The use of internet of things (lot) to produce trainer and remote lab learning media

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Abstract. This research aimed at designing and producing a learning media of Trainer and Remote Lab based on the Internet of Things (IoT), which can be used in learning in the era of the industrial revolution 4.0. This study employed Research and Development (R&D) method with four phases, such as Requirement, Design, and Coding & Testing. The Requirement stage is implemented by doing communication and interviews with lecturers and students. This activity intended to understand the conditions of the learning media used in the laboratory. The Design stage was carried out by preparing requirement specifications by creating an IoT Trainer and Remote Lab IoT system design architecture. While the Coding & Testing stage was applied by coding Firebase, Remote Lab, and Arduino (NodeMCU). Testing was applied to students and lecturers to check the connectivity and system failures. The results of this study were in the form of IoT (Hardware) trainer learning media using NodeMCU and Remote Lab IoT as a software of Android application. After testing the product 21 times, the result showed that an outstanding level of reliability was obtained, reaching 93.33%. Thus the IoT and Remote Lab Trainers are suitable for use as distance learning media.

1. Introduction

The use of the Internet is proliferating in various sectors. Almost all activities use the internet, both in everyday life and in the industrial world. This is a digital process that is connected and includes multiple types of technology, from 3D printing to robotics which is believed to increase productivity [1]. In the educational context, it is necessary to have internet-based learning media. Media is a means by which to gain knowledge. According to [2], “media” is an inseparable part of the teaching and learning process to achieve educational goals in public and learning objectives in particular schools. One example of teaching media combined with the use of the internet is IoT (Internet of Things).

The concept of the Internet of Things (IoT) aims at expanding the benefits of continuously connected internet connectivity. According to [3], we can share data, remote control, and various things via the internet. In simple terms, the Internet of Things is a basic concept that connects any devices to one another, including refrigerators, TVs, washing machines, lamps, smartphones, cars, and even IoT, which can be used to design learning media in the form of trainers.

Based on the results of interviews with lecturers who teach the digital electronics courses in Engineering Faculty Universitas Negeri Makassar, he said that a suitable learning media for the
industrial revolution 4.0 is still not available. Another opinion from the students who programs a Sensor and Transducer practicum said that they hope that there would be a learning media that was more attractive and in accordance with current technological developments. The number of students as respondents were 21 people and had programmed the same course.

Based on these results, a learning media that applied an IoT technology was needed. This media consists of two parts, namely the IoT Trainer (Hardware) and the Remote Lab (Software). The IoT and Remote Lab Trainer learning media consisted of 6 basic logic gates, namely And, Or, Not, Nand, Nor, and X-Nor. The Remote Lab application was connected to the IoT Trainer by utilizing an internet connection so that the students could do the lab work remotely. The expert opinion also strengthens the use of Remote Labs that can be applied in Vocational Schools by looking at development results based on validation of material experts and media experts [4].

IoT systems require real-time databases or data. One of the world’s largest companies, Google, has provided a free real-time service called Firebase. Firebase is an application platform for Android and web development. The IoT Trainer uses the ESP32 as a control to change the value of the digital gate input. ESP32 is a microcontroller equipped with 2.4 GHz Wi-Fi and low power bluetooth technology. Based on the block diagram, the ESP32 chips consist of the 32bit microprocessor, Cryptographic hardware acceleration, DAC, ADC, UART, CAN, SPI, and I2C [8]. Based on this explanation, this research was formulated in the form of a trainer design and remote lab based on the internet of things (IoT) as a learning medium.

2. Research Methods

2.1 Research Development Methods
The method used in this research was Research and Development (R&D) with 4D developing models. The design stage used a waterfall planning model. The waterfall model planning has several systematics stage, namely: requirement, design system, Coding, & Testing [13]. The waterfall stage models can be observed in the figure below:

![Figure 1. Waterfall Planning.](image)

2.2. Research Participants
The participants of this research were the lecturer and the students who programmed the Digital Practicum subject. They were respondents of this study to get some information about the condition of learning media used in the laboratory. This aimed at obtaining the accurate information with several questions for reaching the learning goals, then the information that obtained from the interview will be analyzed to get the data.

2.3. Application development methodology
The design stage was to prepare the needed specification, which makes a trainer IoT system and remote lab design architecture. The system design helped to determine the hardware and software. Setting up the requirements of media required, it could help us define the whole system architecture. The figure below shows us the concept of system architecture.
The remote lab IoT needs a software Solidworks, Diptrace, Corel Draw, Adobe XD, Android studio, and Arduino IDE, while the process to make hardware was required some tools and materials. The tools used to make hardware such as Jigsaw, solder, cutter, screwdriver, ruler, pencil, cutting pliers, sharp pliers, nippers, and desoldering. The materials were tin, ESP 32, LED, Gate IC, PCB, header male and female, cable, and resistor. All of these materials were assembling in the PCB according to the layout design.

