Preliminary design of simple IoT-based Smart Home trainer for kids

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Abstract. In the Industrial 4.0 era, all household appliances have been connected to the internet, i.e., lights, curtains, fans, and so on. Users can control it via a smartphone as a remote. The competency to master the concepts and practices related to IoT are useful. The basic concept of IoT can be introduced to students since they are in primary school. In this paper, we design an Internet-of-Things trainer to demonstrate one of simple IoT applications to children. A smart home system is selected as a use case; we select simple household appliances to represent a smart home environment. The trainer is divided into two parts: Android app as a remote system and the end-device as the node. The node is then divided into three types: mechanical-based (door lock), electrical-based (mini DC fan, generic power switch), and sensor (temperature & humidity sensor). We used a 4-D research and development model to develop this trainer. However, this paper is limited to the “Define,” “Design,” and “Development” stages. All nodes are tested their performance, and according to the functional test, it can work properly as expected: the nodes can be controlled (OFF to ON, or vice versa) and monitored (temperature and humidity) by using a smartphone. This trainer kit can be taught for 6th grade of elementary school students (about 12 – 14 years old).

1. Introduction
Technology is the primary key in education at various levels today, which brings excellent progress. One of the technologies that will significantly impact the next few years is the Internet-of-Things (IoT) [1]. In the future, there will be significant demand for experts or specialists who master this field for hardware engineers, software developers, and information technology experts [2]. The challenges faced in the next few years related to IoT are very diverse, requiring quality human resources and new expertise in a sustainable manner [3].

For this reason, several universities in Indonesia have made adaptations by including IoT courses in their curriculum, as in Ekayana [4] and Irfan et al [5]. Various hardware (trainer kits) or special learning modules have been developed, which can be used for practical or laboratory purposes on campus, such as done by Hasanah et al., [6], Wagyana and Rahmat [7], Sendari et al., [8], Somantri et al., [9], Ruhiyat et al., [10] and Hariyanto [11].
Several universities in Indonesia have also carried out community service programs (In Bahasa: Program Pengabdian kepada Masyarakat), with junior high school, senior high school, or vocational school as the application target. This activity is encouraged to facilitate IoT learning devices at the school level [12,13].

In this paper, we try to design and implement IoT learning devices with the Smart Home case. This learning media is intended for elementary school children in Indonesia. The acceleration of improving the human resources quality in terms of IoT dynamics adaption can also be done through primary education. Although the IoT-based smart home is not a cutting-edge technology abroad, for developing countries (especially in Indonesia), this technology is still relatively modern from the perspective of rural communities. IoT-based smart home trainers will have an appeal for elementary students. Elementary students are given/introduced examples of simple IoT applications to control household appliances such as turning off and turning on lights & fans, locking and unlocking the doors, and monitoring their living environment temperature. It is hoped that with this trainer, they will be motivated and interested in taking part in a field.

2. Methods

In the “Define” step, literature reviews are conducted, and we found there is no IoT-based trainer kit specifically for children. Therefore, this trainer needs to be developed. Later, we design the IoT-based Smart Home trainer, as depicted in Figure 1. According to the difficult level, this trainer kit can be taught for 6th grade of elementary school students (about 12 – 14 years old).

In the “Design” step, we determine the functions for this trainer kit: controlling and monitoring functions, divided into several functions that are often found in general households. The following are function categories:

- Sensors (Temperature and Humidity)
- Actuators (Relays, DC motors, Solenoid)
- Remote control (smartphone-based applications for interfaces). For this trainer kit, the Wi-Fi-based control medium is chosen because of its broader coverage compared to Bluetooth [14].

The ESP8266 module is used as a Gateway as well as Nodes. This module functioned as a wireless communication device between one node to other nodes within the coverage. The ESP8266 provides an ESP-MESH feature that allows IoT-based Smart Home Trainer kit to be Mesh connected. Then, the definition of each end-device is as follows:

