, JSON/XML data, and everything else that will be uploaded on today's IoT devices, as in Figure 1.

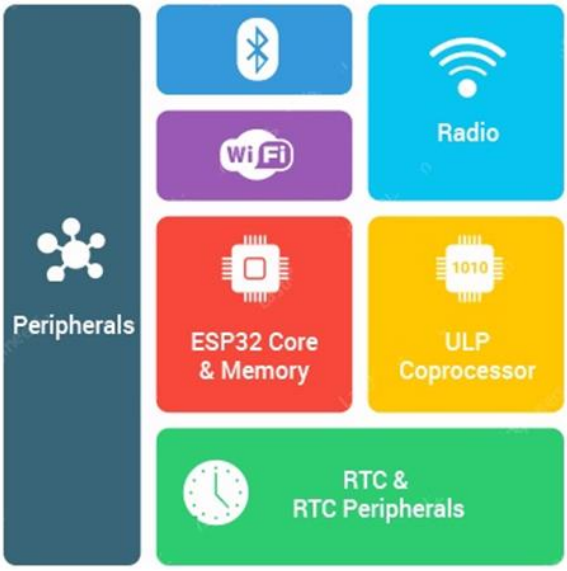

Figure 1. ESP32 internal block diagram

The HT40 802.11b/g/n Wi-Fi transceiver is included in the ESP32, allowing it to not only connect to a WiFi network and communicate with the Internet but also to create its network, allowing other devices to connect directly to the ESP32. In addition, the ESP32 also supports WiFi Direct, which is quite decent for a peer-to-peer connection option that does not require an access point. WiFi Direct is easy to set up and has a considerably faster data transmission rate than Bluetooth. The chip likewise has double mode Bluetooth capacity, which implies it upholds both Bluetooth 4.0 (BLE/Bluetooth Smart) and Bluetooth Classic (BT), making it significantly more adaptable.

Since the working voltage scope of the ESP32 is 2.2V to 3.6V, the ESP32 board is furnished with an LDO voltage controller to keep the voltage stable at 3.3V, it can supply up to 600mA, which ought to be a sizable amount when the ESP32 needs as much as 250mA of current during RF transmission. The yield from the controller has likewise parted aside from the ESP32 board and is marked as 3V3 (3.3-volt handle). These pins can be utilized to supply capacity to outside components, as displayed in Figure 2.

Power to the ESP32 board is provided using the implicit Micro-USB connector. On the other hand, on the off chance that you have a managed 5V voltage source, the VIN pin can be utilized to supply the ESP32 and its peripherals straightforwardly. The ESP32 requires a 3.3V force supply and a 3.3V rationale level for correspondence. The GPIO pins are not 5V safe. Assuming you need to associate a board with 5V (or higher) components it will be important to do some level shifting. Peripheral Input/Output of ESP32 has an aggregate of 48 GPIO pins, just 25 of which show up as nail headers to one or the other side of the improvement board. These pins can be utilized for a wide range of fringe errands, including:

- 15 ADC channels - 15 12-bit SAR ADC channels. The ADC reach can be set, in the firmware, to 0-1V, 0-1.4V, 0-2V, or 0-4V.
- 2 UART interfaces - 2 UART interfaces. One is utilized for sequentially transferring code and stream control shows and supports IrDA too.
- 25 PWM Outputs - 25 channel PWM pins for darkening LEDs or controlling engines.

- 2 channel DAC - 8-bit DAC for genuine simple voltage yield.
- SPI, I2C and I2S interfaces - There are 3 SPI interfaces and one I2C for associating a wide range of sensors and peripherals, in addition to two I2S interfaces assuming you need to add voice input.
- 9 TouchPad - 9 GPIOs are outfitted with capacitive touch sensors.

Training program

The workshop was held on July 9, 2021, and was carried out in an online scheme via Zoom and Youtube because at that time it was still in the Java-Bali PPKM period. The workshop consists of several sessions. The sessions flow of the material presented can be seen in Figure 3.