The coding and testing of the trainer IoT system and remote lab were done to ensure each feature to run well and integrate to the next stage. The coding stage was divided into 3, namely: 1. firebase coding, 2. remote lab, 3. Arduino coding and NodeMCU. Each of the units was developed and tested for the functionality which was known as a testing unit. This stage was used to ensure that the IoT’s trainer and remote lab could well connect to the internet.

2.4. Data Collection
The data were collected from the testing between students and lecturers to check for connectivity and system failures, each function was tested by each user to maximize the performance of the IoT Trainer and Remote Lab. Testing experiments were carried out on students as many as 10 basic logic gate questions with 21 experiments. This stage was assessed if the IoT Trainer’s response was taken under 10 seconds from the IoT Remote Lab command, then it was given a value of 1. If the trainer’s response was over 10 seconds, then the value was 0, if there was a connection error or function of each IoT Trainer and Remote Lab feature.

2.5. Data analysis
The analysis technique used in this study was a descriptive statistic. The result can be shown by the bar chart or graphic to make the information read easily.

3. Results and Discussion

3.1. Results of hardware design
Designing an IoT Trainer (hardware) was a process of making an Interface display to user or students using Corel Draw. This software focused on being used to create a design. The first step was determining the size. The Trainer Interface was designed with a size of 280 x 230. It can be seen in Figure 3. Then, made a gate design, namely Or, Nand, Nor, X-Or, and X-Nor.
The next process combines 2 gates and 3 inputs. Finally, the file was saved in PNG format. The following is the result of making Interface Trainer using Corel Draw. The next stage was to make the circuit using Diptrace software. The electronic components used were 24lsxx gate IC (Integrated Circuit), 5mm LEDs, Transistors, SMD Resistors, and Arduino NodeMCU. The PCB size was made according to the Interface Trainer of 280 x 230 and printed using the Gerber file as the following Figure 4.

Figure 3. Trainer interface design results.

Designing a box trainer required a 3D software such as Solidwork. Its size was 280 x 230, which can be seen in figure 5 from the model and the thickness of it. The material selected to make this box was Multiplex or Plywood with a thickness of 10 mm, and it was covered by HPL (High-Pressure Laminate).

Figure 4. Diptrace Schematic Design Results.
3.2. Results of Software Design

The User Interface designing of the Remote Lab (Software) was displayed to the User to be able to interact with the system. In this case, we used Android as the Operating System. The software used was Adobe Xd to create a view for the User.

There were many gates used in this interface such as And, Or, Nand, Nor, X-Or, and X-Nor. The user view of basic gate images created as many as 27, which can be seen in the image above. The gates were defined by color and images. Then, android programs created using android studio with insert vector files in scalable vector graphics (SFG) format created by Adobe Xd app. These files was used to create a User Interface (UI) view in an application that can be seen in figure 7.
Each image in android programming is labeled to make it easier to call and display in the App. Furthermore, the program’s creation was object-oriented using the Kotlin programming language, which would set the action when interacting with the Application.

The software used to create the program was Arduino IDE. It was used to create programs using C Language. The first step was to create definitions and pin modes, then NodeMCU pins should match to the set that has been created. These pins served to control the input value of each gate, then inserted the program into the NodeMCU to see the suitability of the definition and pin mode. The last step was to create a program command to be able to communicate with Firebase.

Firebase is a service from Google used to make it easier for app developers to develop the apps. The first step was done by opening the https://firebase.google.com then signed in using your Gmail account. Then selected the add project, and entered the project name. Next, chose an account to Google Analytics, set the default account for Firebase for the same account in the previous login. Firebase was created successfully. Configure the real-time database, chose the database in the menu section, and then created the database in the real-time database. The last step as the security rule, it was done by selecting Start in test mode. It was intended to read and write to the created real-time database. Then the database was ready to be used and tested. For more information, it can be seen in figure 9.

The product of learning media was divided into two i.e., IoT Trainer (Hardware) can be seen in figure 10 and Remote Lab IoT (Software) can be seen in figure 11, Internet media was required for interconnecting IoT Trainer and Remote Lab IoT. The system should be connected to the clouds in order to communicate from IoT Trainer and Remote Lab IoT. The cloud was used to store databases so that
Trainer and Remote Lab IoT could connect in real-time. The design results could be seen in the image. Real-time trials were conducted at a later stage.