- Temperature and Humidity sensors are designed in a package that is simple, small, and portable. In this design, the DHT11 module is used as a sensor to measure temperature and humidity conditions. The sensor’s output has been calibrated with the standard coefficient stored in the module memory. Data communication uses the one-wire communication method, which requires calculating the number of pulses in a certain period to represent the measurement data. The range of temperature measurement is 0 to 50ºC with ± 2ºC error, and the range of humidity measurement is 20 to 5% with ± 5% of error [15,16].
- This mini DC fan’s speed can be controlled ON/OFF from the developed Smartphone apps.
- This generic power switch is a solution for everyone who wants to control their existing electronic equipment without changing the furniture. Of course, furniture connected to this socket is safe to control ON / OFF, such as rice cookers, televisions, lights, etc. The main power supply comes from AC ~ 220V, so that an AC to DC converter module is needed [17].
- The standard lamp in the socket form is designed for the trainer kit applies a plug-and-play principle. Thus, ordinary lamps used in homes can be paired with the prepared threaded interface [17]. Then, this socket can be attached to any power outlet in the house. We expect this is very practical because there is no need to change the electrical installation at home.
- The door lock, which is made into a prototype, uses the pull-relax solenoid principle to lock and unlock the door. It is a proof of concept that the device design for door locks controls when the solenoid is pulled (NO) or relaxed (NC). We use the normally closed (NC) principle to save
electricity usage [18,19].

- Android interface, the use of mobile devices will be directly related to internet service providers. An Android-based interface for controlling and monitoring to be accessed via the internet will be chosen [20–22].

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**Figure 1.** The prototype of the IoT-based Smart Home trainer kit with the dimension (l x w) of 41.15 cm x 60.0 cm.

3. Results and analysis
In this section, we report the development step of this R&D research. This R&D research is the IoT-based Smart Home Trainer kit, mainly divided into three products, i.e., 1) five Nodes, 2) Gateway, and 3) specific Android Apps. As depicted in Figure 2, the Nodes are programmed to be monitored and controlled wirelessly by smartphones. An Android application is created using Android Studio®. The appearance of developed Apps is visualized in Figure 4. Five buttons, which is represented by the symbol of each Node, are provided in the App. The Node consists of integrated electronic modules (e.g.,
AC/DC converter, Relay, DC/DC converter, etc.), which are well packaged to meet aesthetic aspects and eligibility for educational purposes [23,24].

Each Node is then tested for its functionality before being integrated with a smartphone; the test method connects the Gateway into the Personal Computer (PC) via USB cable. The test results via PC is an ideal condition. If the test has not been successful at this stage, then the Android application’s system integration cannot be carried out. This will require some troubleshooting for the appeared bugs in the programs. An experimental setup is carried out until the Gateway connected to the PC can communicate with Nodes. The parameters observed at this test stage are Log data sent “from” or “to the Node. It is also tried by sending a command to turn ON/OFF the node and request Temperature & Humidity data via PC. The test result for single nodes scenario is shown in Figure 3 (a) to Figure 3 (d). Later, we control/monitor the nodes at the same time (multiple node test scenario). The result is shown in Figure 3 (e). The test results by viewing the data “from” or “to” the Node through a PC have been successful.

Furthermore, Node-Gateway is integrated into the Smartphone through the Wi-Fi medium. Thus, we can control the ON/OFF wirelessly. Figure 4(a) shows the Smartphone’s test results in monitoring the Temperature and Humidity, while the fan control function’s test results are also displayed in Figure 4(a). From the Android App, we can see that Temperature and Humidity parameters in an indoor environment can be monitored wirelessly, i.e., 29.3°C of Temperature and 65% of Humidity. The Fan symbol button on the Apps looks green, indicating the mini DC Fan is turned ON. Later, we test other nodes via smartphone control: Solenoid Door Lock, Generic switch, Lamp, which is shown in Figure 4(b), 4(c), and 4(d), respectively.

Figure 2. A photograph of the developed nodes: (a) Temperature and Humidity sensor, (b) Generic switch, (c) Lamp, (d) mini DC Fan, (e) Solenoid Door Lock, and (f) Gateway.
4. Conclusion and future work
In this paper, the IoT-based Smart Home trainer introducing the IoT concept to the children has been developed through 4-D research and development model. However, we limit this work to three steps
from four steps: Define, Design, and Development. The gateway has been developed based on the ESP8266 following with five nodes, including (1) Temperature and Humidity sensors using DHT11, (2) General switch, (3) Lamp, (4) mini DC Fan, and (5) Solenoid Door lock. The test results show that the node can be monitored and controlled through a smartphone. This trainer kit is suitable for 12 – 14 years old children.

We will realize a mockup in a trainer kit referring to the design defined in Section II for further work. The trainer kit’s base comprises a stand-up board where the nodes and gateways are placed on the board. With an attractive/exciting display, this IoT-based Smart Home Trainer kit deserves to be introduced to students (especially for elementary students) or the public. After the validation and field test have been done, we will continue to the dissemination step.

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