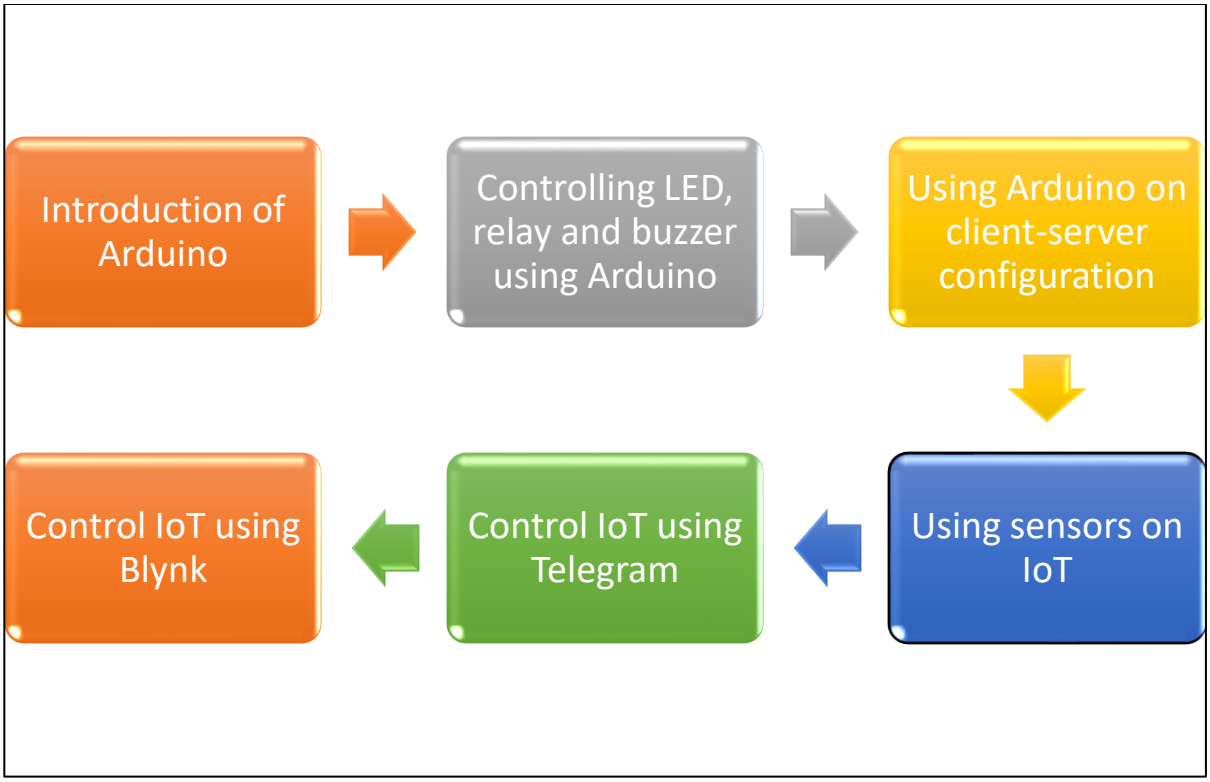

Figure 3. The flow of teaching materials in the workshop

The details of each session are as follows:

- Introduction of Arduino: in this session, we will give a brief introduction to the Arduino ESP32 board. It also explains how to connect the ESP32 board to a WiFi network.
- Controlling LED, relay and buzzer using Arduino: this session will practice how we control the LED lights, starting from one, then increasing to eight. In the last experiment, the control of the LED, relay, and buzzer was tested to demonstrate the Arduino's ability to control more than one output.
- Using Arduino on client-server configuration: this session will demonstrate how the Arduino board will function as a server. On the board, we installed an OLED panel to see its server log.
- Using sensors on IoT: this session is a session where the presenter demonstrates how to use ultrasonic sensors to measure distance and monitor temperature and humidity with the DHT11 sensor. The software used in this demonstration is Thingspeak, a tool to display sensor measurement results on a web page.
- Control IoT using Telegram: in this session we will demonstrate how Telegram can be used as a tool to control IoT from a smartphone. The Arduino ability demonstrated in this session is controlling LED lights.

- Control IoT using Blynk: This session will demonstrate the operation of servomotors and DC-motors using an ESP32 board assisted by the Android-based Blynk application.

Results and Discussion

The workshop is being held on 9th July 2021 via online meetings because of COVID-19 Pandemics. This activity can be watched again on the YouTube channel at the link https://youtu.be/OHcrzFCWFLY. This decision was taken because at that time the Java-Bali Emergency PPKM – to suppress the Covid-19 pandemic – was still in effect. The presentation of the material was carried out by the Head of the team, I Gede Susrama Mas Diyasa, assisted by 2 members of the team, namely Trimono from UPN Veteran Jawa Timur and Slamet Winardi from Narotama University. Participants from SMK Negeri 1 Dlanggu consist of students and teachers from the Department of Computer and Network Engineering (TKJ). This activity lasted for approximately 2 hours and all the material that was planned to be presented had been conveyed well.

Participants will practice with the support of an ESP-32 Microcontroller-Based IoT Learning Module whose cover can be seen in Figure 4 and an IoT Trainer with ESP32 as shown in Figure 5.