![Figure 9. Trainer IoT & Remote Lab IoT.](image)

Application testing was performed to check that each application system was connected between Remote Lab IoT and IoT Trainer. At this stage, it took some supporting hardware such as a PC/Laptop and Camera. The PC was used to change programs created in the event of an error. The camera was used to perform live streaming experiments on Trainer. Test results without errors and successfully sending data to Firebase indicated that the App worked properly. Test indicators on IoT Trainer and Remote Lab IoT, namely, Connection, User Login, IoT Trainer System, Streaming, Gate test, and Logout. The changes in variable values 1 and 0 on the database indicated that Trainer and Remote Lab could connect properly.

Furthermore, the Testing Phase became the basis decision-making in fixing the shortcomings of the devices made. The testing was involved 10 students who practiced 10 basic logic gates as many as 21 experiments. This stage would be given a value of 1 if the trainer’s response was taken 10 seconds from the Remote Lab IoT command. If the Trainer’s response was above 10 seconds, then given a value of 0. In the first experiment, the trainer’s response was very good, did not decrease, the change in input value was brought 10 seconds, and in question number 5 experienced a decrease in response to the gate input. Then again experienced an increase in response to the next question. Based on experiments, it can be concluded that the Remote Lab Response to IoT Trainer obtained a result of 93.33%. The results of the experiment can be seen in figure 10.

![Figure 10. IoT Trainer Responses Experiment Graphic.](chart)
3.3. Discussion

IoT Trainer and Remote Lab research used Android as one of the essential parts for connecting users and IoT Trainers. The use of Android was highly developed in various sectors, one of which was the design of learning media supported by research [5] entitled “Learning Media Development Based on Android Subjects Graphic Design Class X Using Android as a Learning Medium”. IoT Trainer design and IoT Based Remote Lab were learning media using Firebase as a link between Remote Lab and IoT Trainer. It was in line with the research conducted by [6] entitled “Implementation of Firebase Technology In-Camera Service Location Search App Based on Android-based Rating”, which used Firebase. Thus, it can be concluded that to create an IoT system, it was very supportive when using Firebase as a database manager.

Research conducted by [7] under the title “Development of Heat Exchanger Control Trainer with IoT System for Smart Manufacturing” was classified into three aspects: IoT devices, connectivity, and cloud or application systems. In this study, conclusiveness became one of the main factors because it was a response assessment between IoT Trainers and IoT Remote Labs, the cloud used Firebase, and the last was the system between IoT Trainer and Remote Lab IoT.

Controllers used in IoT Trainers was NodeMCU. One of the advantages of NodeMCU was as the higher response of rate, as evidenced by the results of experiments conducted, reaching 93.33%. To support the development of IoT, we can also use ESP32 as report [8]. The rapid use of the internet presented a breakthrough ESP32 to support the development of IoT.

The research conducted [9] under the title “Improving Temperature Sensor Accuracy in the IoT Trainer Kit by Linear Regression Method” revealed a comparison between error and standard deviation before and after regression was performed, the error rate dropped from 80.9% from 7.3 to 1.39. The standard deviation was a presentation of tolerance from a 20% sensor dropped from 0.88 to 0.704. Based on these results, there has been a decrease in reading errors in the sensor using internet-connected esp. 8266.

Based on the results of research [10] IoT-based Arduino Uno Microcontroller Trainer Kit learning media developed worthy and well used as a learning medium in the subjects of Programmatic Control System at SMKN 1 Jenangan Ponorogo. Internet of Things (IoT) based Trainer and Remote Lab research as also worth using because it achieved 93.33% response or connectivity.

Research of [11] entitled “Internet-Based Smart Laboratory of Things In Faculty of Electrical Engineering Muhammmadiyah University Sidoarjo” produced IoT products that could regulate laboratory room temperature based on indications of people entering or exiting the room as well as the lighting of rooms that were monitored and controlled in real-time via smartphones with internet networks. This is in line with research design trainers and remote labs based on the internet of things (IoT) because each one produced an IoT product design.

4. Conclusion

The IoT Trainer design used a NodeMCU controller by controlling 6 basic Logic gates consisting of 2 inputs and 3 Inputs packed in 1 box made of High-Pressure Laminate (HPL). Trainer IoT and Remote Lab IoT used Firebase to manage databases with internet media, to connect users to IoT Trainers using Android where there was a Remote Lab IoT application with an excellent response rate of 93.33%. Thus, IoT Trainer and IoT Remote Lab could be used by lecturers as a teaching medium with 6 basic logic gate experiments, and students could practice remotely.

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