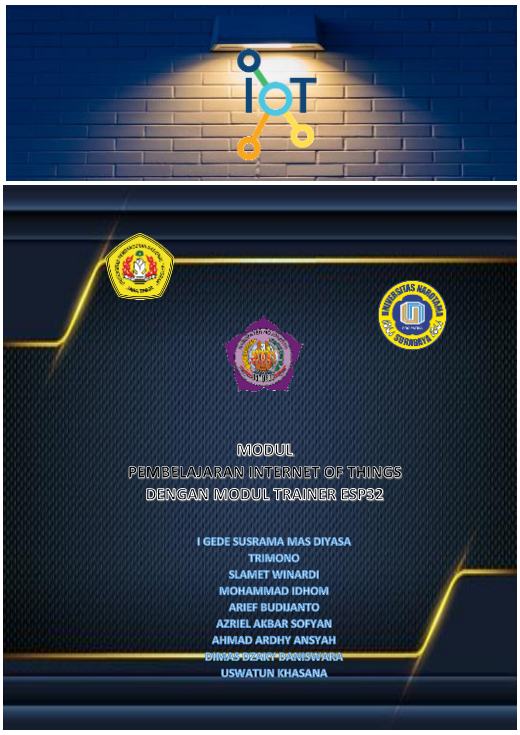

Figure 4. Cover of ESP-32 Microcontroller Based IoT Learning Module

The materials provided are in the form of hardware, software, and internet networks, hardware consists of sensors and actuators (Proximity Sensors, Temperature and humidity, potentiometers, pushbuttons, actuators in the form of LEDs, buzzers, OLED displays, relays, servo motors, and DC motors). The software used is Arduino IDE with ESP32 Board to implement IoT devices with HTTP protocol, website platform with *Thingspeak*, IoT Socia-media with *Telegram* application, and Android application, namely *Blynk*. While the internet network through access points to connect IoT devices in the workshop to the Internet so that the devices can be accessed from anywhere.

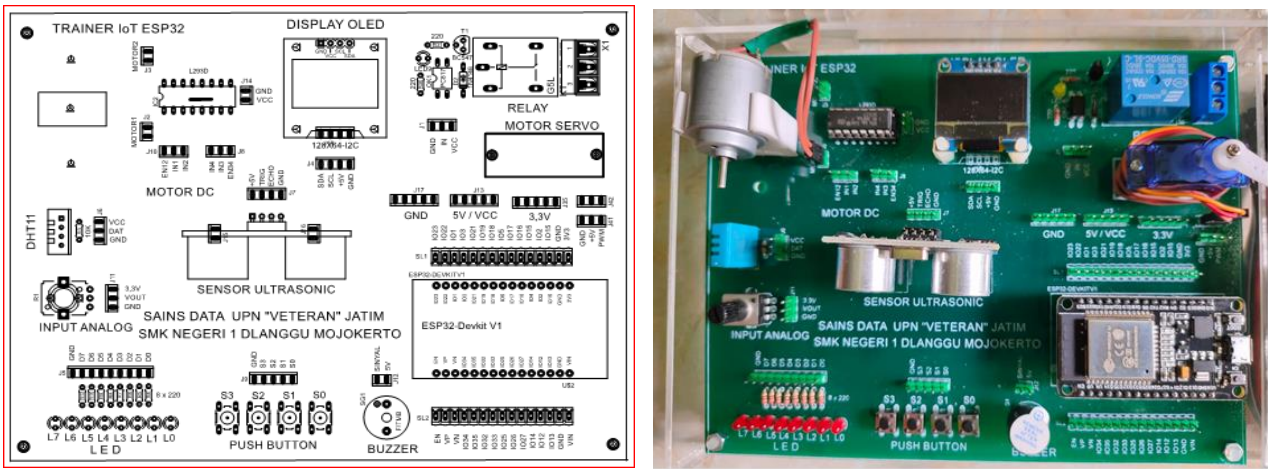

Figure 5. IoT Trainer Products with ESP32

The device that is being demonstrated in this workshop is still using the IP address version 4, with a total length of 32 bits so that 4 billion hosts can be addressed (to be precise, 4,294,967,296). However, in the era of 5G technology, there will be a massive installation of IoT devices so that the IP address that uses version 4 is no longer sufficient, it will switch to IPv6 with a bit length of 128, so the address used to connect the host becomes 3.4 x 10^36 addresses. Unique IPs. Preparing a generation of vocational students to be proficient in operating IoT is very urgent and this workshop will be a very useful provision for them in the future. Because they will become skilled young workers in welcoming the era of 5G technology. In the future, we hope that students from SMK Negeri 1 Dlanggu can develop IoT devices in schools, villages, or even industries that will use IoT for company operational efficiency.

Conclusion

In this community service activity, we will provide theoretical and practical knowledge in understanding the concept of IoT using an ESP32 trainer who has good performance to implement IoT in the community. UPN Veteran East Java and Narotama University collaborated to hold a workshop on IoT at SMK Negeri 1 Dlanggu, Mojokerto Regency aimed at providing education about IoT to teachers and students to learn about making hardware and software about IoT. There were around 14 participants in the online workshop due to the pandemic. Offline activities, it is still in the negotiation process because restrictions are carried out here and there. The workshop material provided is in the form of an ESP32 microcontroller. Sensors consist of proximity, temperature, and humidity sensors as well as potentiometers as analog inputs and push buttons, while the actuators consist of LEDs, buzzers, relays, OLED displays, DC motors, and servo motors. After conducting this IoT workshop, participants are expected to be able to develop several applications with the IoT platform, namely the HTTP protocol, Client-server, Thingspeak, Social Media Telegram, and the Android Blynk application by creating simple applications.

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